

INTERNATIONAL STANDARD

NORME INTERNATIONALE

**Low-voltage switchgear and controlgear –
Part 3: Switches, disconnectors, switch-disconnectors and fuse-combination
units**

**Appareillage à basse tension –
Partie 3: Interrupteurs, sectionneurs, interrupteurs-sectionneurs et combinés-
fusibles**



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INTERNATIONAL ELECTROTECHNICAL COMMISSION

LOW-VOLTAGE SWITCHGEAR AND CONTROLGEAR –**Part 3: Switches, disconnectors, switch-disconnectors
and fuse-combination units**

FOREWORD

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International Standard IEC 60947-3 has been prepared by subcommittee 121A: Low-voltage switchgear and controlgear, of IEC technical committee 121: Switchgear and controlgear and their assemblies for low voltage.

This fourth edition cancels and replaces the third edition published in 2008, Amendment 1:2012 and Amendment 2:2015. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

- addition of critical load current tests for DC switches (see 9.3.9);
- addition of requirements for a conditional short-circuit rating for disconnectors, switches, and switch-disconnectors protected by circuit-breakers (see 9.3.7.2);
- addition of new categories for high-efficiency motors switching (see Annex A);

- addition of new Annex E for connection to aluminium conductors;
- addition of new Annex F for power losses measurement.

The text of this International Standard is based on the following documents:

FDIS	Report on voting
121A/340/FDIS	121A/354/RVD

Full information on the voting for the approval of this International Standard can be found in the report on voting indicated in the above table.

This document has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts in the IEC 60947 series, published under the general title *Low-voltage switchgear and controlgear*, can be found on the IEC website.

This part is to be used in conjunction with the sixth edition of IEC 60947-1:2020. The numbering of the subclauses is sometimes not continuous because it is based on IEC 60947-1:2020.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under "<http://webstore.iec.ch>" in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

INTRODUCTION

The provisions of the general rules dealt with in IEC 60947-1 are applicable to this document, where specifically called for. Clauses and subclauses, tables, figures and annexes of the general rules thus applicable are identified by reference to the sixth edition of IEC 60947-1:2020, for example, 5.3.4.1 of IEC 60947-1:2020, Table 4 of IEC 60947-1:2020, or Annex A of IEC 60947-1:2020.

LOW-VOLTAGE SWITCHGEAR AND CONTROLGEAR –

Part 3: Switches, disconnectors, switch-disconnectors and fuse-combination units

1 Scope

This part of IEC 60947 applies to switches, disconnectors, switch-disconnectors and fuse-combination units and their dedicated accessories to be used in distribution circuits and motor circuits of which the rated voltage does not exceed 1 000 V AC or 1 500 V DC.

NOTE 1 Accessories are interconnecting units, extended terminals, internal coils, auxiliary contacts, motor operator, etc. offered as options with the basic unit.

This document does not apply to equipment coming within the scope of IEC 60947-2, IEC 60947-4-1 and IEC 60947-5-1.

Particular requirements for switches, disconnectors, switch-disconnectors and fuse-combination units for use in photovoltaic (PV) DC applications are given in Annex D.

Specific requirements for LV switchgear intended for the connections of aluminium conductors are given in Annex E.

Guidance on measurement of power loss is provided in Annex F.

This document does not include the additional requirements necessary for electrical apparatus for explosive gas atmospheres.

NOTE 2 Depending on its design, a switch (or disconnector) can be referred to as "a rotary switch (disconnector)", "cam-operated switch (disconnector)", "knife-switch (disconnector)", etc.

NOTE 3 In this document, the word "switch" also applies to the apparatus referred to in French as "commutateurs", intended to modify the connections between several circuits and *inter alia* to substitute a part of a circuit for another.

NOTE 4 In general, throughout this document, switches, disconnectors, switch-disconnectors and fuse-combination units will be referred to as "equipment".

The object of this document is to state:

- a) the characteristics of the equipment;
- b) the conditions that apply to the equipment with reference to:
 - 1) operation and behaviour in normal service;
 - 2) operation and behaviour in case of specified abnormal conditions, e.g. short-circuit;
 - 3) dielectric properties;
- c) the tests for confirming that these conditions have been met and the methods that are adopted for these tests;
- d) the information relevant to the marking of the equipment or made available by the manufacturer, e.g. in the catalogue.

Specific items requiring agreement between the user and the manufacturer are identified in Annex B.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60050-441, *International Electrotechnical Vocabulary – Part 441: Switchgear, controlgear and fuses* (available at <http://www.electropedia.org>)

IEC 60034-12:2016, *Rotating electrical machines – Part 12: Starting performance of single-speed three-phase cage induction motors*

IEC 60034-30-1:2014, *Rotating electrical machines – Part 30-1: Efficiency classes of line operated AC motors (IE code)*

IEC 60228:2004, *Conductors of insulated cable*

IEC 60269 (all parts), *Low-voltage fuses*

IEC 60417, *Graphical symbols for use on equipment* (available at <http://www.graphical-symbols.info/equipment>)

IEC 60695-2-11:2014, *Fire hazard testing – Part 2-11: Glowing/hot-wire based test methods – Glow-wire flammability test method for end-products (GWEPT)*

IEC 60947-1:2020, *Low-voltage switchgear and controlgear – Part 1: General rules*

IEC 60947-5-1:2016, *Low-voltage switchgear and controlgear – Part 5-1: Control circuit devices and switching elements – Electromechanical control circuit devices*

IEC 61000-4-2:2008, *Electromagnetic compatibility (EMC) – Part 4-2: Testing and measurement techniques – Electrostatic discharge immunity test*

IEC 61000-4-3:2006, *Electromagnetic compatibility (EMC) – Part 4-3: Testing and measurement techniques – Radiated, radio-frequency, electromagnetic field immunity test*

IEC 61000-4-3:2006/AMD1:2007

IEC 61000-4-3:2006/AMD2:2010

IEC 61000-4-4:2012, *Electromagnetic compatibility (EMC) – Part 4-4: Testing and measurement techniques – Electrical fast transient/burst immunity test*

IEC 61000-4-5:2014, *Electromagnetic compatibility (EMC) – Part 4-5: Testing and measurement techniques – Surge immunity test*

IEC 61000-4-5:2014/AMD1:2017

IEC 61000-4-6:2013, *Electromagnetic compatibility (EMC) – Part 4-6: Testing and measurement techniques – Immunity to conducted disturbances, induced by radio-frequency fields*

IEC 61545:1996, *Connecting devices – Devices for the connection of aluminium conductors in clamping units of any material and copper conductors in aluminium bodied clamping units*

IEC 62208:2011, *Empty enclosures for low-voltage switchgear and controlgear assemblies – General requirements*

IEC 62475:2010, *High-current test techniques – Definitions and requirements for test currents and measuring systems*

ISO 2859-1:1999, *Sampling procedures for inspection by attributes – Part 1: Sampling schemes indexed by acceptance quality limit (AQL) for lot-by-lot inspection*
ISO 2859-1:1999/AMD1:2011

CISPR 11:2015, *Industrial, scientific and medical equipment – Radio-frequency disturbance characteristics – Limits and methods of measurement*
CISPR 11:2015/AMD1:2016

CISPR 32:2015, *Electromagnetic compatibility of multimedia equipment – Emission requirements*

3 Terms, definitions and index of terms

3.1 General

For the purposes of this document, the terms and definitions given in IEC 60050-441 and IEC 60947-1 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at <http://www.electropedia.org/>
- ISO Online browsing platform: available at <http://www.iso.org/obp>

3.2 Alphabetical index of terms

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3.3 General terms

3.3.1

disconnecter

mechanical switching device which, in the open position, complies with the requirements specified for the isolating function

Note 1 to entry: A disconnector is capable of opening and closing a circuit when either a negligible current is broken or made, or when no significant change in the voltage across the terminals of each of the poles of the disconnector occurs. It is also capable of carrying currents under normal circuit conditions and carrying, for a specified time, currents under abnormal conditions such as those of short-circuit.

[SOURCE: IEC 60050-441:2000, 441-14-05, modified – Reference to isolating function instead of isolating distance.]

3.3.2

fuse-combination unit

combination of a mechanical switching device and one or more fuses in a composite unit, assembled by the manufacturer or in accordance with his instructions

[SOURCE: IEC 60050-441:2000, 441-14-04, modified – The note has been deleted.]

3.3.3

switch-fuse

switch in which one or more poles have a fuse in series in a composite unit

[SOURCE: IEC 60050-441:2000, 441-14-14]

3.3.3.1

switch-fuse single opening

switch-fuse which provides an interruption in the circuit on one side of the fuse-link only

Note 1 to entry: With this arrangement, safety precautions may be necessary when removing fuse-links.

3.3.3.2

switch-fuse double opening

switch-fuse which provides an interruption in the circuit on both sides of the fuse-link

Note 1 to entry: With this arrangement, safety precautions may be necessary when removing fuse-links.

