

INTERNATIONAL STANDARD

NORME INTERNATIONALE



**Low-voltage switchgear and controlgear –
Part 6-1: Multiple function equipment – Transfer switching equipment**

**Appareillage à basse tension –
Partie 6-1: Matériels à fonctions multiples – Equipement de transfert de source**



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INTERNATIONAL ELECTROTECHNICAL COMMISSION

LOW-VOLTAGE SWITCHGEAR AND CONTROLGEAR –

**Part 6-1: Multiple function equipment –
Transfer switching equipment**

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International Standard IEC 60947-6-1 has been prepared by sub-committee 121A: Low-voltage switchgear and controlgear, of IEC technical committee 121: Switchgear and controlgear and their assemblies for low voltage.

This third edition cancels and replaces the second edition published in 2005, and its Amendment 1:2013. This edition constitutes a technical revision.

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

- clarification of scope and object;
- clarification of terms and definitions;
- removal of unnecessary definitions;
- modification of characteristics;

- modification of utilization categories definitions;
- introduction of new markings requirements;
- addition of new requirements for clearances and creepage distances;
- addition of new requirements and tests for mechanical and electrical interlocks;
- clarification of transfer sequences;
- modification of requirements for rated short-time withstand currents;
- modification of new requirements for electromagnetic compatibility;
- clarification of performance requirements for CB type TSE, in alignment with requirements stated in IEC 60947-2;
- addition of new test sequence V: Critical load current performance of equipment with DC ratings.

The text of this document is based on the following documents:

FDIS	Report on voting
121A/403/FDIS	121A/411/RVD

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

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

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

This document shall be read in conjunction with IEC 60947-1:2020, *Low voltage switchgear and controlgear – Part 1: General rules*.

The provisions of the general rules are applicable to IEC 60947-1 where specifically called for. General rules clauses and subclauses thus applicable as well as tables, figures and appendices are identified by reference to IEC 60947-1:2020, for example, 1.2.3, Table 4, or Annex A of IEC 60947-1:2020. The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC website under "<http://webstore.iec.ch>" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
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INTRODUCTION

The availability of power in low voltage electrical installations is playing an ever increasing role in modern society. In actual fact, this requirement is a fundamental characteristic for the creation of economically and functionally efficient installations. A system able to switch a load from one source to another safely and with minimum disturbance to the load reduces problems caused by faulty conditions in the normal supply to the minimum.

All these operations, commonly known as “transfer switching”, control the installations and can be done automatically, remotely or manually.

Therefore, an installation with installed “transfer switching” capability:

- ensures the continuity of production processes;
- provides a backup source of power if the main network is out of service;
- reduces the effect caused by network faults on parts of the installation;
- achieves a good compromise between reliability, simplicity and cost-effectiveness;
- provides the facility manager and managing system with a power source able to supply all or part of the installation.

Key factors motivating customers to use Transfer Switch Equipment (TSE) include:

- the continuous world growth population, the increasing number of electronic devices and the new demands of electric vehicles;
- the mediated pressure on climate change with a resulting increase in the cost of energy;
- the evolution of the electricity market with a greater number of alternate energy sources;
- the user’s expectations of better grid reliability, better economic performance, and a desire to manage their energy.

Stakeholders involved in the management of electricity also have new expectations:

- customers want to reduce the cost of their energy and to have a quality energy supply;
- suppliers want to reinforce confidence to their customers;
- producers expect to optimize their investments;
- governments and regulators are willing to create a competitive and sustainable energy market.

Today, the performance of Transfer Switching Equipment is defined by TSE manufacturers and also by this document. Consultants, integrators, facility managers and end users rely on this document for their power availability needs.

Transfer switching are often realised by implementing a transfer function within the electrical installation, but this critical function can be inappropriately designed. Using a TSE following the requirements of this document ensures the safety and the performance of the transfer function which are necessary for reaching the objectives listed above.

LOW-VOLTAGE SWITCHGEAR AND CONTROLGEAR –

Part 6-1: Multiple function equipment – Transfer switching equipment

1 Scope

This document applies to transfer switching equipment (TSE), to be used in power systems for ensuring the continuity of the supply and allowing the energy management of the installation, by transferring a load between power supply sources, the rated voltage of which does not exceed 1 000 V AC or 1 500 V DC.

It covers:

- manually operated transfer switching equipment (MTSE);
- remotely operated transfer switching equipment (RTSE);
- automatic transfer switching equipment (ATSE), including the controller.

It does not cover:

- 1) TSE configurations that are either not manufacturer tested and/or not marked according to this document as a complete transfer switch;
- 2) auxiliary contacts (for guidance, see IEC 60947-5-1);
- 3) transfer switches used in explosive atmospheres (for guidance, see IEC 60079 (all parts));
- 4) embedded software design (for guidance, see IEC TR 63201);
- 5) cybersecurity aspects (for guidance, see IEC TS 63208);
- 6) TSE rated for direct-on-line starting asynchronous motor of design NE and HE, according to IEC 60034-12:2016 (for guidance, see AC-3e utilisation category according IEC 60947-4-1:2018);
- 7) other types of TSE under consideration including closed transition TSE, overlapping neutral TSE, multi-source TSE (i.e. TSE with more than two sources of supply), stand-alone ATS controllers, bypass isolation TSE, TSE with load-shedding functions and bus-tie TSE.

NOTE TSE used for safety services and for emergency escape lighting systems as described in IEC 60364-5-56 are subject to specific rules and/or legal requirements.

The object of this document is to state:

- 1) the characteristics of the equipment;
- 2) the conditions of the equipment with respect to:
 - a) operation for which the equipment is intended;
 - b) operation and behaviour in case of specified abnormal conditions, for example, short-circuit;
 - c) dielectric properties;
- 3) the tests intended to confirm that these conditions have been met and the methods for performing these tests;
- 4) the product information to be provided by the manufacturer.

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 60068-2-2:2007, *Environmental testing – Part 2-2: Tests – Test B: Dry heat*

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

IEC 60715:2017, *Dimensions of low-voltage switchgear and controlgear – Standardized mounting on rails for mechanical support of switchgear, controlgear and accessories*

IEC 60812, *Failure modes and effects analysis (FMEA and FMECA)*

IEC 60947 (all parts), *Low-voltage switchgear and controlgear*

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

IEC 60947-2:2016, *Low-voltage switchgear and controlgear – Part 2: Circuit-breakers*
IEC 60947-2:2016/AMD1:2019

IEC 60947-3:2020, *Low-voltage switchgear and controlgear – Part 3: Switches, disconnectors, switch-disconnectors and fuse-combination units*

IEC 60947-4-1:2018, *Low-voltage switchgear and controlgear – Part 4-1: Contactors and motor-starters – Electromechanical contactors and motor-starters*

IEC 61000-4-13:2002, *Electromagnetic compatibility (EMC) – Part 4-13: Testing and measurement techniques – Harmonics and interharmonics including mains signalling at a.c. power port, low frequency immunity tests*
IEC 61000-4-13:2002/AMD1:2009
IEC 61000-4-13:2002/AMD2:2015

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

3 Terms and definitions

3.1 General

For the purposes of this document, the terms and definitions given in Clause 3 of IEC 60947-1:2020, and the following apply.

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

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

3.2 Alphabetical index of terms

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3.3 Transfer switching devices

3.3.1

transfer switching equipment

TSE

equipment containing one or more switching devices and associated operating mechanism for disconnecting load circuits from one supply and connecting to another supply

3.3.2**manually operated transfer switching equipment****MTSE**

transfer switching equipment operated manually and non-electrically

3.3.3**remotely operated transfer switching equipment****RTSE**

transfer switching equipment that is electrically operated and not self-acting

Note 1 to entry: RTSE can have a feature for local and/or manual operation.

3.3.4**automatic transfer switching equipment****ATSE**

self-acting transfer switching equipment, including all necessary sensing inputs, monitoring, and control logic for transferring operations

Note 1 to entry: ATSE can have a feature for local and/or remote and/or manual operation.

3.3.5**derived transfer switching equipment****derived TSE**

TSE based on switching devices that have certain tests required for compliance with IEC 60947-6-1 as defined in Table 9, covered by IEC 60947-3 for Class PC, IEC 60947-2 or IEC 60947-6-2 for Class CB, or IEC 60947-4-1 for Class CC

Note 1 to entry: It is not necessary to repeat tests fully covered in the switching devices product standards.

