IEC 62271-112

Edition 2.0 2021-07

INTERNATIONAL STANDARD

NORME INTERNATIONALE

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High-voltage switchgear and controlgear – Part 112: Alternating current high-speed earthing switches for secondary arc extinction on transmission lines

Appareillage à haute tension – Partie 112: Sectionneurs de terre rapides à courant alternatif pour l'extinction de l'arc secondaire sur les lignes de transport

IEC 62271-112:2021-07(en-fr)

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

COMMISSION ELECTROTECHNIQUE INTERNATIONALE

ICS 29.130.10; 29.130.99

ISBN 978-2-8322-1001-6

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HIGH-VOLTAGE SWITCHGEAR AND CONTROLGEAR –

Part 112: Alternating current high-speed earthing switches for secondary arc extinction on transmission lines

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IEC 62271-112 has been prepared by subcommittee 17A: Switching devices, of IEC technical committee 17: High-voltage switchgear and controlgear. It is an International Standard.

This second edition cancels and replaces the first edition published in 2013. This edition constitutes a technical revision.

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

The document has been updated to the second edition of IEC 62271-1:2017.

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

FDIS	Report on voting
17A/1311/FDIS	17A/1314/RVD

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

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/standardsdev/publications.

This International Standard should be read in conjunction with IEC 62271-1:2017, to which it refers and which is applicable, unless otherwise specified. In order to simplify the indication of corresponding requirements, the same numbering of clauses and subclauses is used as in IEC 62271-1:2017. Amendments to these clauses and subclauses are given under the same numbering, whilst additional subclauses, are numbered from 101.

A list of all parts in the IEC 62271 series, published under the general title *High-voltage switchgear and controlgear*, can be found on the IEC website.

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

- reconfirmed,
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HIGH-VOLTAGE SWITCHGEAR AND CONTROLGEAR –

Part 112: Alternating current high-speed earthing switches for secondary arc extinction on transmission lines

1 Scope

This part of IEC 62271 applies to AC high-speed earthing switches (hereinafter termed HSES) designed for indoor and outdoor installation and for operation at service frequencies of 50 Hz and 60 Hz on systems having rated voltages of 550 kV and above.

HSESs described in this document are intended to extinguish the secondary arc remaining after clearing faults on transmission lines by the circuit-breakers.

For more detailed information on HSESs, refer to Annex A.

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 60050-441:1984, *International Electrotechnical Vocabulary (IEV) – Part 441: Switchgear, controlgear and fuses*
IEC 60050-441:1984/AMD1:2000

IEC 62271-1:2017, *High-voltage switchgear and controlgear – Part 1: Common specifications for alternating current switchgear and controlgear*

IEC 62271-100:2021, *High-voltage switchgear and controlgear – Part 100: Alternating current circuit-breakers*

IEC 62271-102:2018, *High-voltage switchgear and controlgear – Part 102: Alternating current disconnectors and earthing switches*

IEC 62271-200:2011, *High-voltage switchgear and controlgear – Part 200: AC metal-enclosed switchgear and controlgear for rated voltages above 1 kV and up to and including 52 kV*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in Clause 3 of IEC 62271-1:2017, as well as 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

Additional terms and definitions are classified so as to be aligned with the classification used in IEC 60050-441.

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3.1 General terms and definitions

3.1.101
secondary arc
arc that remains at the faulted point after interruption of the short-circuit current fed by the network

Note 1 to entry: This secondary arc is supplied by electrostatic or electromagnetic induction from the adjacent live phases.

3.1.102
single-phase auto-reclosing scheme
auto-reclosing scheme in which a faulted phase circuit is opened and automatically re-closed independently from the other phases

3.1.103
multi-phase auto-reclosing scheme
auto-reclosing scheme applied to double circuit overhead lines in which all faulted phase circuits are opened and re-closed independently provided that at least two different phases remain un-faulted

Note 1 to entry: An example of multi-phase auto-reclosing scheme is indicated in Figure 1.