3.3.4

fuse-switch

switch in which a fuse-link or a fuse-carrier with fuse-link forms the moving contact

[SOURCE: IEC 60050-441:2000, 441-14-17]

3.3.4.1

fuse-switch single opening

fuse-switch which provides an interruption in the circuit on one side of the fuse-link only

Note 1 to entry: With this arrangement, safety precautions may be necessary when removing fuse-links.

3.3.4.2

fuse-switch double opening

fuse-switch which provides an interruption in the circuit on both sides of the fuse-link

Note 1 to entry: With this arrangement, safety precautions may be necessary when removing fuse-links.

3.3.5

disconnecter-fuse

disconnecter in which one or more poles have a fuse in series in a composite unit

[SOURCE: IEC 60050-441:2000, 441-14-15]

3.3.5.1

disconnecter-fuse single opening

disconnecter-fuse which provides an opening in the circuit on at least one side of the fuse-link, that satisfies the requirements specified for the isolating function

Note 1 to entry: With this arrangement, safety precautions may be necessary when removing fuse-links.

3.3.5.2

disconnecter-fuse double opening

disconnecter-fuse which provides an opening in the circuit that satisfies the requirements specified for the isolating function on both sides of the fuse-link

3.3.6

fuse-disconnector

disconnecter in which a fuse-link or fuse-carrier with fuse-link forms the moving contact

[SOURCE: IEC 60050-441:2000, 441-14-18]

3.3.6.1

fuse-disconnector single opening

fuse-disconnector which provides an opening in the circuit on at least one side of the fuse-link that satisfies the requirements specified for the isolating function

Note 1 to entry: With this arrangement, safety precautions may be necessary when removing fuse-links.

3.3.6.2

fuse-disconnector double opening

fuse-disconnector which provides an opening in the circuit, that satisfies the requirements specified for the isolating function, on both sides of the fuse-link

3.3.7

switch-disconnector-fuse

switch-disconnector in which one or more poles have a fuse in series in a composite unit

[SOURCE: IEC 60050-441:2000, 441-14-16]

3.3.7.1

switch-disconnector-fuse single opening

switch-disconnector-fuse which provides an interruption in the circuit on at least one side of the fuse-link that satisfies the requirements specified for the isolating function

Note 1 to entry: With this arrangement, safety precautions may be necessary when removing fuse-links.

3.3.7.2

switch-disconnector-fuse double opening

switch-disconnector-fuse which provides an interruption in the circuit on both sides of the fuse-link that satisfies the requirements specified for the isolating function

3.3.8

fuse-switch-disconnector

switch-disconnector in which a fuse-link or a fuse-carrier with fuse-link forms the moving contact

[SOURCE: IEC 60050-441:2000, 441-14-19]

3.3.8.1

fuse-switch-disconnector single opening

fuse-switch-disconnector which provides an interruption in the circuit on at least one side of the fuse-link that satisfies the requirements specified for the isolating function

Note 1 to entry: With this arrangement, safety precautions may be necessary when removing fuse-links.

3.3.8.2

fuse-switch-disconnector double opening

fuse-switch-disconnector which provides an interruption in the circuit on both sides of the fuse-link that satisfies the requirements specified for the isolating function

3.3.9

single pole operated three-pole device

mechanical unit consisting of three individually operable single pole switches and/or disconnecting units according to this document, rated as a complete unit for use in a three-phase system

Note 1 to entry: These mechanical units are intended for power distribution systems where switching and/or isolation of an individual phase may be necessary and they should not be used for the switching of the primary circuit of three-phase equipment.

3.3.10

semi-independent manual operation

operation solely by means of directly applied manual energy such that the manual force is increased up to a threshold value beyond which the independent switching operation is achieved unless deliberately delayed by the operator

4 Classification

4.1 According to the utilization category

See 5.4.

4.2 According to the method of operation

4.2.1 Manually operated equipment

- dependent manual operation (see 3.6.12 of IEC 60947-1:2020);
- independent manual operation (see 3.6.15 of IEC 60947-1:2020);
- semi-independent manual operation (see 3.3.10).

4.2.2 Remotely operated equipment

Under consideration.

4.3 According to suitability for isolation

- suitable for isolation (see 8.1.7 of IEC 60947-1:2020);
- not suitable for isolation.

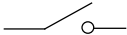
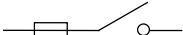
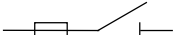
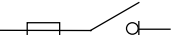
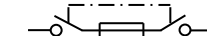
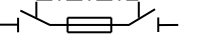
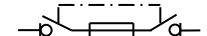
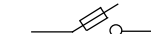
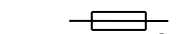
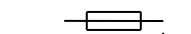
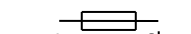
4.4 According to the degree of protection provided

See 8.1.12 of IEC 60947-1:2020.

4.5 Summary of symbols for equipment types

A summary of equipment definitions and relevant diagrams is given in Table 1.

Table 1 – Summary of equipment definitions

Functions		
Making and breaking current	Isolating	Making, breaking and isolating
Switch 	Disconnecter 	Switch-disconnector 
Fuse-combination units		
Switch-fuse single opening ^a 	Disconnecter-fuse single opening ^a 	Switch-disconnector-fuse single opening ^a 
Switch-fuse double opening ^b 	Disconnecter-fuse double opening 	Switch-disconnector-fuse double opening ^b 
Fuse-switch single opening ^a 	Fuse-disconnector single opening ^a 	Fuse-switch-disconnector single opening ^a 
Fuse-switch double opening ^b 	Fuse-disconnector double opening 	Fuse-switch-disconnector double opening ^b 
NOTE Equipment shown as single opening can comprise multiple openings in series.		
^a The fuse may be on either side of the contacts of the equipment. ^b Depending on the design, breaking may take place on one or both sides of the fuse-link.		

5 Characteristics

5.1 Summary of characteristics

The relevant characteristics from 3.10 of IEC 60947-1:2020 apply, with the following addition.

The characteristics of the equipment shall be stated in terms of the following as applicable:

- type of equipment (see 5.2);
- rated and limiting values for the main circuit (see 5.3);
- utilization category (see 5.4);
- control circuits (see 5.5);
- auxiliary circuits (see 5.6);

5.2 Type of equipment

The following information shall be stated.

- number of poles;
- kind of current (alternating current or direct current);
- in the case of alternating current, number of phases and rated frequency;
- number of positions of the main contacts (if more than two);
- breaking arrangement for fused devices (single opening or double opening).

5.3 Rated and limiting values for the main circuit

5.3.1 General

Rated values are assigned by the manufacturer. They shall be stated in accordance with 5.3.2 to 5.3.7.4 noting that some of the listed values may not apply.

5.3.2 Rated voltages

5.3.2.1 Rated operational voltage (U_e)

Subclause 5.3.1.1 of IEC 60947-1:2020 applies.

5.3.2.2 Rated insulation voltage (U_i)

Subclause 5.3.1.2 of IEC 60947-1:2020 applies.

5.3.2.3 Rated impulse withstand voltage (U_{imp})

Subclause 5.3.1.3 of IEC 60947-1:2020 applies.

5.3.3 Currents

5.3.3.1 General

An equipment is defined by the following currents.

5.3.3.2 Conventional free air thermal current (I_{th})

Subclause 5.3.2.1 of IEC 60947-1:2020 applies.

5.3.3.3 Conventional enclosed thermal current (I_{the})

Subclause 5.3.2.2 of IEC 60947-1:2020 applies.

5.3.3.4 Rated operational current (I_e) or rated operational power

Subclause 5.3.2.3 of IEC 60947-1:2020 applies.

5.3.3.5 Rated uninterrupted current (I_u)

Subclause 5.3.2.4 of IEC 60947-1:2020 applies.

5.3.4 Rated frequency

Subclause 5.3.3 of IEC 60947-1:2020 applies.

5.3.5 Rated duty

5.3.5.1 General

The rated duties considered as normal are as follows.

5.3.5.2 Eight-hour duty

Subclause 5.3.4.1 of IEC 60947-1:2020 applies.

5.3.5.3 Uninterrupted duty

Subclause 5.3.4.2 of IEC 60947-1:2020 applies.

5.3.6 Normal load and overload characteristics

5.3.6.1 Ability to withstand motor switching overload currents

See Annex A.

5.3.6.2 Rated making capacity

Subclause 5.3.5.2 of IEC 60947-1:2020 applies with the following additions.

The rated making capacity is stated by reference to the rated operational voltage and rated operational current and to the utilization category according to Table 4.

Not applicable to AC-20 or DC-20 equipment.

5.3.6.3 Rated breaking capacity

Subclause 5.3.5.3 of IEC 60947-1:2020 applies with the following additions.

The rated breaking capacity is stated by reference to the rated operational voltage and rated operational current and to the utilization category according to Table 4.

Not applicable to AC-20 or DC-20 equipment.