3.3.6**Class PC TSE**

transfer switch equipment based on mechanical switching devices, that do not need electrical power to hold the main contacts open or closed and capable of making, carrying, and breaking currents under normal circuit conditions including operating overload conditions, and making and withstanding short-circuit currents

Note 1 to entry: For the purposes of this document, a fuse-combination unit is considered a Class PC device capable of breaking short-circuit current.

Note 2 to entry: Class PC TSE are also capable of withstanding conditional short-circuit currents.

3.3.7**Class CB TSE**

transfer switch equipment based on mechanical switching devices and capable of making, carrying and breaking currents under normal circuit conditions including operating overload conditions, and making and breaking short-circuit currents

Note 1 to entry: Class CB TSE for which the manufacturer has assigned a short-time withstand current are also capable of withstanding short-circuit currents.

3.3.8**Class CC TSE**

transfer switch equipment based on mechanical switching devices having only one position of rest, operating otherwise than by hand, and capable of making, carrying and breaking currents under normal circuit conditions including operating overload conditions

Note 1 to entry: Class CC TSE are not capable of making or breaking short-circuit currents. They are only capable of withstanding conditional short-circuit currents.

Note 2 to entry: Class CC TSE is not suitable for isolation.

3.3.9

ATS controller

device intended for sensing and monitoring the power supply sources, and controlling the automatic transfer sequence

Note 1 to entry: ATS controller can be either integral to the ATSE or stand-alone to be associated with an RTSE.

3.3.10

dedicated wiring accessory

prefabricated connection wiring system specifically intended for identified switchgear or controlgear

Note 1 to entry: A dedicated wiring accessory can be integrated in the switchgear or controlgear or delivered separately.

Note 2 to entry: A typical dedicated wiring accessory is for example a connection link.

3.4 Operation of TSE

3.4.1

operating sequence

automatic transfer of a load from one supply to another in the event of a monitored supply deviation and/or other predefined conditions

Note 1 to entry: This definition applies only for ATSE.

3.4.2

monitored supply deviation

variation in the measured power supply characteristics that exceeds predetermined limits

EXAMPLE Abnormal changes in voltage or frequency of the supply are supply deviations.

Note 1 to entry: This definition applies only for ATSE.

3.4.3

voltage supply deviation

change in voltage level from the nominal voltage of the monitored supply

3.4.4

frequency supply deviation

change in frequency from the nominal operating frequency of the monitored supply

3.4.5

contact transfer time

time measured from the mechanical opening of all poles from one set of main contacts of one power supply to the mechanical closing of any pole of a second set of main contacts on another power supply, with any adjustable time-delay set to the minimum value

Note 1 to entry: Contact transfer time does not apply to three-position MTSE.

3.4.6

operating transfer time

time measured from the instant when the transfer conditions are fulfilled to the closing of the main contacts on the other source, with any adjustable time delay set to the minimum value, transfer condition being typically supply deviations and programmed conditions for ATSE or remote control commands for RTSE

Note 1 to entry: Operating transfer times from source I to source II and from source II to source I can be different, and can vary depending on the monitored supply deviation.

Note 2 to entry: Operating transfer time does not apply to MTSE.

3.4.7**open transition**

a break before make transfer operation that intentionally breaks the load current from one source for a period of time prior to making it to the other source

3.4.8**in-phase transfer**

control function of an ATSE to only allow an open transition transfer when the two sources are considered in phase, at the same voltage and frequency

3.4.9**closed transition**

a make before break transfer operation that intentionally makes the load current of a second synchronized source for a short period of time before breaking it from the first source

3.4.10**interlocking**

<TSE> feature(s) that make(s) the state of two mechanisms mutually exclusive, preventing any of the phases of source I and source II from being connected together

Note 1 to entry: Interlocking prevents the closed position of switching devices to be simultaneously achieved under all conditions. The state of two mechanisms mutually dependent prevents the change of position of operation of one mechanism depending on the position of operation of the other.

3.5 Main contact positions**3.5.1****switching position**

position of the main contacts defining whether the load terminals are connected to source I or source II terminals, or not connected

3.5.2**position I**

contact position of the equipment when the load terminals are connected to source I terminals

3.5.3**position II**

contact position of the equipment when the load terminals are connected to source II terminals

3.5.4**OFF position**

stable contact position of rest of the equipment when the load terminals are connected to neither source I nor source II terminals

Note 1 to entry: The OFF position may also be marked as the O position.

3.6 Symbols and abbreviated terms

EMC	Electromagnetic compatibility	
FMEA	Failure mode effects analysis	9.2.3.2.4
I_c	Current made and broken	Table 3
I_{cm}	Rated short-circuit making capacity	5.3.6.3
I_{cn}	Rated short-circuit breaking capacity	5.3.6.4
I_{cw}	Rated short-time withstand current	5.3.6.2
I_e	Rated operational current	5.3.3
I_q or I_{cc}	Rated conditional short-circuit current	5.3.6.5
SCPD	Short-circuit protective device	
U_e	Rated operational voltage	5.3.2.1
U_i	Rated insulation voltage	5.3.2.2
U_{imp}	Rated impulse withstand voltage	5.3.2.3
U_r	Power frequency or DC steady-state recovery voltage	Table 3

4 Classification

Transfer switching equipment is classified according to:

- a) their characteristics:
 - Class PC;
 - Class CB;
 - Class CC;
- b) the method of controlling the transfer:
 - manually operated switching equipment (MTSE);
 - remotely operated switching equipment (RTSE);
 - automatic transfer switching equipment (ATSE);
- c) the number of main contact positions:
 - TSE with two positions (I – II);
 - TSE with three positions (I – O – II);
- d) their suitability for isolation:
 - TSE suitable for isolation in the OFF position;
 - TSE not suitable for isolation;

NOTE TSE having only two positions (I – II) and all Class CC TSE are not suitable for isolation.

- e) the transition type:
 - open transition;
 - closed transition (under consideration).

5 Characteristics

5.1 Summary of characteristics

Wherever applicable, the characteristics of the TSE shall be stated as follows:

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

Where the TSE uses IEC 60947 products, the relevant characteristics from those standards may also be additionally stated.

Specific characteristics subject to agreement between manufacturer and user are listed in Annex B.

5.2 Type and characteristics of equipment

The following shall be stated:

- a) class and transfer control method of the equipment (see Clause 4);
- b) number of poles;
- c) neutral pole terminal, if applicable, by the letter “N” (see 8.1.8.4 of IEC 60947-1:2020);
- d) kind of current (alternating current or direct current or both);
- e) in case of alternating current, the number of phases and the rated frequency;
- f) number of main contact positions;
- g) suitability for isolation;
- h) transition type;
- i) type of interlock (mechanical, electrical, or electrical-and-mechanical);

NOTE In Canada, Mexico and United States of America open transition transfer switching equipment is required to use mechanical interlocking.

- j) control functions (such as in-phase transfer);
- k) contact transfer time;
- l) in case of RTSE or ATSE, operating transfer time;
- m) in case of ATSE, operating sequences;
- n) the minimum mandatory components needed to achieve compliance as a complete TSE, including:
 - switching device(s);
 - switching mechanism, where applicable;
 - mechanical and/or electrical interlock for use with separate switching devices;
 - actuator, manual (for MTSE);
 - actuator, remote (for RTSE and ATSE);
 - ATS controller for ATSE;
 - signal terminals for input signals (for RTSE and ATSE);
 - source I and source II terminals;
 - load terminals;

- where applicable, bridging conductors or instructions on how to fabricate them;
 - sensing cables or instructions on how to fabricate them (for ATSE).
- o) wiring diagram;
- p) dedicated wiring accessories.

5.3 Rated and limiting values for the main circuit

5.3.1 General

Subclause 5.3 of IEC 60947-1:2020 applies. Rated values may be different between position I and position II.

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 with the following addition:

When different values of U_{imp} are declared for circuits others than the mains, the instruction for installation shall provide specific instruction for ensuring the insulation coordination of the installation as stated by Annex H of IEC 60947-1:2020.