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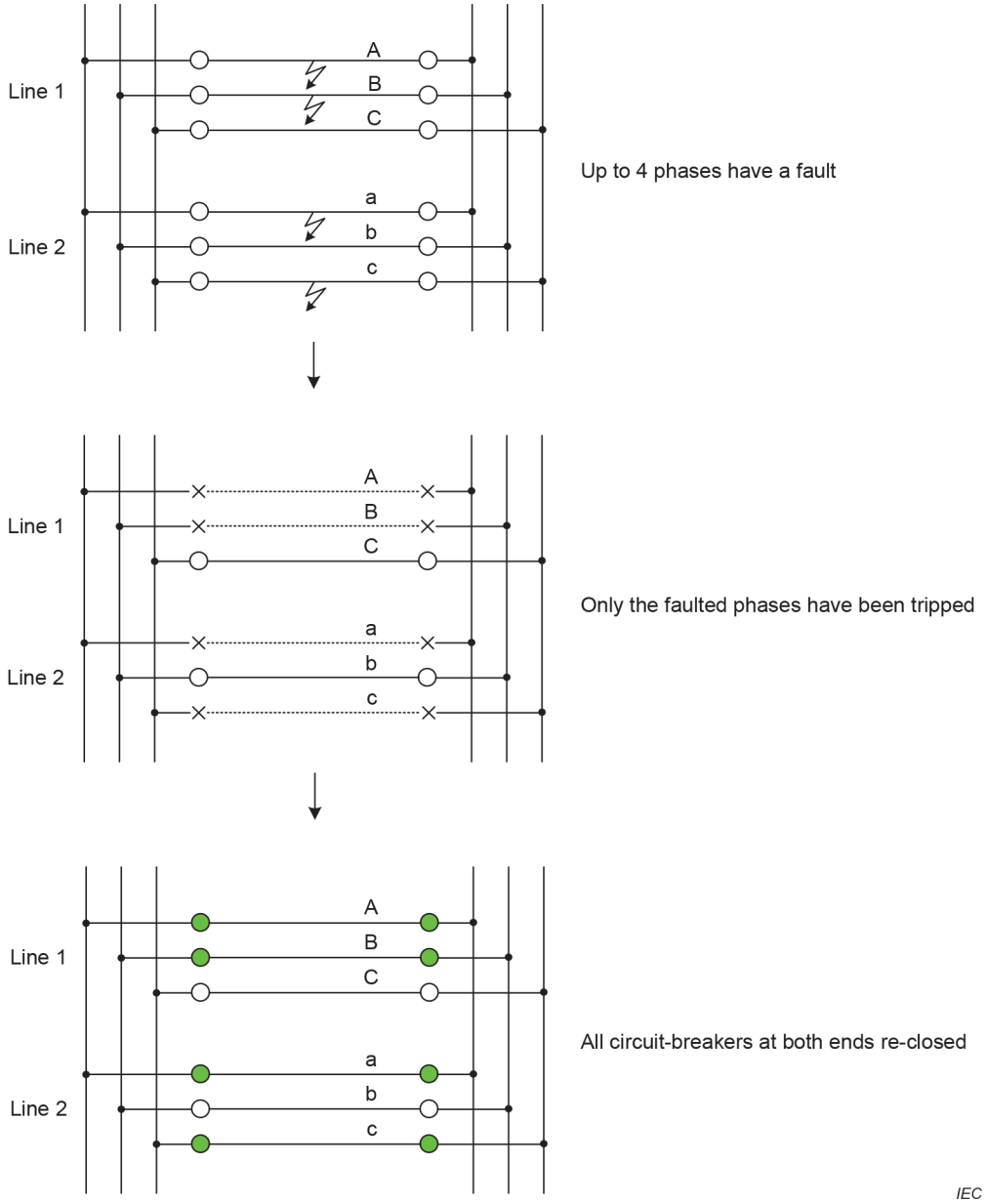

Key

1)	Up to 4 phases have a fault	○	Closed circuit-breaker
2)	Only the faulted phases have been tripped	×	Open circuit-breaker
3)	All circuit-breakers at both ends re-closed	●	Re-closed circuit-breaker

Figure 1 – Explanation of a multi-phase auto-reclosing scheme

Note 2 to entry: Other than the scheme described in 3.1.102 and 3.1.103, a three-phase auto-reclosing scheme is commonly applied. In this scheme, all three phases of one circuit are tripped and re-closed at both ends even if a fault occurred in one phase. So far high-speed earthing switches are rarely applied with this scheme.

3.1.104
successive fault
additional earth fault that occurs in the adjacent phase circuit(s) during the time interval between a single-phase earth fault and the opening of the high-speed earthing switch(es)

3.2 Assemblies of switchgear and controlgear

No particular definitions.

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3.3 Parts of assemblies

No particular definitions.

3.4 Switching devices

3.4.101
high-speed earthing switch
HSES
earthing switch that has the capability to:

– make, carry and interrupt the induced current;
– withstand the recovery voltage caused by electromagnetic and/or by electrostatic couplings prior to circuit re-closure;
– make and carry the rated short-circuit current

Note 1 to entry: The high-speed operation applies normally to both closing and opening.

Note 2 to entry: A high-speed earthing switch is not intended to be used as a maintenance earthing switch.