5.3.7 Short-circuit characteristics

5.3.7.1 Rated short-time withstand current (I_{cw})

The rated short-time withstand current of a switch, a disconnecter or a switch-disconnector is the value of short-time withstand current, assigned by the manufacturer, that the equipment can carry without any damage under the test conditions of 9.3.6.2.

The value of the rated short-time withstand current shall be not less than twelve times the maximum rated operational current. The duration of the current shall be 1 s, unless otherwise stated by the manufacturer.

For alternating current, the value of the current I_{cw} is the RMS value of the AC component and it is assumed that the highest peak value likely to occur does not exceed n times this RMS value, the factor n being given by Table 16 of IEC 60947-1:2020.

5.3.7.2 Rated short-circuit making capacity (I_{cm})

Subclause 5.3.6.2 of IEC 60947-1:2020 applies with the addition of the following note.

NOTE I_{cm} is not applicable to fused devices.

5.3.7.3 Void

5.3.7.4 Rated conditional short-circuit current (I_q , alternatively I_{cc})

Subclause 5.3.6.4 of IEC 60947-1:2020 applies.

5.4 Utilization category

The utilization categories define the intended applications and are given in Table 2.

Each utilization category is characterized by the values of the currents and voltages, expressed as multiples of the rated operational current and the rated operational voltage, as well as the power-factors or time-constants of the circuit. The conditions for making and breaking given in Table 4 correspond in principle to the applications listed in Table 2.

The designation of utilization categories is completed by the suffix A or B according to whether the intended applications require frequent or infrequent operations (see Table 5).

Utilization categories with suffix B are appropriate for devices which, due to design or application, are only intended for infrequent operation. This could apply, for example, to disconnectors normally only operated to provide isolation for maintenance work or switching devices where the fuse-link blade forms the moving contact.

The distinction between frequent and infrequent operation is based on the manufacturer's rated operation and the number of operating cycles used as a test criterion in Table 5.

For a particular rated operational current I_e , a device will be designated for frequent use (category A) if the manufacturer's declared number of operating cycles is equal to or more than the number of operating cycles indicated in columns 3, 4 and 5 of Table 5.

Table 2 – Utilization categories

Nature of current	Utilization categories		Typical application
	Category A	Category B	
Alternating current	AC-20A ^a	AC-20B ^a	– Connecting and disconnecting under no-load conditions
	AC-21A	AC-21B	– Switching of resistive loads including moderate overloads
	AC-22A	AC-22B	– Switching of mixed resistive and inductive loads, including moderate overloads
	AC-23A	AC-23B	– Switching of motor loads or other highly inductive loads
	AC-23Ae	AC-23Be	– Switching of motor loads with higher locked rotor currents ^b
Direct current	DC-20A ^a	DC-20B ^a	– Connecting and disconnecting under no-load conditions
	DC-21A	DC-21B	– Switching of resistive loads including moderate overloads
	DC-22A	DC-22B	– Switching of mixed resistive and inductive loads, including moderate overloads (e.g. shunt motors)
	DC-23A	DC-23B	– Switching of highly inductive loads (e.g. series motors)
^a The use of these utilization categories is not permitted in the USA. ^b Requirements given by asynchronous motors of design NE and HE, according to IEC 60034-12, having extended/higher locked rotor apparent power and current than design N and H respectively, to achieve a higher efficiency class according to the requirements of IEC 60034-30-1.			

Category AC-23 includes occasional switching of individual motors. The switching of capacitors or of tungsten filament lamps shall be subject to agreement between manufacturer and user.

The utilization categories referred to in Table 2 and Table 4 do not apply to an equipment normally used to start, accelerate and/or stop individual motors. The utilization categories for such equipment are dealt with in Annex A.

5.5 Control circuits

Subclause 5.5 of IEC 60947-1:2020 applies.

5.6 Auxiliary circuits

Subclause 5.6 of IEC 60947-1:2020 applies.

5.7 Relays and releases

Subclause 5.7 of IEC 60947-1:2020 applies.

5.8 Co-ordination with short-circuit protective devices (SCPD)

Subclause 5.8 of IEC 60947-1:2020 applies.

6 Product information

6.1 Nature of information

Subclause 6.1 of IEC 60947-1:2020 applies as appropriate for a particular design.

6.2 Marking

Product information shall be provided in a durable and legible manner as indicated in Table 3.

Table 3 – Product information

Item	Information	Marking location ^a
1	Indication of the open and close position. If symbols are used, the open position shall be indicated by graphical symbol IEC 60417-5008:2002-10 and the closed position by graphical symbol IEC 60417-5007:2002-10 (see 8.1.6.1 of IEC 60947-1:2020).	Visible
2	Suitability for isolation. The appropriate symbols of Table 1 shall be used.	Visible
3	Additional marking for disconnectors. Devices of utilization category AC-20A, AC-20B, DC-20A, DC-20B and DC-PV0 shall be marked "Do not operate under load" adjacent to these categories, unless the device has interlocking means to prevent such an operation.	Visible
4	Manufacturer's name or trade mark.	Marked
5	Type designation or catalogue reference.	Marked
6	Rated operational currents (or rated powers) with the corresponding rated operational voltage and utilization category (see 5.3.2, 5.3.3 and Clause 5 and/or D.5.4).	Marked
7	Value (or range) of the rated frequency or the indication "DC" (or the symbol  IEC 60417-5031:2002-10).	Marked
8	For fuse-combination units, the fuse type characteristics and maximum rated current and the maximum power loss of the fuse-link.	Marked ^b
9	IEC 60947-3, if the manufacturer claims compliance with this document.	Marked
10	Degree of protection of enclosed equipment (see Annex C of IEC 60947-1:2020).	Marked
11	Terminals shall be identified "load" and "line", unless the connection is immaterial (see 9.3.4.4.1).	Marked
12	Neutral pole terminal, if applicable, shall be identified by the letter "N" (see 8.1.8.4 of IEC 60947-1:2020).	Marked
13	Protective earth terminal shall be identified by the symbol  IEC 60417-5019:2006-08 (see 8.1.10.3 of IEC 60947-1:2020).	Marked
14	Rated insulation voltage.	Literature
15	Rated impulse withstand voltage for equipment suitable for isolation or when determined.	Literature
16	Pollution degree, if different from 3.	Literature
17	Rated duty (see 5.3.5 and Clause A.2).	Literature
18	Rated short-time withstand current and duration, where applicable.	Literature
19	Rated short-circuit making capacity, where applicable.	Literature
20	Rated conditional short-circuit current, where applicable.	Literature
21	Diagram and method of series connecting poles of mechanical switching devices for each operational rating, if applicable.	Literature
22	For switches in accordance with Annex D – appropriate connections to the PV generator and load, if applicable.	Literature
23	"+" and "-" polarities, if applicable.	Marked
24	For devices in accordance with Annex D – suitable for indoor or outdoor use.	Literature
^a The markings are to be as follows: Visible: visible from the front when the device is installed as in service in accordance with the manufacturer's instructions and the actuator is accessible and operable; Marked: marked on the product; Literature: in the manufacturer's literature. Information relating to auxiliaries shall be marked on the auxiliary or the product. If space is insufficient the data shall be given in the manufacturer's literature. ^b Shall be visible after the product is installed in accordance with the manufacturer's instructions but need not necessarily be visible from the front.		

6.3 Instructions for installation, operation and maintenance, decommissioning and dismantling

Subclause 6.3 of IEC 60947-1:2020 applies with the following addition.

When hazardous emissions including optical emissions are produced during switching operations, the recommendations as given in the manufacturer's instructions in respect of installation and/or the use of personal protective equipment (PPE) shall be observed.

7 Normal service, mounting and transport conditions

Clause 7 of IEC 60947-1:2020 applies with the replacement of the paragraph under the heading "Standard pollution degree of industrial applications:" in 7.1.3.2 "Pollution degree" with the following:

Unless otherwise stated by the manufacturer, the equipment is intended for installation under environmental conditions of pollution degree 3.

8 Constructional and performance requirements

8.1 Constructional requirements

8.1.1 General

Subclause 8.1 of IEC 60947-1:2020 applies, with the following additions.

Specific requirements for LV switchgear intended for the connections of aluminium conductors is given in Annex E.

When switches and fuse-combination units coming into the scope of this document are normally used to start, accelerate and/or stop an individual motor, they shall also comply with the additional requirements given in Annex A.

The requirements for single pole operated three-pole switches are included in Annex C.

Auxiliary switches fitted to equipment within the scope of this document shall comply with the requirements of IEC 60947-5-1.

8.1.2.2 Glow wire testing

Subclause 8.1.2.2 of IEC 60947-1:2020 applies with the following changes and additions.

Parts of insulating material necessary to retain current-carrying parts in position shall conform to the glow-wire tests of 9.2.2.1 of IEC 60947-1:2020 for test temperatures as follows:

- main current carrying parts: 960 °C.
- auxiliary current carrying parts: 850 °C.