5.3.3 Rated operational current (I_e)

The rated operational current of TSE is stated by the manufacturer according to subclause 5.3.2.3 of IEC 60947-1:2020 for uninterrupted duty. It is possible for a device to have several I_e , depending on utilization category and operational voltages U_e .

5.3.4 Rated frequency

Subclause 5.3.3 of IEC 60947-1:2020 applies.

5.3.5 Rated making and breaking capacities

Subclauses 5.3.5.2 and 5.3.5.3 of IEC 60947-1:2020 apply.

The rated making and breaking capacities are the values of current, stated by the manufacturer, which the transfer equipment can satisfactorily make and break under specified conditions. Unless stated otherwise, they are given in terms of a steady state current value. During the making operation, the peak value of the current on contact closing may be higher than the peak value of the steady state current depending on the characteristics of the test circuit (load) and the instant of closing on the voltage wave.

The rated making and breaking capacities are stated with reference to the rated operational voltage, the rated operational current and the utilization category according to Table 3.

For alternating current, the rated making and breaking capacities are expressed by the RMS value of the AC component of the current.

5.3.6 Short-circuit characteristics

5.3.6.1 General

Class PC TSE shall have either a rated short-time withstand current or a rated conditional short-circuit current but may have both.

Class CB TSE shall have a rated short-circuit breaking capacity and a rated short-circuit making capacity and may have a rated short-time withstand current.

Class CC TSE shall have a rated conditional short-circuit current.

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

Subclause 5.3.6.1 of IEC 60947-1:2020 applies under the test conditions specified in 9.2.5.2 and the minimum value of rated short-time withstand current is given in Table 5.

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

Subclause 5.3.6.2 of IEC 60947-1:2020 applies under the test conditions specified in 9.2.5.3.

The rated short-circuit making capacity is the value of short-circuit making capacity assigned by the manufacturer for the rated operational voltage at rated frequency and at a specified power-factor (or time-constant). It is expressed as the maximum prospective peak current. For alternating current, the rated short-circuit making capacity shall be not less than the highest value of short-circuit breaking capacity or short-time withstand current, as applicable, multiplied by the ratio n of Table 16 of IEC 60947-1:2020. For direct current, the rated short-circuit making capacity shall be not less than the highest value of short-circuit breaking capacity or short-time withstand current, as applicable. The manufacturer may assign a higher value of short-circuit making capacity.

5.3.6.4 Rated short-circuit breaking capacity (I_{cn})

This characteristic applies only to Class CB.

Subclause 5.3.6.3 of IEC 60947-1:2020 applies under the test conditions specified in 9.2.5.4.

The rated short-circuit breaking capacity for a Class CB TSE is equivalent to the rated ultimate short-circuit breaking capacity of a circuit breaker according to IEC 60947-2.

5.3.6.5 Rated conditional short-circuit current (I_q or alternatively I_{cc})

Subclause 5.3.6.4 of IEC 60947-1:2020 applies under the test conditions specified in 9.2.6.

The minimum value of the prospective current is given in Table 5 or Table 6 at the discretion of the manufacturer.

5.4 Utilization category

TSE may be assigned to one or more of the standard utilization categories given in Table 1 at one or more rated operational voltages.

The designation of TSE utilization categories is completed by the suffix A or B, according to the type and number of operations (see 3.3.18 of IEC 60947-1:2020, Table 10, Table 11 and Table 12) required by the application.

TSE assigned any TSE utilization category shall comply with the rated making and breaking capacity (see Table 3) and the electrical and mechanical operational performance requirements (see Table 4) corresponding to the assigned utilization category.

Table 1 – Utilization categories

Nature of current	TSE Utilization category		Typical switching load
	Type A	Type B	
Alternating current	AC-31A	AC-31B	Non-inductive or slightly inductive loads
	AC-32A	AC-32B	Switching of mixed resistive and inductive loads, including moderate overloads
	AC-33A	AC-33B	Squirrel-cage motors
	AC-35A	AC-35B	Discharge lamp loads
	AC-36A	AC-36B	Incandescent lamp loads
Direct current	DC-31A	DC-31B	Non-inductive or slightly inductive loads
	DC-33A	DC-33B	Shunt-motors
	DC-36A	DC-36B	Incandescent lamp load

5.5 Control circuits

5.5.1 General

Subclause 5.5 of IEC 60947-1:2020 applies with the following additions for monitored supply (see 3.4.2).

5.5.2 Electro-mechanical devices operating the main circuit

The minimum and maximum values of voltage or voltage and frequency operating limits shall be stated by the manufacturer. The characteristics of the control circuit shall be stated as the minimum and maximum values of the rated control circuit supply voltage.

5.5.3 ATS controller

The manufacturer shall state the following:

- the voltage supply deviations and, if applicable, the frequency supply deviations at which transfer should be initiated;
- the tolerance of the voltage deviations, frequency deviations (where applicable), and anytime delays shall be specified by the manufacturer, but shall not exceed $\pm 10\%$.

Stand-alone TSE controllers are under consideration.

5.6 Auxiliary circuits

Subclause 5.6 of IEC 60947-1:2020 applies.

6 Product information

6.1 Nature of information

All information of Table 2 below shall be given by the manufacturer.

6.2 Marking

Subclause 6.2 of IEC 60947-1:2020 applies, where applicable, and according to Table 2 below.

In addition to Table 2, all controls accessible to the operator shall be marked to indicate their function.

NOTE TSE composed of several components can be delivered with a separate nameplate to be attached to the equipment according to the instructions of the manufacturer.

Table 2 – Product information

Reference	Required marking	Marking location
1.1	Switching position I – II or I – O – II, as applicable, as follows: I (IEC 60417-5007:2002-10) for ON (source I) O (IEC 60417-5008:2002-10) for power OFF II (IEC 60417-6176:2012-11) for ON (source II)	Visible
1.2	Suitability for isolation, where applicable, with the isolation function symbol according to IEC 60417-6169-1:2012-08	Visible
1.3	For RTSE or ATSE with off-load manual operations for maintenance purposes: "OFF-LOAD OPERATION ONLY, switch off all supply sources before operating manually"	Visible
2.1	Manufacturer's name or trade mark	Marked
2.2	Type designation or serial number	Marked
2.3	"IEC 60947-6-1", indicating the product complies with this document	Marked
2.4	Class of equipment (PC, CC, CB), method of controlling (MTSE, RTSE, ATSE) and transition type (open transition, closed transition) according to Clause 4 ^c	Marked
2.5	Rated operational voltage(s) (U_e) as defined in 5.3.2.1 ^d	Marked
2.6	Utilization categories as defined in 5.4 and corresponding operational current(s) as defined in 5.3.3 and 5.3.5 at the rated operational voltage as defined in 5.3.2.1 ^d	Marked
2.7	Value of the rated frequency as defined in 5.3.4, or the indication "DC" or the symbol $\overline{\overline{\overline{\quad}}}$ (IEC 60417-5031:2002-10) ^d	Marked
2.8	Rated short-time withstand current (I_{cw}) as defined in 5.3.6.2, if applicable ^d	Marked
2.9	Rated short-circuit breaking capacities (I_{cn}) as defined in 5.3.6.4, if applicable ^d	Marked
2.10	For ATSE and RTSE, rated control circuit supply voltage and frequency as defined in 5.5.1 ^d	Marked
2.11	Rated impulse withstand voltage (U_{imp}) as defined in 5.3.2.3 ^d	Marked
2.12	Terminal designations and markings ^d	Marked
2.13	Degree of protection of enclosed equipment according to Annex C of IEC 60947-1:2020 if the degree of protection is different than IP00	Marked ^e
2.14	Identification of neutral pole terminals, if applicable	Marked
2.15	For TSE including parts with stored charge components according to 8.1.8, a warning notice shall be provided on the product	Marked
2.16	For TSE Class CB, reference temperature for non-compensated thermal releases, if different than 30 °C	Marked
2.17	For TSE Class CB, range of the current settings (I_r) of the adjustable overload releases	Marked
2.18	For TSE Class CB, range of the rated instantaneous short-circuit current setting (I_i), for adjustable releases	Marked
3.1	Type of interlock as defined in 5.2 item i)	Literature
3.2	Number of poles	Literature
3.3	Rated short-circuit making capacities (I_{cm}) for Class PC and Class CB if higher than the minimum value as defined in 5.3.6.3 ^d	Literature
3.4	Rated conditional short-circuit current (I_q or alternatively I_{cc}) as defined in 5.3.6.5 and associated SCPD if applicable ^d	Literature
3.5	Rated insulation voltage (U_i) as defined in 5.3.2.2 ^d	Literature
3.6	Number of main contact positions ^d	Literature