3.4.102
high-speed earthing switch class M0
high-speed earthing switch having a normal mechanical endurance of 1 000 operation cycles

3.4.103
high-speed earthing switch class M1
high-speed earthing switch having an extended mechanical endurance of 2 000 operation cycles for special requirements

3.5 Parts of switchgear and controlgear

No particular definitions.

3.6 Operational characteristics of switchgear and controlgear

No particular definitions.

3.7 Characteristics quantities

No particular definitions.

4 Normal and special service conditions

Clause 4 of IEC 62271-1:2017 is applicable.

5 Ratings

5.1 General

Clause 5 of IEC 62271-1:2017 is applicable with the following additions.

NOTE Categories corresponding to the fault modes are explained in Annex B.

5.5 Rated continuous current (I_r)

Subclause 5.5 of IEC 62271-1:2017 is not applicable.

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5.101 Rated short-circuit making current (I_{ma})

Subclause 5.101 of IEC 62271-102:2018 is applicable.

5.102 Rated operating sequence

The rated characteristics of the HSES are referred to the rated operating sequence.

a) C – t_{i1} – O,

or

b) C – t_{i1} – O – t_{i2} – C – t_{i1} – O

Where

– t_{i1} is a time that is longer than the time required for secondary arc extinction and for dielectric recovery of air insulation at the faulted point. t_{i1} is determined by users considering system stability. The preferred value of t_{i1} is 0,15 s;

– t_{i2} is the intermediate time that is given by the system protection. t_{i2} includes the closing time of the circuit-breakers after the HSESs open, the duration of a new line fault and the break-time of the circuit-breakers. Following this time t_{i2}, the HSES can be reclosed. The preferred value of t_{i2} is 0,5 s.

In this case the HSES shall be able to operate without intentional time delay.

NOTE t_{i1} and t_{i2} are set by system control scheme and a HSES itself is to be operated according to its own operating time.

Figure 2 shows the time chart for the rated operating sequence of C – t_{i1} – O – t_{i2} – C – t_{i1} – O.

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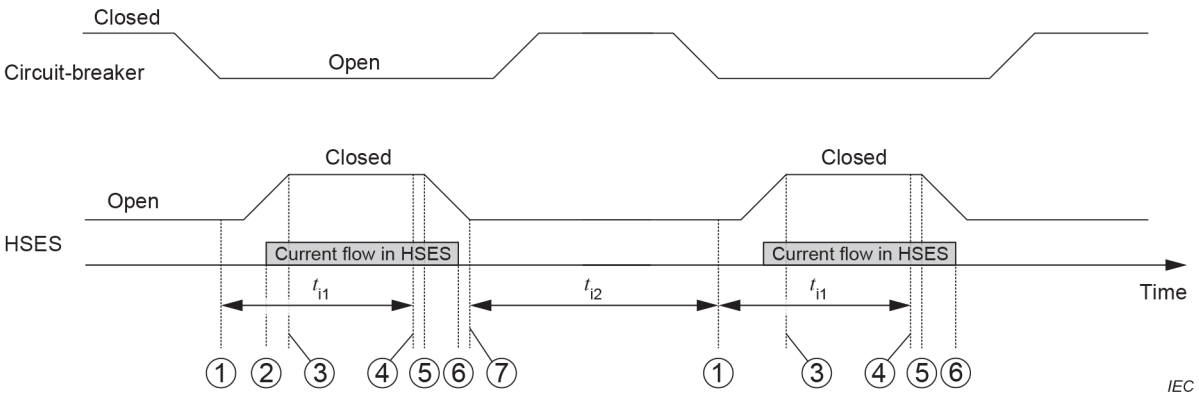

Key

Circuit-breaker	Transmission line circuit-breakers that interrupt the fault	3	Contact touch of HSESs
HSES	High-speed earthing switches	4	Energizing of the opening release of the HSESs
1	Energizing of the closing circuit of the HSESs	5	Contact separation of HSESs
2	Current start in HSESs	6	Arc extinction in HSESs
t_{i1}, t_{i2}	Times defined in 5.102	7	Fully open position of HSESs

NOTE 1 A common value for the re-closing time of the circuit-breaker is 1 s to guarantee system stability.

NOTE 2 t_{i1} is normally within the range of 0,15 s to 0,5 s.

NOTE 3 t_{i2} is normally within the range of 0,5 s to 1 s.

NOTE 4 The operating sequence b) is for system stability requirements to cover cases where another fault occurs on the same phase.

NOTE 5 The HSES closing time is normally less than 0,2 s.

Figure 2 – Timing chart of HSES and circuit-breakers

6 Design and construction

Clause 6 of IEC 62271-1:2017 is applicable with the following modifications.

6.5 Dependent power operation

Subclause 6.5 of IEC 62271-1:2017 is not applicable.