The requirements of 8.1.2.2 of IEC 60947-1:2020 do not apply to parts with a mass lower than 2 g (insignificant mass as defined in 3.14 of IEC 60695-2-11:2014). For products containing a plurality of small parts, the total mass of non-tested parts located in close proximity to each other shall not exceed 10 g. Proximity shall be based on engineering judgment considering the risk of propagation of fire.

8.1.7 Additional requirements for equipment suitable for isolation

8.1.7.1 General

Subclause 8.1.7 of IEC 60947-1:2020 applies with the following additions.

8.1.7.2 Additional constructional requirements

The equipment shall be marked according to Table 3, item 2.

When no indication of the position of the contacts is provided, for example by the actuator or a separate indicator, all the main contacts shall be clearly visible in the open position.

The strength of the actuating mechanism and the reliability of the indication of the open position shall be checked according to 9.2.6. Moreover, when means are provided by the manufacturer to lock the equipment in the open position, locking shall only be possible when the main contacts are in the open position (see 9.2.6).

This requirement does not apply to equipment where the main contact position is visible in the open position and/or the open position is indicated by other means than the actuator.

NOTE Locking in the closed position can be required for particular applications.

The clearance across the open contacts of the same pole when in the open position shall not be less than the minimum clearance given in Table 13 of IEC 60947-1:2020 and shall also comply with the requirements of 8.2.3.2 item 1) b) of IEC 60947-1:2020.

8.1.9 Additional requirements for equipment provided with a neutral pole

Subclause 8.1.9 of IEC 60947-1:2020 applies except the fourth paragraph.

8.2 Performance requirements

8.2.1 Operating conditions

8.2.1.1 General

Subclause 8.2.1.1 of IEC 60947-1:2020 applies with the following additions.

The following requirements apply to fuse-switches, fuse-disconnectors and fuse-switch-disconnectors with a rated short-circuit making capacity exceeding 10 kA and for which the closing operation is by direct manual operation without an interposing mechanism (for dependent and semi-independent manual operation see 3.6.12 of IEC 60947-1:2020 and 3.3.10).

The test speed for the making operations specified in 9.3.7.3 shall be determined as follows.

- a) The equipment shall be operated 15 times manually under no-load conditions in accordance with the manufacturer's instructions, 5 times each, by three persons. The velocity of the hand actuator at the instant of contact closure of the last closing contact shall be determined by oscillographic or other appropriate means at any convenient part of the device.

The point at which the measurement is made and the velocity at the measurement point shall be stated in the test report. The mean velocity shall be determined after deleting the highest and lowest values.

- b) The test apparatus shall ensure that the equipment under test fully closes and that there is no impediment to the free closing movement of the device. The actual test speed shall not exceed the mean velocity determined according to a).

The mass of the moving parts of the test apparatus (without the equipment under test) shall be $2 \text{ kg} \pm 10 \%$.

8.2.1.2 Limits of operation of power operated equipment

Subclause 8.2.1.2 of IEC 60947-1:2020 applies.

8.2.1.3 Limits of operation of under-voltage relays and releases

Subclause 8.2.1.3 of IEC 60947-1:2020 applies.

8.2.1.4 Limits of operation of shunt releases

Subclause 8.2.1.4 of IEC 60947-1:2020 applies.

8.2.2 Temperature-rise

Subclause 8.2.2 of IEC 60947-1:2020 applies with the following addition.

For fuse-combination units, the temperature-rise of the fuse-link contacts during the test according to 9.3.4.2 shall not cause any damage of a nature which impairs the subsequent performance of the equipment in test sequence I.

8.2.3 Dielectric properties

8.2.3.1 General

Subclause 8.2.3 of IEC 60947-1:2020 applies with the following additions.

8.2.3.2 Impulse withstand voltage

Subclause 8.2.3.2 of IEC 60947-1:2020 applies with the following addition.

Clearances across the open contacts of a device not suitable for isolation shall withstand the test voltage given in Table 12 of IEC 60947-1:2020 appropriate to the rated impulse withstand voltage.

8.2.3.3 Power-frequency or DC withstand voltage of the main, auxiliary and control circuits

Subclause 8.2.3.3 c) of IEC 60947-1:2020 applies with the following addition.

For equipment suitable for isolation, maximum values of leakage current are specified for all the test sequences in 9.3.4.6, 9.3.5.4, 9.3.6.5, 9.3.7.5 and 9.3.8.4, respectively.

8.2.4 Ability to make and break under no-load, normal load and overload conditions

8.2.4.1 Making and breaking capacities

The rated making and breaking capacities are stated by reference to the rated operational voltage and rated operational current and to the utilization category according to Table 4.

The test conditions are specified in 9.3.4.4.1.

Table 4 – Verification of rated making and breaking capacities (see 9.3.4.4) – Conditions for making and breaking corresponding to the various utilization categories

Utilization categories		Rated operational current	Making ^a			Breaking			Number of operating cycles ^c	
			I/I_e	U/U_e	$\cos \phi$	I_c/I_e	U_r/U_e	$\cos \phi$		
AC-20A ^b	AC-20B ^b	All values	–	–	–	–	–	–	5	
AC-21A	AC-21B	All values	1,5	1,05	0,95	1,5	1,05	0,95		
AC-22A	AC-22B	All values	3	1,05	0,65	3	1,05	0,65		5
AC-23A	AC-23B	$0 < I_e \leq 100 \text{ A}$	10	1,05	0,45	8	1,05	0,45		5
		$100 \text{ A} < I_e$	10	1,05	0,35	8	1,05	0,35		3 ^d
AC-23Ae	AC-23Be	$0 < I_e \leq 100 \text{ A}$	12 ^e	1,05	0,35	8,5	1,05	0,45	5	
		$100 \text{ A} < I_e$	12 ^e	1,05	0,25	8,5	1,05	0,35	3 ^d	
Utilization categories		Rated operational categories	I/I_e	U/U_e	L/R ms	I_c/I_e	U_r/U_e	L/R ms	Number of operating cycles	
DC-20A ^b	DC-20B ^b	All values	–	–	–	–	–	–	5	
DC-21A	DC-21B	All values	1,5	1,05	1	1,5	1,05	1		
DC-22A	DC-22B	All values	4	1,05	2,5	4	1,05	2,5		5
DC-23A	DC-23B	All values	4	1,05	15	4	1,05	15		5
Key										
I = making current										
I_c = breaking current										
I_e = rated operational current										
U = applied voltage										
U_e = rated operational voltage										
U_r = power frequency recovery voltage or DC recovery voltage										
L/R = time constant of test circuit										
^a For alternating current the making current is expressed by the RMS value of the periodic component of the current.										
^b The use of these utilization categories is not permitted in the USA.										
^c One switching operation without current between each making and breaking operation is allowed, providing it does not alter the time interval between the required operations as defined in 9.3.4.4.1.										
^d In order to cover both AC-21 and AC-22 categories, an increase in the number of operations for AC-23 and AC-23e from 3 to 5 is allowed with the agreement of the manufacturer.										
^e It is at the discretion of the manufacturer to choose any factor of I/I_e between 12 and 13 and the respective $\cos \phi$ given by the following formula: $I_e \leq 100 \text{ A}$: $\cos \phi = 0,1 \times I/I_e - 0,85$ $I_e > 100 \text{ A}$: $\cos \phi = 0,1 \times I/I_e - 0,95$										

8.2.4.2 Operational performance

Tests concerning the verification of the operational performance of equipment are intended to verify that the equipment is capable of making and breaking without failure the currents flowing in its main circuit for the intended use.

The number of operating cycles and the test circuit parameters for the operational performance test for the various utilization categories are given in Table 5 and Table 6.

The test conditions are specified in 9.3.5.2.

**Table 5 – Verification of operational performance –
Number of operating cycles corresponding to the rated operational current**

1	2	3	4	5	6	7	8
Rated operational current I_e	Number of operating cycles per hour	Number of operating cycles					
		Alternating and direct current A categories			Alternating and direct current B categories		
		Without current	With current	Total	Without current	With current	Total
$0 < I_e \leq 100$	120	8 500	1 500	10 000	1 700	300	2 000
$100 < I_e \leq 315$	120	7 000	1 000	8 000	1 400	200	1 600
$315 < I_e \leq 630$	60	4 000	1 000	5 000	800	200	1 000
$630 < I_e \leq 2 500$	20	2 500	500	3 000	500	100	600
$2 500 < I_e$	10	1 500	500	2 000	300	100	400

The values in the table apply to all utilization categories except AC-20A, AC-20B, DC-20A and DC-20B. These categories shall comply with the total number of operating cycles in columns 5 or 8 without current. Column 2 gives the minimum operating rate. The operating rate for any utilization category may be increased with the consent of the manufacturer.