Reference	Required marking	Marking location
3.7	For RTSE and ATSE, operating limits of electromechanical devices operating the main circuit, as defined in 5.5.2 ^d	Literature
3.8	For ATSE, monitored supply deviations and operating limits as defined in 5.5.3 ^d	Literature
3.9	Auxiliary circuits characteristics as defined in 5.6 ^d	Literature
3.10	For ATSE, operating sequence ^d	Literature
3.11	Contact transfer time ^{a, d} and operating transfer time ^{b, d} and additional information including time delays with their position in the operating sequence, if any	Literature
3.12	EMC Environment A or B as defined in 8.3.1 of IEC 60947-1:2020	Literature
3.13	Conductor strip length ^d	Literature
3.14	Maximum number of conductors which may be clamped ^d	Literature
3.15	Conductor designation for non-universal screwless terminals ^d : - “s” or “sol” for rigid-solid conductors - “r” for rigid (solid and stranded) conductors - “f” for flexible conductors	Literature
3.16	References of minimum mandatory component of the complete unit which are required for the TSE (refer to 5.2 item n))	Literature
3.17	Control functions ^d such as in-phase transfer	Literature
3.18	Wiring diagram	Literature
3.19	Dedicated wiring accessories (if applicable)	Literature
3.20	For TSE Class CB only (see 9.2.5.4.3) – tripping/time characteristic – temperature/current characteristic, if applicable	Literature
Key Visible The marking on the product shall be visible to the operator after the product is installed. Marked On equipment or nameplate Literature In provided literature		
NOTE In the case of electronically controlled electromagnets, other information can also be considered for example the control circuit configuration (see 5.5 and Annex U of IEC 60947-1:2020).		
^a Not required for three-position MTSE. ^b Not required for MTSE. ^c Closed transition is under consideration. ^d Where the characteristic is different for position I versus position II, the manufacturer shall state both. ^e Several degrees of protections may be given in the literature for different types of access such as front face, terminals, etc.		

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

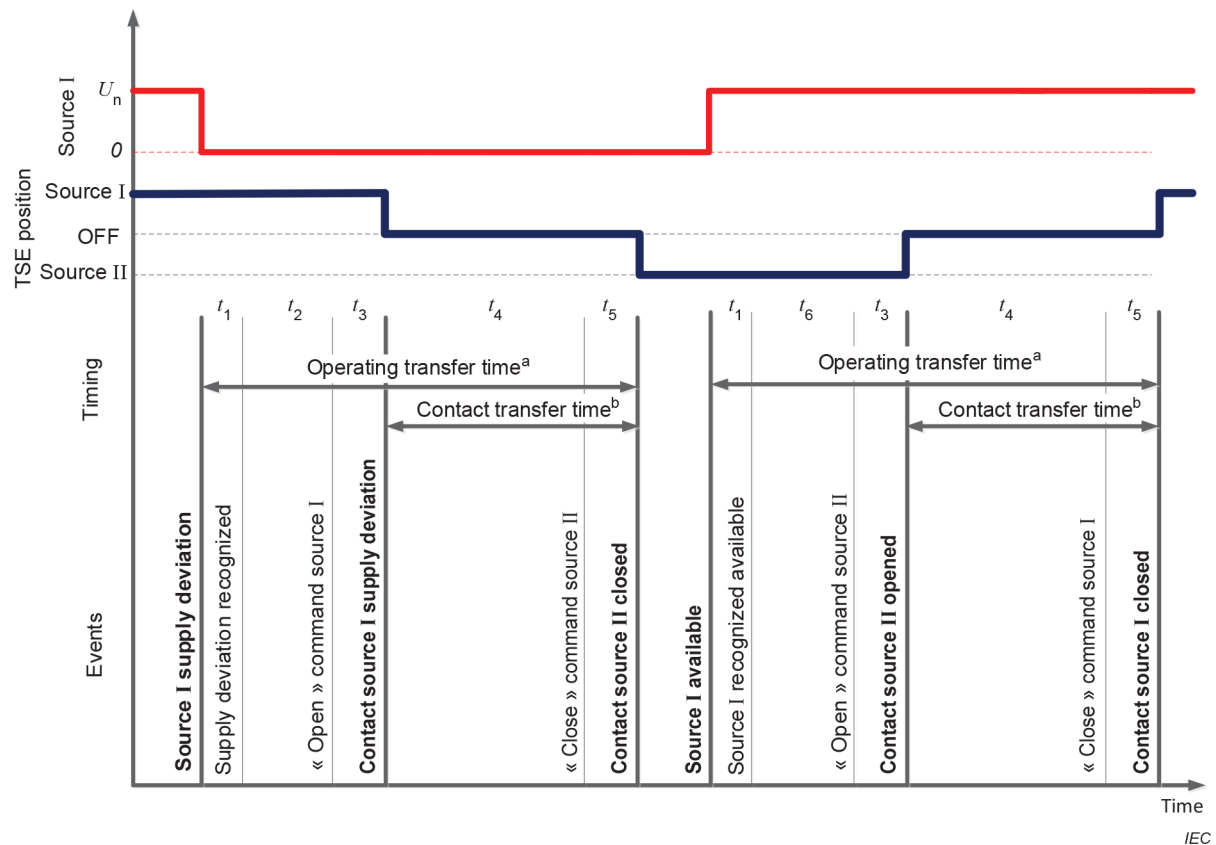
Subclause 6.3 of IEC 60947-1:2020 applies with the following addition.

The instructions shall also cover the dedicated wiring accessories, if applicable.

For TSE tested according to this document and delivered to the customer unassembled or partially assembled, the TSE manufacturer shall provide instructions for proper assembly, wiring, marking, any remaining routine tests as defined in 9.3, commissioning, operation and maintenance of the TSE. For sensing cables and bridging conductors not supplied with the TSE or not made available as a type tested accessory, the manufacturer shall provide instructions on how to fabricate.

NOTE The instruction can include appropriate references to IEC 61439 (all parts) for the integration of the TSE into an assembly.

The operation manual of the TSE shall include the description of the operating sequences. An example is shown in Figure 1.



Key

- t_1 time to detect source I supply deviation
- t_2 purposely introduced adjustable transfer time delay
- t_3 system induced time delay
- t_4 purposely introduced adjustable OFF position time delay
- t_5 system induced time delay
- t_6 purposely introduced adjustable return time delay

NOTE This figure assumes source II is available.

^a equal to operating transfer time when all purposely introduced time delays (t_2 , respectively t_6 , t_4) are set to a minimum value.

^b equal to contacts transfer time when all purposely introduced time delays (t_4) are set to a minimum value.

Figure 1 – Example of operating sequences for TSE with three positions

6.4 Environmental information

When required, material declarations shall be established according to Annex W of IEC 60947-1:2020.

NOTE IEC TS 63058 gives the method for assessing the environmental impact of switchgear and controlgear.

7 Normal service, mounting and transport conditions

Clause 7 of IEC 60947-1:2020 applies.

Standard conditions of vibration are defined in footnote b of Table Q.1 of IEC 60947-1:2020.

Rail mounting shall be specified according to IEC 60715:2017, when relevant.

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.

Subclauses 8.1.1 through 8.1.10 of this document apply.

Measures shall be provided to reduce the likelihood of injury and property damage, under installation, maintenance, normal operation conditions, abnormal operation conditions and reasonably foreseeable misuses. The requirements of this document are generically providing these measures.

Where the product is intended to be used together with specific auxiliary equipment and dedicated wiring accessories, the safety evaluation and test shall include this auxiliary equipment and accessories unless it can be shown that it does not affect the safety of any equipment.

The accessible part of the device and especially the operating means shall not present sharp edges and corners which can injure the operator.

The minimum components which shall be verified by the manufacturer as a complete unit to achieve compliance as a TSE are defined in 5.2 item n):

For sensing cables and bridging conductors not supplied with the TSE or not made available as a type tested accessory, the manufacturer shall provide instructions on how to fabricate.

Where different ratings are declared for position I and position II, each position shall be tested.

For CC class TSE, standard conditions of vibration are defined in footnote b of Table Q.1 of IEC 60947-1:2020.

NOTE Refer to Annex O of IEC 60947-1:2020 for considerations for substitution or reduction in use of hazardous substances.

8.1.2 Materials

Subclause 8.1.2 of IEC 60947-1:2020 applies.

When tests on the equipment or on sections taken from the equipment are used, parts of insulating materials necessary to retain current-carrying parts of power circuits in position shall conform to the glow wire test of 9.2.2.1 of IEC 60947-1:2020 with a test temperature of:

- 850 °C for Class CC TSE, or
- 960 °C for Class CB and Class PC TSE.

NOTE Fire risk analysis and risk reduction measures of switchgear and controlgear are given by IEC TR 63054.

8.1.3 Indication of the switching position

The indicating means of TSE shall indicate the source I position, source II position, and if any, the OFF position.

8.1.4 Equipment suitable for isolation

Subclause 8.1.7 and 8.2.7 of IEC 60947-1:2020 applies.

8.1.5 Opening and closing of main contacts

The main moving contacts of all phase poles of the switching device of a multipole TSE shall be so mechanically coupled that they make and break substantially together, whether operated manually, remotely, or automatically.

The manual actuator of the TSE shall be insulated. The requirements of 8.1.5.1 of IEC 60947-1:2020 applies.

There shall be no path or opening which allows incandescent particles to be discharged from the area of the manual operating means.

For TSE equipped with neutral poles, 8.1.9 of IEC 60947-1:2020 applies.

For any TSE with manual operating means intended for on-load use, opening and closing of the main contacts shall be independent of the speed with which the manual operating means is operated.

If the manual means is intended only for off-load use with all sources de-energized and is so marked according to Table 2 item 1.3, this requirement does not apply.

8.1.6 Clearances and creepage distances

Subclause 8.1.4 of IEC 60947-1:2020 applies with the following additions.

Where SELV and PELV circuits of the complete TSE are accessible, they shall be separated from other hazardous live-part according to the requirements of Annex N of IEC 60947-1:2020.

NOTE If some circuits are only accessible under maintenance or similar conditions, they can, depending on the risk level (severity of harm and the probability of occurrence), be considered under normal service conditions, and use only basic insulation.

8.1.7 Provision for protective earthing

Subclause 8.1.10 of IEC 60947-1:2020 applies with the following additions.

8.1.8 Stored charge energy circuit

Parts including stored charge (capacitors) that are removable for servicing (such as coil replacement), installation, or disconnection shall present no risk of electric energy hazard after disconnection.

Capacitors connected to accessible hazardous live parts shall be discharged to an energy level less than 0,5 mJ within 5 s after the removal of power. Otherwise, a readily visible warning notice shall be provided on the product, indicating the time of discharge to the limit values or a preferable method how to discharge the capacitor before touching the connecting parts.

8.1.9 Stored energy closing

The stored energy closing mechanism shall be capable of ensuring the operation of TSE in any condition between no-load and its rated making capacity.

When the stored energy is retained within the TSE, a device shall be provided which indicates when the storing mechanism is fully charged. A device shall also be provided to indicate when the storing mechanism is not charged sufficiently to allow operation. These charge indications shall be operational with and without the availability of electrical power.

Means for charging the operating mechanism, as well as the closing control components, shall be capable of operating when the auxiliary supply voltage is between 85 % and 110 % of the rated control supply voltage.

It shall not be possible for the moving contacts to move from the open position unless the charge is sufficient for satisfactory completion of the closing operation.

When the energy storing mechanism is manually operated, the direction of operation shall be indicated. This last requirement does not apply to TSE with an independent manual closing operation.

8.1.10 Dedicated enclosures for TSE

Subclause 8.1.11 of IEC 60947-1:2020 applies.

NOTE For TSE incorporated into non-dedicated enclosure, refer to IEC 61439 (all parts).

8.2 Performance requirements

8.2.1 Operating conditions

8.2.1.1 General

Subclause 8.2.1 of IEC 60947-1:2020 applies with the following additions.

Subclauses 8.2.1.2 and 8.2.1.3 of this document apply.

Type tests shall be performed with and without the dedicated wiring accessories, if relevant.

8.2.1.2 Operating mechanism

A TSE shall comply with the following requirements:

- a) TSE shall be capable of operating for all conditions of their marked intended performance.
- b) switching devices used in CC class TSE shall be only of the normally-open type, except if a mechanical interlock is provided.
- c) the operating mechanism shall be mechanically and/or electrically interlocked to prevent simultaneous connection to both source I and source II supplies under all conditions, including any individual failure, such as but not limited to an open control circuit, any single welded auxiliary or main contact, or failure of the controller. Removal of doors or access panels shall not result in defeating the interlocking feature.
- d) any unintentional overriding of the interlock shall not be possible.
- e) interlocking feature shall remain fully functional in case of any power loss.
- f) for class CC, mirror contacts according to Annex F of IEC 60947-4-1:2018 shall be used in electrical interlock, when applicable.
- g) specification of reliability and strength of the interlocking feature is dependent on risk analysis.

Verification of the operation and the robustness of the interlock according to upper items a), c), d), e) and g) shall be made in compliance with 9.2.3.2.2, 9.2.3.2.3 and 9.2.3.2.4.

For CB class TSE, the requirement of 8.3.2.6.1 b) of IEC 60947-2:2016 shall be fulfilled.

8.2.1.3 Controls, sequence and limits of operation

a) Voltage limits of control circuits

Subclause 8.2.1.2 of IEC 60947-1:2020 applies.

b) Operation on loss of supply voltage

As a minimum requirement, the ATSE shall be able to transfer the load from source I supply to source II upon the interruption for a predetermined period of any or all of the monitored phases of the source I supply and return to the source I supply when it is restored. The ATSE may include additional logic sequences, such as delayed or non-automatic return.

c) Operation on source I supply deviation conditions

If the TSE is provided with means to initiate transfer from source I to source II upon supply deviation of the main supply, the transfer shall be initiated within the limits stated by the manufacturer.

d) Transfer condition on source supply with in-phase transfer function

Transfer shall be allowed within the limits for voltage, frequency and phase angle as specified by the manufacturer.

EXAMPLE Limits with a tolerance of $\pm 10^\circ$ on phase angle and $\pm 5\%$ on voltage and ± 1 Hz on frequency.

e) Transfer condition on source II supply deviation conditions

Transfer shall be effected within the limits specified by the manufacturer.

f) Any time delay and operating transfer time to transfer from one source to the other source shall be within the limits specified by the manufacturer.

g) Contact transfer time shall be within the limits specified by the manufacturer and verified in accordance with 9.2.3.2.4. For Class CC TSE, the minimum contact transfer time value shall not be less than 50 ms.

Compliance with the above requirements and the requirements of 5.5.3 is verified by the tests of 9.2.3.3.

8.2.2 Temperature-rise

When tested at the highest rated operational current under the conditions described in 9.2.3.5, TSE shall not attain a temperature at any point to constitute a fire hazard or to damage any materials employed in the device and shall not exceed the temperature-rise values stated in 8.2.2 of IEC 60947-1:2020.

8.2.3 Dielectric properties

Subclause 8.2.3 of IEC 60947-1:2020 applies.

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

8.2.4.1 Making and breaking capacities

Subclause 8.2.4.1 of IEC 60947-1:2020 applies.

TSE shall make and break currents without failure under the conditions stated in Table 3 for the required utilization categories when tested as specified in 9.2.4.1. See also Annex A.