Table 6 – Test circuit parameters for Table 5

Utilization categories		Values of the rated operational current I_e	Making ^a			Breaking		
			I/I_e	U/U_e	$\cos \phi$	I_c/I_e	U_r/U_e	$\cos \phi$
AC-21A	AC-21B	All values	1	1	0,95	1	1	0,95
AC-22A	AC-22B	All values	1	1	0,8	1	1	0,8
AC-23A	AC-23B	All values	1	1	0,65	1	1	0,65
AC-23Ae	AC-23Be	All values	1	1	0,65	1	1	0,65
			I/I_e	U/U_e	L/R ms	I_c/I_e	U_r/U_e	L/R ms
DC-21A	DC-21B	All values	1	1	1	1	1	1
DC-22A	DC-22B	All values	1	1	2	1	1	2
DC-23A	DC-23B	All values	1	1	7,5	1	1	7,5

Key

I = making current
 I_c = breaking current
 I_e = rated operational current
 U = voltage before make (applied voltage)
 U_e = rated operational voltage
 U_r = power frequency recovery voltage or DC recovery voltage
 L/R = time constant of test circuit

^a For alternating current, the making current is expressed by the RMS value of the periodic component of the current.

8.2.4.3 Mechanical durability

Subclause 8.2.4.3.1 of IEC 60947-1:2020 applies. Test conditions are specified in 9.5.2.

8.2.4.4 Electrical durability

Subclause 8.2.4.3.2 of IEC 60947-1:2020 applies. Test conditions are specified in 9.5.3.

8.2.5 Ability to make, break or withstand short-circuit currents

The equipment shall be so constructed as to be capable of withstanding, under the conditions specified in this document, the thermal, dynamic and electrical stresses resulting from short-circuit currents.

Short-circuit currents may be encountered during current making, current carrying in the closed position and current interruption.

The ability of the equipment to make, carry and break short-circuit currents is stated in terms of one or more of the following ratings (see also Table 9):

- a) rated short-time withstand current (see 5.3.7.1);
- b) rated short-circuit making capacity (see 5.3.7.2);
- c) rated conditional short-circuit current (see 5.3.7.4).

8.2.6 Void

8.2.7 Additional performance requirements for equipment suitable for isolation

These requirements only apply to equipment with rated operational voltage greater than 50 V.

With the equipment in new condition and the contacts in the open position the equipment shall withstand the dielectric test of 9.3.4.3.

If tests according to 9.3.4.4 and 9.3.5.2 have been made, the equipment in the condition after the tests shall meet the leakage current requirements of 9.3.4.6.

8.2.8 Critical load current performance: DC equipment

The main circuits of equipment shall be capable of making and breaking its critical load current according to 9.3.9.3 and as verified by test sequence VI.

8.2.9 Overload requirements for equipment incorporating fuses

The main circuit of an equipment shall be capable of carrying an overload current according to 9.3.8.2 and shall not cause any damage of a nature which impairs the subsequent performance of the equipment in test sequence V.

8.3 Electromagnetic compatibility (EMC)

8.3.1 General

Subclause 8.3.1 of IEC 60947-1:2020 applies.

8.3.2 Immunity

8.3.2.1 General

Subclause 8.3.2 of IEC 60947-1:2020 applies with the following change and addition.

8.3.2.2 Equipment incorporating electronic circuits

Equipment incorporating electronic circuits (for example fuse-blowing indicator) shall have satisfactory immunity to electromagnetic disturbances (see 9.4.2.1).

For the appropriate tests to verify the compliance with these requirements, see 9.4 of IEC 60947-1:2020. Table 7 below provides the specific immunity performance criteria to be considered.

Table 7 – Immunity tests ^a

Types of test or test description ^a	Basic standard	Test level required	Acceptance criteria (as defined in Table 24 of IEC 60947-1:2020)
Electrostatic discharges	IEC 61000-4-2	Test level in accordance with Table 23 of IEC 60947-1:2020	B
Radiated radio-frequency electromagnetic field	IEC 61000-4-3		A
Electrical fast transient/burst	IEC 61000-4-4		B
Surge	IEC 61000-4-5		B
Conducted disturbances induced by radio-frequency	IEC 61000-4-6		A
^a A simple rectifier is not sensitive to electromagnetic disturbances in normal service conditions and does not therefore require immunity tests.			

8.3.3 Emission

8.3.3.1 Equipment not incorporating electronic circuits

Subclause 8.3.3 of IEC 60947-1:2020 applies.

8.3.3.2 Equipment incorporating electronic circuits

Equipment incorporating electronic circuits (e.g. an electronic fuse-blowing indicator) may generate continuous electromagnetic disturbances.

Emission shall fulfil the requirements of class A, group 1 of CISPR 11 or those of class A of CISPR 32 (see 9.4.3.2). See Table 8.

Table 8 – Emission limits

Ports	Frequency ranges MHz	Limits ^d	Standards
Enclosure ^b	30 to 230 ^a	30 dB (µV/m) quasi peak measured at 30 m distance ^c	CISPR 11
	230 to 1 000 ^a	37 dB (µV/m) quasi peak measured at 30 m distance ^c	Class A – Group 1
AC power	0,15 to 0,5 ^a	79 dB (µV) quasi peak 66 dB (µV) average	or
	0,5 to 5 ^a	73 dB (µV) quasi peak 60 dB (µV) average	CISPR 32
	5 to 30 ^a	73 dB (µV) quasi peak 60 dB (µV) average	Class A
^a The lower limit should apply at the transition frequency. ^b Applicable only to mechanical switching devices containing parts which operate at frequencies higher than 9 kHz, e.g. microprocessors. ^c May also be measured at a 10 m distance using the limits increased by 10 dB, or at a 3 m distance using the limits increased by 20 dB. ^d These limits have been copied, without alteration, from CISPR 11 and CISPR 32. They are also in accordance with IEC 60947-1:2020.			

These limits are given for mechanical switching devices which are used exclusively in an industrial environment. When there exists a likelihood of use outside the industrial environment, the following notice shall be included in the manufacturer's published information.

WARNING

This product has been designed for environment A.
Use of this product in environment B may cause unwanted electromagnetic disturbances in which case the user may be required to take adequate mitigation measures.

9 Tests

9.1 Kinds of test

9.1.1 General

Subclause 9.1.1 of IEC 60947-1:2020 applies.

9.1.2 Type tests

Subclause 9.1.2 of IEC 60947-1:2020 applies. Type tests are given in Table 9.

9.1.3 Routine tests

9.1.3.1 General

Subclause 9.1.3 of IEC 60947-1:2020 applies with the following additions.

The following tests apply:

- mechanical operation test (see 9.1.3.2)
operation of the switch, disconnector, switch-disconnector or fuse-combination unit during manufacture and/or other routine test may take the place of the tests listed above, provided the same conditions apply and the number of operations is not less than that specified;
- dielectric test (see 9.1.3.3)
if, by the control of materials and manufacturing processes, the integrity of the dielectric properties has been proven, these tests may be replaced by sampling tests according to a recognized sampling plan (see ISO 2859-1).

9.1.3.2 Mechanical operation test

A test shall be made to verify the correct mechanical operation of the equipment by five closing and opening operations.

9.1.3.3 Dielectric test

The test conditions shall be in accordance with 9.3.3.4.2 of IEC 60947-1:2020. As an alternative, the combined test according to 9.3.3.4.2, item 3), of IEC 60947-1:2020 is allowed. The value of the test voltage shall be in accordance with that given in Table 19 of IEC 60947-1:2020. The duration of the test shall not be less than 1 s and the test voltage shall be applied as follows:

- with the equipment in the open position, between each pair of terminals which are electrically connected together when the equipment is closed;

- with the equipment in the closed position, between each pole and the adjacent pole(s) and between each pole and the frame;
- for equipment incorporating electronic circuits connected to the main poles, with the equipment in the open position, between each pole and the adjacent pole(s) and between each pole and the frame, either on the incoming side or the outgoing side depending on the position of the electronic components.

Alternatively, disconnection of the electronic circuit(s) is permitted during dielectric tests.

9.1.4 Sampling tests

Sampling tests for verification of clearances shall be made according to 9.3.3.4.3 of IEC 60947-1:2020 in accordance with a recognized sampling plan (see ISO 2859-1).

9.1.5 Special tests

Special tests (see 3.8.4 of IEC 60947-1:2020) are specified in 9.5.

9.2 Compliance with constructional requirements

9.2.1 General

Subclause 9.2 of IEC 60947-1:2020 applies with the following additions.

9.2.5 Mechanical and electrical properties of terminals

Subclause 9.2.5 of IEC 60947-1:2020 applies with the following addition.

Where equipment is designed to be provided with different designs of terminals, the tests shall be conducted on every design.

9.2.6 Verification of the effectiveness of indication of the main contact position of equipment suitable for isolation

9.2.6.1 General

Subclause 9.2.6 of IEC 60947-1:2020 applies with the following additions.

9.2.6.2 Condition of equipment for tests

The test of the actuator mechanism and position indicating device shall be conducted as part of test sequence I (see 9.3.4 and Table 11).