**Table 3 – Verification of making and breaking capacity –
Conditions for making and breaking corresponding to the utilization categories**

	Utilization category	Make and break conditions					
		I_c/I_e	U_r/U_e	$\cos \varphi^a$	ON-time minimum (s)	Cycle time min	Number of operating cycles
AC	AC-31A, AC-31B	1,5	1,05	0,80	0,05	b	b
	AC-32A, AC-32B	3,0	1,05	0,65	0,05	b	b
	AC-33A, AC-33B	10 ^h	1,05	^g	0,05	b	b
	AC-35A, AC-35B	3,0	1,05	0,50 ^c	0,05	b	b
	AC-36A, AC-36B	1,5 ^c	1,05		0,05		
				L/R^d ms			
DC	DC-31A, DC-31B	1,5	1,05	^f	0,05	b	b, e
	DC-33A, DC-33B	4,0	1,05	2,5 ^c	0,05	b	b, e
	DC-36A, DC-36B	1,5 ^c	1,05		0,05	b	b, e
I_c = Current made and broken. The making current is expressed in DC or AC RMS symmetrical values but it is understood that, for AC-36A, AC-36B, DC-36A and DC-36B categories, the actual peak value during the making operation may assume a higher value than the symmetrical peak value. I_e = Rated operational current. U_r = Power frequency or DC steady-state recovery voltage. U_e = Rated operational voltage.							
^a Tolerance for $\cos \varphi$ is $\pm 0,05$. ^b See Table 10. ^c Tests shall be carried out with an incandescent light load in accordance with the general test conditions as specified in 9.2.4.1.2. ^d Tolerance for L/R is $\pm 15\%$. ^e If the polarity is not marked, half the number of operating cycles is effected with one polarity and half with reverse polarity. ^f No intentional time constant. ^g $\cos \varphi = 0,45$ for $I_e \leq 100$ A and $\cos \varphi = 0,35$ for $I_e > 100$ A. ^h Breaking current may be 8 times I_e .							

8.2.4.2 Operational performance

8.2.4.2.1 General

Subclause 8.2.4.2 of IEC 60947-1:2020 applies.

8.2.4.2.2 Electrical operational performance

Following the making and breaking capacity test, TSE shall make and break current without failure under the test conditions stated in Table 4 for the required utilization categories when tested according to 9.2.4.2.2. See also Annex A.

8.2.4.2.3 Mechanical operational performance

Following the electrical operational performance test, TSE shall perform, without failure, the number of no-load operations given in Table 11 and Table 12 when tested as specified in 9.2.4.2.3. See also Annex A.

**Table 4 – Verification of operational performance –
Conditions for making and breaking corresponding to the utilization categories**

	Utilization category	Make and break conditions					
		I_c/I_e	U_r/U_e	$\cos \varphi^a$	ON-time minimum (s)	Cycle time min	Number of operating cycles
AC	AC-31A, AC-31B	1,0	1,05	1,0	0,05	b	b
	AC-32A, AC-32B	1,0	1,05	0,8	0,05	b	b
	AC-33A, AC-33B	2,0 ^g	1,05	0,8	0,05	b	b
	AC-35A, AC-35B	2,0 ^g	1,05	0,8	0,05	b	b
	AC-36A, AC-36B	1,0 ^c	1,05	^c	0,05		
				L/R^d ms			
DC	DC-31A, DC-31B	1,0	1,05	f	0,05	b	b, e
	DC-33A, DC-33B	2,5 ^h	1,05	2,5	0,05	b	b, e
	DC-36A, DC-36B	1,0 ^c	1,05	^c	0,05	b	b, e
I_c = Current made and broken. The making current is expressed in DC or AC RMS symmetrical values but it is understood that, for AC-36A, AC-36B, DC-36A and DC-36B categories, the actual peak value during the making operation may assume a higher value than the symmetrical peak value. I_e = Rated operational current. U_r = Power frequency or DC recovery voltage. U_e = Rated operational voltage. ^a Tolerance for $\cos \varphi$ is $\pm 0,05$. ^b See Table 11 and Table 12. ^c Tests shall be carried out with an incandescent light load in accordance with the general test conditions as specified in 9.2.4.1.2. ^d Tolerance for L/R is $\pm 15\%$. ^e If the polarity is not marked, half the number of operating cycles is effected with one polarity and half with reverse polarity. ^f No intentional time constant. ^g One-half of the operating cycles shall be done at $I_c/I_e = 1$, except for AC-33B and AC-35B where all operating cycles shall be done at $I_c/I_e = 1$. ^h One-half of the operating cycles shall be done at $I_c/I_e = 1$, except for DC-33B where all operating cycles shall be at $I_c/I_e = 1$.							

8.2.4.3 Durability

Subclause 8.2.4.3 of IEC 60947-1:2020 applies.

8.2.5 Ability to make and break under short-circuit conditions

8.2.5.1 Rated short-time withstand current

TSE for which the manufacturer has assigned a rated short-time withstand current shall withstand the test given in 9.2.5.2.

The minimum value of the short-time withstand current shall be as listed in Table 5.

The minimum durations are:

- 3 half-cycles of the rated frequency or 0,025 s for direct current for rated operational currents up to and including 400 A;

- 3 cycles of the rated frequency or 0,05 s for direct current for rated operational currents higher than 400 A.

Additional values of short-time withstand current for other durations may be stated by the manufacturer.

8.2.5.2 Rated short-circuit making capacity

TSE Class CB and PC for which the manufacturer has assigned a rated short-time withstand current shall make the test currents in accordance with the value stated by the manufacturer.

The rated short-circuit making capacity shall be in accordance with 5.3.6.3.

8.2.5.3 Rated short-circuit breaking capacity

Subclause 8.2.5 of IEC 60947-1:2020 applies with the following amplification.

For Class CB TSE, the rated short-circuit breaking capacity shall be in accordance with 5.3.6.4 and shall break the test currents given in Table 5 or Table 6, at the discretion of the manufacturer. If the manufacturer assigns a short-circuit breaking capacity greater than the test current given in Table 5 or Table 6, the TSE shall also break this assigned value of current.

8.2.5.4 Rated conditional short-circuit current

Class CC TSE shall have a conditional short-circuit current with a minimum value according to Table 5 or Table 6, at the discretion of the manufacturer. Class PC TSE may have conditional short-circuit current in which case the minimum value shall comply with Table 5 or Table 6.

SCPD used shall comply with its product standard at ratings not lower than those assigned in this document.

Table 5 – Value of the test current for the verification of the ability to operate under short-circuit conditions

Rated operational current I_e (RMS) A	Test current (RMS) ^a
$I_e \leq 100$	5 kA
$100 < I_e \leq 500$	10 kA
$500 < I_e \leq 1\,000$	$20 \times I_e$
$1\,000 < I_e$	$20 \times I_e$ or 50 kA, whichever is the lower
^a The power factors, time constants and ratio between peak and RMS values of current shall be as given in Table 16 of IEC 60947-1:2020.	

Table 6 – Value of the test current for the verification of the ability to operate under short-circuit conditions (harmonized table)

Rated operational current I_e ^c A	Test current kA ^d (RMS)	Power factor
$I_e \leq 100$ ^a	5	0,7 through 0,8
$100 < I_e \leq 250$ ^b	10	0,5 through 0,7
$250 < I_e \leq 500$	18	0,2 through 0,3
$500 < I_e \leq 800$	30	0,2 through 0,3
$800 < I_e \leq 1\,300$	42	0,2 through 0,3
$1\,300 < I_e$	Subject to agreement between manufacturer and user.	0,2 through 0,3
NOTE Table 6 has been introduced for harmonization purpose with CSA-C22.2 No.60947-4-1-14 and UL 60947-4-1.		
^a At 690 V and above: $I_e \leq 125$ A. ^b At 690 V and above: $125 < I_e$ (A) ≤ 250 . ^c Rated operational current may be marked "current rating" in North America. ^d Test current may be called "fault current rating" in North America.		

8.2.6 Critical load current performance (DC equipment)

The main circuits of equipment shall be capable of making and breaking its critical load current according to 9.2.7 and as verified by test sequence V.

8.3 Electromagnetic compatibility (EMC)

8.3.1 General

Subclause 8.3.1 of IEC 60947-1:2020 applies with the following additions.

Power-frequency magnetic field tests are not required because the devices are naturally submitted to such fields. Immunity is demonstrated by the successful completion of the operational performance capability tests (see 9.2.4.1 and 9.2.4.2).

8.3.2 Immunity

Subclause 8.3.2 of IEC 60947-1:2020 applies with the following additions.