If different types of actuators exist, either additional or integral, only one design shall be tested during sequence I. Moreover, the sample representative of the more critical case shall be tested according to 9.3.4.8.

Table 9 – List of type tests applicable to a given equipment

Tests	Switch	Fuse-switch	Switch-fuse	Disconnector	Disconnector-fuse	Fuse-disconnector	Switch-disconnector	Switch-disconnector-fuse	Fuse-switch-disconnector
Temperature-rise ^a	o	o	o	o	o	o	o	o	o
Temperature-rise verification	o	o	o	o	o	o	o	o	o
Dielectric properties	o	o	o	o	o	o	o	o	o
Dielectric verification	o	o	o	o	o	o	o	o	o
Leakage current	–	–	–	o	o	o	o	o	o
Rated making and breaking capacities (overload)	o	o	o	–	–	–	o	o	o
Operational performance	o	o	o	o	o	o	o	o	o
Rated short-time withstand current	o	–	–	o	–	–	o	–	–
Rated short-circuit making capacity	o	–	–	–	–	–	o	–	–
Rated conditional short-circuit current	o	o	o	o	o	o	o	o	o
Strength of actuator mechanism	–	–	–	o	o	o	o	o	o
Overload test	–	o	o	–	o	o	–	o	o
Critical load current test (DC equipment)	o	o	o	–	–	–	o	o	o
Key o = test – = no test required NOTE This list of type tests is for information only, see also footnote ^a in Table 14, Table 15 and Table 16.									
^a Applies to 9.3.3.4 only.									

9.3 Performance

9.3.1 General

Performance type tests to which equipment may be submitted according to its kind are listed in Table 9.

9.3.2 Test sequences

Type tests are grouped together in a number of sequences as shown in Table 10.

For each sequence, tests shall be made in the order listed in accordance with the requirements of the appropriate subclause, apart from the temperature-rise test (simplified testing only) and dielectric properties test of test sequence I, which may be conducted on a separate sample.

Table 10 – Overall scheme of test sequences

Sequences	Tests
Test Sequence I: General performance characteristics (see 9.3.4 and Table 11)	Temperature-rise ^{e f} Dielectric properties ^e Making and breaking capacities ^a Dielectric verification ^a Leakage current ^b Temperature-rise verification Strength of actuator mechanism
Test Sequence II: Operational performance capability (see 9.3.5 and Table 13)	Operational performance Dielectric verification Leakage current ^b Temperature-rise verification
Test Sequence III: Short-circuit performance capability ^c (see 9.3.6 and Table 14)	Short-time withstand current Short-circuit making capacity ^a Dielectric verification Leakage current ^b Temperature-rise verification
Test Sequence IV: Conditional short-circuit current ^c (see 9.3.7, Table 15 and Table 16)	Short-circuit withstand Short-circuit making ^a Dielectric verification Leakage current ^b Temperature-rise verification
Test Sequence V: Overload performance capability ^d (see 9.3.8 and Table 17)	Overload test Dielectric verification Leakage current ^b Temperature-rise verification
Test Sequence VI: Critical load current (DC) performance (see 9.3.9 and Table 20)	Critical load current test Dielectric verification Leakage current ^b Temperature-rise verification
^a Not applicable to AC-20 or DC-20 equipment. See 5.3.6.2 and 5.3.6.3. ^b Only required for equipment suitable for isolation of rated voltage greater than 50 V. ^c Either test sequence III or test sequence IV to be made according to the ratings stated by the manufacturer. ^d Not required for switches, disconnectors and switch-disconnectors. ^e May be conducted outside of the sequence, see 9.3.2. ^f Applies to 9.3.3.4 only.	

9.3.3 General test conditions

9.3.3.1 General requirements

Subclause 9.3.2.1 of IEC 60947-1:2020 applies to all type tests as applicable. The equipment at the start of any test sequence shall be in new and clean condition.

The force applied for any opening operation shall not be greater than the test force determined in 9.2.6.2 of IEC 60947-1:2020 and shall be applied in the same manner without shock.

Where doubt exists as to the correct opening operation, no more than three attempts to operate the equipment to the open position are allowed.

In order to reduce multiple testing for the same fundamental design of equipment, the following test requirements may be used.

9.3.3.2 Simplified test for equipment having the same fundamental design

When submitting simultaneously a range of switches, disconnectors, switch-disconnectors or fuse combination units of the same fundamental design, the following variations are permitted provided the equipment complies in all other respects.

9.3.3.3 Requirements for equipment having the same fundamental design

Switches, disconnectors, switch-disconnectors or fuse combination units shall be evaluated with respect to the following criteria during the determination of acceptance as the same fundamental design:

- a) the material, finish and dimensions of the current-carrying parts are identical, except for variation in design of terminals and means of fuse attachment;
- b) the contact size, material, configuration and method of attachment are identical;
- c) the operating mechanism is of the same fundamental design, materials and physical characteristics are identical;
- d) the closing and opening speeds of contacts are substantially the same;
- e) moulding and insulating materials are identical;
- f) method, materials and construction of any arc extinction device are identical.

The following variations are also permitted, provided the simplified test procedure given in 9.3.3.4 is used:

- g) utilization category and operational voltage;
- h) application for 50 Hz or 60 Hz;
- i) three or four pole equipment (switched or non-switched neutral), provided the requirements of 8.1.9 are applicable;
- j) design of terminal provided that clearances and creepage distance are not reduced (see 9.2.5 and 9.3.4.3 of this document and also see 8.1.4 of IEC 60947-1:2020);
- k) different types of actuators, either additional or integral, provided the requirements for strength of actuator are verified (see 9.2.6) on each type of actuator, one of which during test sequence I;
- l) fuse-base contacts of switch-fuses, disconnector-fuses and switch-disconnector-fuses with different types of fuse-links (fuse-link removed only under no-load conditions).

9.3.3.4 Simplified test procedure

The following simplified test procedure shall be used.

- a) If equipment having the same fundamental design is marked claiming more than one utilization category and/or more than one operational voltage, the number of test samples may be reduced, providing the tests are conducted under the most severe conditions.

For short-circuit, making and breaking, and operational performance tests, the conditions are deemed more severe if the following conditions are simultaneously fulfilled:

- operational rated voltage equal or higher;
- test current equal or higher;
- power factor equal or lower;
- number of operations equal or higher.

- b) Tests performed at 50 Hz are deemed to cover 60 Hz applications and vice versa with the following exceptions:

- temperature-rise test according to 9.3.4.2 for devices having a current greater than 800 A;

NOTE By agreement between manufacturer and user, tests at 50 Hz can be accepted for operation at 60 Hz and vice versa for currents greater than 800 A.

- temperature-rise and operational performance of relays and releases (see 8.2.2 and 8.2.2.7 of IEC 60947-1:2020). Temperature-rise tests of coils shall be performed for each frequency, but only one included in the relevant test sequence, and if separate supplying of coils and other circuits is possible, it is accepted that other circuits remain supplied at 50 Hz.

- c) Tests performed on three pole devices are deemed to cover also four pole devices with a non-switched neutral pole, provided a single-phase test on the neutral pole is performed according to 9.3.3.3.4 of IEC 60947-1:2020.

Tests performed on four switched pole devices are deemed to cover also three switched pole devices provided that all poles are identical and the closing and opening speeds of contacts are substantially the same (only the requirements of 8.1.9 are applicable concerning closing and opening of the neutral pole). However, the four switched pole devices shall always be connected in a three-phase arrangement (see Figure 11 of IEC 60947-1:2020).

- d) Tests performed with different types of fuse-base contacts.

Where switch-fuses, disconnecter-fuses or switch-disconnector-fuses are designed to be provided with different types of fuse-base contacts, temperature-rise tests according to 9.3.4.2 shall be conducted on each type at the corresponding highest fuse rated current.

The type having the maximum temperature-rise among those of the maximum test current shall be used for tests to sequences I, II and V.

Sequence IV shall be conducted on each type of fuse-base contacts whose fuse connecting means are other than bolted connection, at the highest rated conditional short-circuit corresponding current, and, if different, with the type of fuse having the maximum let-through energy at the highest test voltage.

- e) Tests performed with different terminal designs.

Where equipment is designed to be provided with different designs of terminal, the requirements and tests according to 9.3.4.2 of this document and 9.2.5 of IEC 60947-1:2020 shall be conducted on each design. These tests can be performed on separate samples.

Where equipment has terminals to be used on plug-on busbars, a test according to 9.3.4.2 shall be carried out. In addition, a test in accordance with 9.3.6.2 or 9.3.7.3.1 a) or 9.3.7.2.1 a), as applicable, shall be performed. Verification of the plugging operation shall be made. The number of operating cycles shall be 50, the cycle being from the connected position to the disconnected position and back to the connected position. The plugging operation test can be performed on a separate sample.

The test is considered to be satisfactory if the equipment remains mechanically operable.