The procedures are given in 9.2.8.

The test results are specified using the performance criteria given in Table 7.

Table 7 – Acceptance criteria of immunity test

Item	Acceptance criteria (performance criteria during tests)		
	A	B	C
Overall performance	Normal TSE operations without noticeable changes of the operating characteristic.	Temporary degradation or loss of performance which is self-recoverable	Temporary degradation or loss of performance which, after the test, requires operator intervention or system reset. There shall not be any damaged component.
Power switching operation, auxiliary contacts, interlocking and controller functions	No unwanted operation of the TSE, no change of state of the controller. No change of the auxiliary contacts. TSE fully operational.	Temporary degradation mode of the controller which is self-recoverable. No unwanted operation of the TSE. No change of the auxiliary contacts.	Temporary or loss of the transfer function availability, which, after the test, is recoverable by operator intervention or the reset of the controller or any electronics. No unwanted operation of the TSE. No change of the auxiliary contacts.
Operation of displays, and control panels	No changes to visible display information. Only slight light intensity fluctuation, or slight movement of displayed information.	Temporary visible changes on the display (flickering). Undesired display illumination No change of the operating mode.	Shutdown or permanent loss of display. Recoverable after the test by operator intervention or the controller reset.
Information processing, communication, and sensing functions	Undisturbed communication, sensing functions and information exchange to external devices.	Temporarily variation of analogic values, disturbed communication, possible error reports of the internal and external devices. No irreversible loss of data.	Loss of data and/or information. Erroneous processing of information, errors in communication recoverable, after the test, by operator intervention or the controller reset.

8.3.3 Emission

Subclause 8.3.3 of IEC 60947-1:2020 applies with the following addition.

The test values and procedures are given in 9.2.8.

9 Tests

9.1 Kinds of tests

Subclause 9.1 of IEC 60947-1:2020 applies.

9.2 Type tests

9.2.1 General test conditions

The condition of the equipment for the tests shall be as stated in 9.3.2 of IEC 60947-1:2020.

NOTE It is not necessary to test values for all test values corresponding to assigned utilization categories. See Annex A.

9.2.2 Test sequences

Type tests are grouped together in a number of sequences as shown in Table 8 for TSE other than derived TSE, or Table 9 for derived TSE.

For each sequence, tests shall be made in the order listed, unless otherwise indicated.

Table 8 – List of type tests (overall scheme of test sequences)

Test sequence	Tests	Ref.	Applicable to class of TSE			N° sample ^a
			PC	CB	CC	
I General performance characteristics	Constructional requirements	9.2.3.1	X	X	X	1
	Operation ^f	9.2.3.2	X	X	X	
	Controls, sequence and limits of operation ^f	9.2.3.3	X	X	X	
	Tripping limits and characteristics ^f	9.2.3.4		X		
	Temperature-rise	9.2.3.5	X	X	X	
	Dielectric properties ^f	9.2.3.6	X	X	X	
II Operating performance capability	Making and breaking capacities	9.2.4.1	X	X	X	1
	Operational performance capability ^e	9.2.4.2	X	X	X	
	Verification of dielectric withstand	9.2.4.3	X	X	X	
	Verification of temperature-rise	9.2.4.4	X	X	X	
	Verification of overload releases	9.2.4.5		X		
	Verification of main contact position ^{b, f}	9.2.4.6	X	X		
III Short-circuit performance capability	General requirements	9.2.5.1	X	X	X	1
	Short-time withstand current	9.2.5.2	X ^c	X ^c		
	Short-circuit making capacity	9.2.5.3	X ^c	X ^c		
	Short-circuit breaking capacity	9.2.5.4		X		
	Verification of dielectric withstand	9.2.5.5	X ^c	X		
	Verification of temperature-rise	9.2.5.6	X ^c	X		
IV Conditional short-circuit current	Conditional short-circuit current	9.2.6.3	X ^d		X	1
	Dielectric withstand verification	9.2.6.4	X ^d		X	
	Temperature-rise verification	9.2.6.5	X ^d		X	
V Critical load current performance of equipment with a DC rating	Determination of critical load current	9.2.7.2	X	X	X	1
	Critical load current performance	9.2.7.3	X	X	X	
VI EMC tests	Electromagnetic compatibility	9.2.8	X	X	X	1

^a Multiple test sequences can be performed on the same sample at the manufacturer's discretion.

^b This test is only required if the TSE is declared suitable for isolation.

^c This test is only required if the manufacturer has assigned a short-time withstand current.

^d This test is only required for fuse combination units, or if the manufacturer has assigned a conditional short-circuit current.

^e Covers both mechanical and electrical.

^f May be omitted from the sequence and made on separate samples.

Table 9 – List of type tests to which a derived TSE shall be submitted

Test sequence	Tests	Ref.	Applicable to class of TSE			N° sample ^a
			PC	CB	CC	
I General performance characteristics	Constructional requirements	9.2.3.1	X ^b	X ^b	X ^b	1
	Operation ^j	9.2.3.2	X	X	X	
	Controls, sequence and limits of operation ^j	9.2.3.3	X	X	X	
	Tripping limits and characteristics	9.2.3.4				
	Temperature-rise	9.2.3.5	X ^c	X ^c	X ^c	
	Dielectric properties ^j	9.2.3.6	X	X	X	
II Operating performance capability	Making and breaking capacities Class PC ^d Class CB ^d	9.2.4.1	X ^d	X ^d	X	1
	Operational performance capability Class PC ^d Class CB ^d	9.2.4.2	X ^d	X ^d	X	
	Verification of dielectric withstand	9.2.4.3	X	X	X	
	Verification of temperature-rise	9.2.4.4	X	X	X	
	Verification of overload releases	9.2.4.5		X		
	Verification of main contact position ^{e, i}	9.2.4.6	X	X		
III Short-circuit performance capability	General requirements	9.2.5.1	X	X	X	1
	Short-time withstand current	9.2.5.2	X ^f	X ^f		
	Short-circuit making capacity	9.2.5.3	X ^f	X ^f		
	Short-circuit breaking capacity	9.2.5.4		X ^g		
	Verification of dielectric withstand	9.2.5.5	X ^f	X ^g		
	Verification of temperature-rise	9.2.5.6	X ^f	X ^g		
IV Conditional short-circuit current	Conditional short-circuit current	9.2.6.3	X ^h		X ^h	1
	Dielectric withstand verification	9.2.6.4	X ^h		X ^h	
	Temperature-rise verification	9.2.6.5	X ^h		X ^h	
V Critical load current performance of equipment with a DC rating	Determination of critical load current	9.2.7.2	X	X	X	1
	Critical load current performance	9.2.7.3	X	X	X	
VI EMC tests	Electromagnetic compatibility	9.2.8	X	X	X	1
^a Multiple test sequences can be performed on the same sample at the manufacturer's discretion. ^b See 9.2.3.1.1. ^c If applicable (see 9.2.3.5). ^d If applicable (see 9.2.4.1.1 or 9.2.4.2.1). ^e This test is only required when the TSE is declared suitable for isolation. ^f If applicable (see 9.2.5.2.1 and 9.2.5.3.1). ^g If applicable (see 9.2.5.4.1). ^h If applicable (see 9.2.6.1). ⁱ May be omitted from the sequence and made on separate samples.						

9.2.3 Test sequence I – General performance characteristics

9.2.3.1 Compliance with constructional requirements

9.2.3.1.1 General

Subclauses 9.2.1, 9.2.2, 9.2.3, 9.2.5, 9.2.8 and 9.2.9 of IEC 60947-1:2020 applies with the following exceptions.

For derived TSE, constructional requirement tests covered by the relevant IEC 60947 product standard are not required to be repeated on the switching devices, but all other components forming parts of the TSE shall be tested.

9.2.3.1.2 Electrical performance of screwless-type clamping units

Subclause 9.2.5.7 of IEC 60947-1:2020 applies with following additions:

The insertion and disconnection of the conductors shall be made in accordance with the manufacturer's instructions.

The measurement methods and the results shall be documented in the test report. The test current shall be the maximum I_e .

9.2.3.1.3 Ageing test for screwless-type clamping units

Subclause 9.2.5.8 of IEC 60947-1:2020 applies with the following additions:

The test shall be done on the device equipped with the clamping units.