- f) When conducting the tests according to 9.3.3.4, items d) and e) the temperature-rise at terminals and accessible parts can be measured. If the temperature-rise limits of accessible parts comply with Table 3 of IEC 60947-1:2020, no further tests of these parts according to 9.3.4.7 are necessary.

Since the intention of the tests according to 9.3.3.4, items d) and e), is to establish the worst case, the values of Table 2 of IEC 60947-1:2020 do not apply.

9.3.3.5 Test quantities

Subclause 9.3.2.2 of IEC 60947-1:2020 applies.

9.3.3.6 DC test current ripple

The DC test current ripple shall comply with the requirements of 6.3.1 of IEC 62475:2010.

9.3.3.7 Evaluation of test results

The behaviour of the equipment during the tests and its condition after the tests are specified in the appropriate test clause.

9.3.3.8 Test reports

Subclause 9.3.2.4 of IEC 60947-1:2020 applies.

9.3.4 Test sequence I: general performance characteristics

9.3.4.1 General

This test sequence applies to the types of equipment listed in Table 11 and comprises the tests according to this table.

9.3.4.2 Temperature-rise

Subclause 9.3.3.3 of IEC 60947-1:2020 applies with the following additions.

Aluminium test conductors equivalent to the copper conductors given in IEC 60947-1 are given in Annex E of this document.

As a minimum, the test shall be carried out at the rated operational current I_e . At the manufacturer's discretion, when I_{th} and/or I_{the} are higher than I_e , the higher value may be used. In the case of an AC-20 or DC-20 rating, the temperature-rise test shall be carried out at I_{th} , or I_{the} if the device is in a specified enclosure. Fuse-combination units shall be fitted with fuse-links having a rated current equal to the conventional thermal current of the combination unit.

The fuse-link shall have a power loss not exceeding the maximum value specified by the equipment manufacturer. The test may be made with a "dummy" fuse-link of essentially similar design to the standardized fuse-link and having the specified power loss.

In the case of tests carried out on a fuse-switch, a fuse-disconnector or a fuse-switch-disconnector where the blades of the fuse-links are part of the make-breaking contacts, fuse-links shall be used.

NOTE For a fuse-switch or a fuse-switch-disconnector where the blades of the fuse-links are part of the make-breaking contacts, dummies or copper links cannot replace the fuse-links due to the fact that the blades of the fuse-links in these devices wear. The wear of the fuse-blades influences the thermal verification according to 9.3.4.7.

Details of the fuse-links used for the test, i.e. the manufacturer's name and reference, the rated current, the power loss of the fuse-link, and the breaking capacity, shall be given in the test report. The type test with the specified fuse-links shall be deemed to cover the use of any other fuse-link having a power loss, at the conventional thermal current of the combination unit, not exceeding the power loss of the fuse-link used for the test.

Table 11 – Test sequence I: general performance characteristics

			Types of equipment and order of tests					
Tests	Sub-clause No.	Samples	Switch	Fuse-switch and switch-fuse	Disconnector	Disconnector-fuse and fuse-disconnector	Switch-disconnector	Switch-disconnector-fuse and fuse-switch-disconnector
Temperature-rise ^{d, e}	9.3.4.2	A, B, C, F	1	1	1	1	1	1
Dielectric properties ^d	9.3.4.3	A, C, F	2	2	2	2	2	2
Making and breaking capacities	9.3.4.4	A, D	3	3	^a	^a	3	3
Dielectric verification	9.3.4.5	A, D	4	4	^a	^a	4	4
Leakage current ^b	9.3.4.6	A, D	-	-	3	3	5	5
Temperature-rise verification	9.3.4.7	A, D	5	5	4	4	6	6
Strength of actuator mechanism	9.3.4.8	A, E	-	-	5	5	7	7
^a This test is not required for disconnectors (AC-20 or DC-20). See 5.3.6.2 and 5.3.6.3. ^b Test required only for U_e greater than 50 V. ^c Only tests marked by the same letter shall be applied in sequence to a given sample: "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, item d). Other samples if applicable: "B" is a different sample for 60 Hz test, if applicable, according to 9.3.3.4, item b); "C" are samples of each other terminal design tested at correspondent maximum rated current; "D" are samples to verify as many combinations of U_e , I_e , AC or DC voltage ratings, to be tested (see 9.3.3.4); "E" is the extra sample as specified in 9.2.6.2 and can be one of the samples B, C or D; "F" are samples of every type of fuse-carrier of fuse-combination unit according to 9.3.3.4, item d). ^d May be conducted outside of the sequence, see 9.3.2. ^e Applies only to 9.3.3.4.								

9.3.4.3 Test of dielectric properties

9.3.4.3.1 General

Subclause 9.3.3.4.1, items 1), 2), 3), 7) and, if applicable, 8) of IEC 60947-1:2020 applies with the following addition.

When, in agreement with the manufacturer, devices are disconnected for the test according to 9.3.3.4.1, item 3) c) of IEC 60947-1:2020, the test report shall state which devices were disconnected for the test. For equipment suitable for isolation (see 4.3) having an operational voltage U_e greater than 50 V, 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 0,5 mA.

9.3.4.4 Making and breaking capacities

9.3.4.4.1 General test conditions

Subclause 9.3.3.5 of IEC 60947-1:2020 applies to equipment provided with a neutral pole.

The test values are stated in 8.2.4.1, Table 4, according to the utilization category.

The stated number of make-break operating cycles shall be made with a time interval between close-open cycles of $30\text{ s} \pm 10\text{ s}$ except that for equipment of conventional thermal current of 400 A or more, the time interval may be increased by agreement between manufacturer and user and the interval shall be stated in the test report.

During each make-break operating cycle, equipment need only stay in the closed position for a period long enough to allow the switching operation to be completed and to enable the current value to be established and the moving parts of the equipment to come to rest. After each operating cycle, the recovery voltage shall be maintained for at least 0,05 s.

For convenience of testing, equipment of utilization categories AC-23A, AC-23Ae, AC-23B and AC-23Be, make-break operating cycles may be replaced, with the agreement of the manufacturer, by the stated number of make cycles followed by the same number of break cycles.

For alternating current, the power-factor of the test circuit shall be determined in accordance with 9.3.4.1.3 of IEC 60947-1:2020. The values shall be in accordance with Table 4.

For direct current, the time-constant of the test circuit shall be determined in accordance with 9.3.4.1.4 of IEC 60947-1:2020. The values shall be in accordance with Table 4.

The test voltage and the load shall be applied to the appropriate terminals of the equipment. For equipment in which a moving contact remains connected to one of the terminals when the equipment is in the open position, this test shall be repeated with the supply and load connections interchanged, unless the terminals are specifically and clearly marked for load and supply.

In the case of tests carried out on a fuse-switch or a fuse-switch-disconnector where the blades of the fuse-links are part of the make-breaking contacts, fuse-links shall be used.

NOTE For a fuse-switch or a fuse-switch-disconnector where the blades of the fuse-links are part of the make-breaking contacts, dummies or copper links cannot replace the fuse-links due to the fact that the blades of the fuse-links in these devices wear. The wear of the fuse-blades influences the thermal verification according to 9.3.4.7.

Details of the fuse-links used for the test, i.e. the manufacturer's name and reference, the rated current, the power loss of the fuse-link and the breaking capacity, shall be given in the test report.

In the case of tests carried out on a switch-fuse or a switch-disconnector-fuse, fuse-links may be replaced by suitable copper links of dimensions and mass electrically equivalent to those of the fuse-links recommended by the manufacturer. If the test is carried out with fuse-links, at the manufacturer's discretion, the fuse-link may be changed after each operation. If the fuse-link is changed, the time between operations shall be noted in the report.

9.3.4.4.2 Test circuit

Subclause 9.3.3.5.2 of IEC 60947-1:2020 applies.

9.3.4.4.3 Characteristics of transient recovery voltage

Subclause 9.3.3.5.3 of IEC 60947-1:2020 applies only to utilization categories AC-22, AC-23 and AC-23e. For tests for utilization categories DC-22 and DC-23 the test circuit load may be replaced by a motor producing the specified current and time constant value if agreed between manufacturer and user.

9.3.4.4.4 Behaviour of the equipment during and after making and breaking capacity tests

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 be no 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.

9.3.4.4.5 Condition of equipment after the making and breaking capacity tests

It shall be demonstrated immediately after the test that the equipment will close and open satisfactorily during a no-load close/open 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 requirements of 9.3.4.5.

The contacts shall be in a suitable condition to carry the rated operational current without maintenance and shall comply with the temperature-rise verification of 9.3.4.7.

If the equipment is suitable for isolation, it shall comply with 9.3.4.6 and 9.3.4.8.

9.3.4.5 Dielectric verification

After the test according to 9.3.4.4, a test shall be made according to 9.3.3.4.1, item 4) of IEC 60947-1:2020.