The test current shall be the maximum I_e . The air temperature in the cabinet is raised in approximately 20 min to 40 °C or the highest temperature for service conditions as declared by the manufacturer.

9.2.3.2 Operation

9.2.3.2.1 General

It shall be verified that the TSE operates without malfunction of the transfer switch as stated in 8.2.1.2 c) and at the limits given in 8.2.1.3 a). The TSE shall be operated in each position (I, II and O if applicable) and each position of the switching device contacts shall be verified by electrical continuity test.

For Class CC TSE, the drop-out test requirements of 9.3.3.2.1 of IEC 60947-1:2020 shall be verified.

Compliance to 8.1.5 is checked by inspection and by manual test, using any appropriate means (e.g. indicator lights, oscilloscope).

9.2.3.2.2 Interlocking function verification

9.2.3.2.2.1 General

The following tests shall be applied to all possible combinations of manual, remote and automatic operated transfer switches respectively.

9.2.3.2.2.2 Manual operation

The test shall be performed without any electrical power available.

For TSE equipped with a single manual actuator, when the actuator is moved from position I to position II, it shall be verified that the terminals of source I are disconnected from the load terminals before the source II terminals are connected to the load terminals. The test shall be repeated from position II to position I.

For TSE equipped with distinct manual actuators for each source switching device, the following sequence shall be verified:

- a) With source I switching device in closed position, it shall be verified that source II switching device cannot be manually switched to closed position;
- b) With source II switching device in closed position, it shall be verified that source I switching device cannot be manually switched to closed position;
- c) With source I and source II switching devices both in open position, it shall be verified that simultaneous closing operations do not result in the closure of both switching devices at any time.

9.2.3.2.2.3 Electrically controlled operation

The following tests shall be performed with the control circuit supply voltage at 85 % and 110 % of rated value. If the interlock of the TSE requires electrical power, the test shall be conducted with this power supply connected and disconnected.

- 1) for TSE equipped of a single remote actuator, when a remote order to transfer from position I to position II is applied, it shall be verified that the load terminals are disconnected from source I terminals before being connected to source II terminals. The test shall be repeated from position II to position I.
- 2) for TSE equipped of distinct remote actuators for each switching device, the following sequence shall be verified:
 - a) With source I and source II switching devices in the open position, it shall be verified that giving the order to switch both switching devices to close simultaneously for 5 s does not result in the closure of both devices. This test is applicable only to RTSE and ATSE allowing to send simultaneous transfer orders to position I and position II.
 - b) With source I switching device in closed position, it shall be verified that sending a remote closing order on source II switching device for 5 s does not result in the closure of both switching devices at any time.
 - c) With source II switching device in closed position, it shall be verified that sending a remote closing order on source I switching device for 5 s does not result in the closure of both switching devices at any time.

9.2.3.2.3 Verification of the robustness of the interlock

9.2.3.2.3.1 General

This test is intended to verify that the interlocking function remains operational when the main contacts of one source are unable to open (welded or jammed, for example).

The test shall be conducted in both position I and position II of the TSE. If the construction of the TSE is such that there is no significant physical difference between position I and position II that would influence the test results, the tests can be done in either position I or II. If it can be determined that one position represents a more difficult case, the tests are only required to be done in that position.

MTSE shall be tested using manual operation means. RTSE and ATSE shall be tested using remote operation means, and manual operation means if applicable.

In the case of multiple tip contact TSE, the least number of parallel contact tips shall be fixed together as necessary to hold the contact closed in order to allow the test force to be applied without the contacts separating.

To simulate the occurrence of welding on one main pole, one main contact shall be maintained in the closed position, e.g. by welding or gluing each point of contact (e.g. for double breaking contact, welding is carried out at the two contact points). The thickness of welding or gluing shall be such that the distance between contacts is not modified significantly and the method used shall be described in the test report.

Verification shall be made according to 9.2.3.2.3.5.

9.2.3.2.3.2 Manual operation

The test shall be performed without any electrical power available.

For any TSE that includes manual operation, the force necessary to operate the device from one position to another shall be measured at the extremity of the actuator. The measured force F shall be equal to the average value of the maximum force obtained from three consecutive operations including all interlocks with the TSE in a clean and new condition. This force F shall then be used for the establishment of the test force in Table 17 of IEC 60947-1:2020.

With the TSE closed in position I, the fixed and moving contacts of one pole for which the test is deemed to be the most severe shall be fixed together, for example, by welding.

The actuator(s) shall attempt to switch to position II by being submitted to a test force of $3 \times F$ but not less than the minimum values nor more than the maximum values given in Table 17 of IEC 60947-1:2020, corresponding to the type of actuator.

For TSE equipped with a single manual actuator, the test force shall be applied without shock to the extremity of the actuator, for a duration of 10 s, in the direction to open the contacts previously fixed together and close the other source switching device.

For TSE equipped with distinct manual actuators for each switching device, the following sequence shall be performed:

- the test force shall be applied without shock to the extremity of the actuator, for a duration of 10 s, in the direction to open the contacts previously fixed together;
- as a second step, it shall be verified that the other source switching device cannot be manually switched to the closed position.

9.2.3.2.3.3 Dependent power operation

For RTSE and ATSE with dependent power operation the TSE shall be closed in position I whilst the fixed and moving contacts of one pole for which the test is deemed to be the most severe shall be fixed together, for example, by welding.

The supply voltage to the power operator shall be applied at 110 % of its normal rated value to attempt to reach position II. If the interlock of the TSE requires electrical power, this power supply shall be disconnected.

Three attempts to operate the equipment by the power operator in the direction to reach position II shall be made at 5 min intervals, each for a duration of 5 s, unless an associated protective device of the power operator limits the time to a shorter duration.

9.2.3.2.3.4 Independent power operation

For RTSE and ATSE with independent power operation the TSE shall be closed in position I whilst the fixed and moving contacts of one pole for which the test is deemed to be the most severe shall be fixed together, for example, by welding.

If the interlock of the TSE requires electrical power, this power supply shall be disconnected.

The stored energy of the power operator shall be released to attempt to reach position II.

Three attempts to operate the equipment by releasing the stored energy shall be made.

9.2.3.2.3.5 Condition of equipment during and after test

During and after the test, none of the main contacts of the other source switching device shall close whether temporarily or definitely using suitable measurement equipment for temporary events, e.g. an oscilloscope.

9.2.3.2.4 Verification of electrical interlock in case of individual failure

This subclause applies when the equipment is equipped with only electrical interlock, or with only electrically driven mechanical interlock, and no mechanical interlock. Verification of 8.2.1.2 item c) shall be performed using either a FMEA according to IEC 60812, or by simulating any possible individual failure (including but not limited to welded main contacts, welded auxiliary contacts, open-wiring and controller failure).

9.2.3.2.5 Verification of the contact transfer time

The TSE contact transfer time shall be verified by test for each mode of operation (mechanical and electrical) as applicable.

For TSE having a single mechanical operating handle, the handle shall be operated with an operating speed during actuation of 1 m/s $\pm 25\%$, this speed being measured where the operating means of the test apparatus touches the actuating means of the TSE under test. For rotary handles, the angular velocity shall correspond substantially to the above conditions, referred to the speed of the operating means (at its extremities) of the TSE under test.

For TSE having mechanical operating means requiring multiple motions to complete the transfer, each portion of the transfer operation shall be performed as simultaneously as possible taking into account the operation of the mechanical interlock, with an operating speed as specified above.

For ATSE or RTSE, the contact transfer time shall be measured under electrical operation, with the control circuit supply voltage at 100 % of rated value.

9.2.3.3 Controls, sequence and limits of operation

9.2.3.3.1 General

The TSE shall be tested to verify its performance according to the requirements given in 8.2.1.3. Test details are given in the following subclauses.

9.2.3.3.2 Operation on loss of supply voltage

This test only applies to ATSE.

If the ATSE is provided with adjustable time delay(s), the test shall be made once with the time delay(s) set to the minimum value, and once with the time delay(s) set to the maximum value.

The ATSE shall be set in position I, and both source terminals supplied with the rated voltage and frequency as shown in Figure 2.