9.3.4.6 Leakage current

This test is made only on equipment suitable for isolation of rated operational voltage U_e greater than 50 V. The leakage current shall be checked across the contact gaps as follows:

- a) disconnector and switch-disconnector: between load and line terminals;
- b) disconnector-fuse, switch-disconnector-fuse, fuse-disconnector and fuse-switch-disconnector single opening: between load and line terminals;
- c) disconnector-fuse, switch-disconnector-fuse, fuse-disconnector and fuse-switch-disconnector double opening: (i) between line terminals and the fuse-links; (ii) between load terminals and the fuse-links; and (iii) between load and line terminals.

The value of leakage current, with a test voltage equal to 1,1 times the rated operational voltage of equipment shall not exceed

- 0,5 mA per pole for equipment of utilization category AC-20A, AC-20B, DC-20A or DC-20B;
- 2 mA per pole for equipment of all other utilization categories.

9.3.4.7 Temperature-rise verification

After the tests according to 9.3.4.4, the temperature-rise of the terminals and accessible parts shall be checked according to 9.3.4.2, except that where a utilization category is assigned, the tests are made at the rated operational current I_e of the equipment tested.

The terminals and accessible parts shall not exceed the limiting values stated in Table 12.

Table 12 – Temperature-rise limits for terminals and accessible parts

Description of part ^a	Temperature-rise limit ^b K
Terminals for external connections	80
Manual operating means: – metallic – non-metallic	25 35
Parts intended to be touched but not hand-held: – metallic – non-metallic	40 50
Parts which need not be touched for normal operation: – metallic – non-metallic	50 60
^a No value is specified for parts other than those listed but no damage shall be caused to adjacent parts of insulating materials. ^b The temperature-rise limits specified are not intended to apply to a new sample but are those applicable to the temperature-rise verifications during the appropriate test sequences specified in Table 10.	

9.3.4.8 Strength of actuator mechanism

Subclause 9.2.6 applies to equipment suitable for isolation.

9.3.5 Test sequence II: operational performance capability

9.3.5.1 General

This test sequence applies to the types of equipment listed in Table 13 and comprises the tests according to this table.

They are made to verify compliance with 8.2.4.2.

Table 13 – Test sequence II: operational performance capability

			Types of equipment and order of tests					
Tests	Sub-clause No.	Samples	Switch	Fuse-switch and switch-fuse	Disconnector	Disconnector-fuse and fuse-disconnector	Switch-disconnector	Switch-disconnector-fuse and fuse-switch-disconnector
Operational performance	9.3.5.2	A, B	1	1	1	1	1	1
Dielectric verification	9.3.5.3	A, B	2	2	2	2	2	2
Leakage current ^a	9.3.5.4	A, B	–	–	3	3	3	3
Temperature-rise verification	9.3.5.5	A, B	3	3	4	4	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). "B", if applicable, are samples to verify as many combinations of U_e , I_e , AC or DC voltage ratings, to be tested.								

9.3.5.2 Operational performance test

9.3.5.2.1 Test values and conditions

The test values are stated in Table 5 and Table 6, according to the utilization category.

The time interval between Table 5 operating cycles with current and without current and the sequential order of the tests shall be stated in the test report.

During each make-break operating cycle, the equipment need only stay in the closed position for a period long enough to allow the switching operation to be completed and to enable the current value to be established and the moving parts of the equipment to come to rest. After each operating cycle, the recovery voltage shall be maintained for at least 0,05 s.

For alternating current, the power-factor of the test circuit shall be determined in accordance with 9.3.4.1.3 of IEC 60947-1:2020. The values shall be in accordance with Table 6.

For direct current, the time-constant of the test circuit shall be determined in accordance with 9.3.4.1.4 of IEC 60947-1:2020. The values shall be in accordance with Table 6.

9.3.5.2.2 Test circuit

Subclause 9.3.3.5.2 of IEC 60947-1:2020 applies.

9.3.5.2.3 Transient recovery voltage

It is not necessary to adjust the transient recovery voltage.

9.3.5.2.4 Switching overvoltages

Under consideration.

9.3.5.2.5 Behaviour of the equipment during the operational performance 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 be no 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.

Some wear on the mechanism and contacts is allowed provided that the equipment functions correctly.

9.3.5.2.6 Condition of the equipment after the operational performance test

It shall be demonstrated immediately after the test that the equipment will close and open satisfactorily during a no-load close/open 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 tests and without maintenance the equipment shall comply with the requirements of 9.3.5.3.

The contacts shall be in a suitable condition to carry the rated operational current without maintenance and shall comply with the temperature-rise verification of 9.3.5.5.

If the equipment is suitable for isolation, it shall comply with 9.3.5.4.

9.3.5.3 Dielectric verification

Subclause 9.3.4.5 applies.

9.3.5.4 Leakage current

Subclause 9.3.4.6 applies.

9.3.5.5 Temperature-rise verification

Subclause 9.3.4.7 applies.

9.3.6 Test sequence III: short-circuit performance capability

9.3.6.1 General

This test sequence applies to the types of equipment listed in Table 14 and comprises the tests according to this table.

This test sequence is not mandatory if a value of rated short-circuit making capacity is not stated by the manufacturer (see 9.3.6.3.1) and test sequence IV (see 9.3.7) is carried out.

The tests are made to verify compliance with 8.2.5.

Table 14 – Test sequence III: short-circuit performance capability

			Types of equipment and order of tests					
Tests	Sub-clause No.	Samples ^d	Switch	Fuse-switch and switch-fuse	Disconnector	Disconnector-fuse and fuse-disconnector	Switch-disconnector	Switch-disconnector-fuse and fuse-switch-disconnector
Short-time withstand current	9.3.6.2	A	1		1		1	
Short-circuit making capacity ^{a b}	9.3.6.3	A, B	2		–		2	
Dielectric verification	9.3.6.4	A, B	3	Not applicable	2	Not applicable	3	Not applicable
Leakage current ^c	9.3.6.5	A, B	–		3		4	
Temperature-rise verification	9.3.6.6	A, B	4		4		5	
^a Test sequence III is not mandatory if test sequence IV is carried out. ^b Switches and switch-disconnectors not having a rated short-circuit making capacity (see 5.3.7.2) shall meet the requirements of test sequence IV (see Table 16) ^c Test required only for U_e greater than 50 V. ^d "A" is a sample from each fundamental design, chosen from the highest I_{cw} current. "B", if applicable, are samples to verify as many combinations of U_e , I_{cw} or I_{cm} , AC or DC voltage ratings, to be tested.								

9.3.6.2 Short-time withstand current test**9.3.6.2.1 Test values and conditions**

The test conditions of 9.3.4.3 of IEC 60947-1:2020 apply.

The test current shall be the rated short-time withstand current stated according to 5.3.7.1.

9.3.6.2.2 Test circuit

Subclause 9.3.4.1.2 of IEC 60947-1:2020 applies.

For alternating current, the power-factor of the test circuit shall be in accordance with 9.3.4.1.3 of IEC 60947-1:2020.

For direct current, the time-constant of the test circuit shall be in accordance with 9.3.4.1.4 of IEC 60947-1:2020.

9.3.6.2.3 Calibration of the test circuit

Subclause 9.3.4.1.5 of IEC 60947-1:2020 applies with the following addition at the end of the first paragraph.

See Figures 3, 4, 5 and 6 of IEC 60947-1:2020.

9.3.6.2.4 Test procedure

The temporary connections B are replaced by the equipment under test and the test current is applied for the specified time with the equipment in the closed position.

9.3.6.2.5 Behaviour of the equipment during the test

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

There shall be no 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.

9.3.6.2.6 Conditions of the equipment after the test

It shall be demonstrated, immediately after the test, that the equipment will close and open satisfactorily during a no-load close/open 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, if the equipment is a switch or a switch-disconnector, it shall be subjected to the short-circuit making capacity test, 9.3.6.3, as listed in Table 14.

If the equipment is suitable for isolation, it shall comply without maintenance with the dielectric verification of 9.3.6.4.

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

9.3.6.3 Short-circuit making capacity test

9.3.6.3.1 Test values and conditions

The test shall be made on the same equipment as for the test of 9.3.6.2 without any maintenance.

The test current shall be that assigned by the manufacturer as stated in 5.3.7.2.

9.3.6.3.2 Test circuit

Subclause 9.3.6.2.2 applies.

9.3.6.3.3 Test circuit calibration

The calibration of the test circuit is carried out by placing temporary connections B of negligible impedance as close as reasonably possible to the terminals provided for connecting the equipment under test.

Depending upon whether the equipment is rated alternating current or direct current, the calibration is made as follows.

a) For alternating current:

The tests shall be made at the rated frequency of the equipment.

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 $1,05 \times U_e$, 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	Disconnect ^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 $1,05 \times U_e$, 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	Disconnector ^a	Disconnector-fuse and fuse-disconnector	Switch-disconnector ^a	Switch-disconnector-fuse and fuse-switch-disconnector
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 $1,6 \times I_{the}$ or $1,6 \times I_{th}$ 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.