6.7 Independent unlatched operation (independent manual or power operation)

Subclause 6.7 of IEC 62271-1:2017 is not applicable.

6.11 Nameplates

The designation of the equipment is specified as HSES.

Items to be indicated on the nameplate are listed in Table 1.

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Table 1 – Nameplate information

Item	Abbreviation	Unit
Name of manufacturer		
Type designation		
Serial number Year of manufacture		
Rated voltage	U_r	kV
Rated lightning impulse withstand voltage	U_p	kV
Rated switching impulse withstand voltage	U_s	kV
Rated power-frequency withstand voltage	U_d	kV
Rated short-time withstand current	I_k	kA
Rate peak withstand current	I_p	kA
Rated duration of short-circuit	t_k	s
Rated short-circuit making current	I_{ma}	kA
Filling pressure for insulation	P_{re}	MPa
Filling pressure for operation	P_{rm}	MPa
Rated supply voltage(s) of auxiliary and control circuits Specify DC/AC (with rated frequency)	U_a	V
Rated frequency	f_r	Hz
Mechanical endurance class	M_1/M_2	
Electrical endurance class	E_1/E_2	
Type and mass fluid (liquid or gas) for insulation	M_f	kg
Mass (including fluid)	M	kg
Operating sequence	C-t_{r1}-O or C-t_{r1}-O-t_{r2}-C-t_{r1}-O (t_{r1}, t_{r2})	
Minimum and maximum ambient temperature		°C
Category (option)[a]		
[a] Category is to refer to Clause B.2		

6.12 Locking devices

Subclause 6.12 of IEC 62271-1:2017 is not applicable.

6.101 Anti-pumping device

Anti-pumping device shall be provided for pneumatic and hydraulic operating mechanism.

6.102 Special requirements for HSES

A HSES shall be able to earth transmission lines and re-open to achieve their full voltage withstand within the dead time of the auto-reclosing duty cycle of the transmission line circuit-breakers. The dead time is defined by system stability and is normally set around 1 s enabling dielectric recovery of insulation capability at the fault location. Fast operating capability for both making and breaking is required.

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The HSES shall have a capability to by-pass secondary arc current on the transmission lines.

The HSES shall have a capability to break induced current by electromagnetic and/or electrostatic coupling on transmission lines with a transient recovery voltage specified in Table 2.

The HSES shall have a capability to withstand recovery voltage after interruption and rated power frequency voltage to earth ($U_r/\sqrt{3}$) in open position.

The HSES shall be single-pole operated, unless otherwise specified.

7 Type tests

7.1 General

Clause 7 of IEC 62271-1:2017 is applicable with the following additions.

The dielectric performance shall be verified for phase-to-earth in the open position only in accordance with IEC 62271-1:2017.

7.3 Radio interference voltage (RIV) test

Subclause 7.3 of IEC 62271-1:2017 is applicable for open position only.

7.5 Continuous current tests

Subclause 7.5 of IEC 62271-1:2017 is not applicable.

7.101 Tests to prove the short-circuit making performance

Subclause 7.101 of IEC 62271-102:2018 is applicable.

7.102 Operating and mechanical endurance tests

Subclause 7.102 of IEC 62271-102:2018 is applicable with the following modifications.

The rated operating sequence shall be verified during mechanical operation.

The mechanical operating sequence for class M0 shall be one of the following:

a) A HSES with a specified duty cycle required C – t_{i1} – O:
   - 1 000 C – t_{i1} – O operations.

b) A HSES with a specified duty cycle C – t_{i1} – O – t_{i2} – C – t_{i1} – O
   - 500 C – t_{i1} – O operations, plus
   - 250 C – t_{i1} – O – t_{i2} – C – t_{i1} – O operations.

For class M1, the number of operations shall be twice the sequence specified.

Mechanical travel characteristics shall be recorded and acceptance criteria are referred to 7.102.4.1 of IEC 62271-100:2021 with the modification of the total tolerance to 20 % (for example $^{+20}_{-0}$ %, $^{+10}_{-10}$ % or $^{+0}_{-20}$ %).

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7.103 Operation under severe ice conditions

Subclause 7.103 of 62271-102:2018 is applicable.

7.104 Low- and high-temperature tests

Subclause 7.104 of 62271-102:2018 is applicable.

7.105 Tests to prove the induced current making and breaking performance of HSES

7.105.1 General test conditions

Tests shall be performed in accordance with the standard condition values for HSES specified in Table 2.

Table 2 – Standard values of rated induced currents and voltages

Rated voltage U_r	Electromagnetic coupling				Electrostatic coupling	
	Rated induced current ($^{+10}_{-0}$ %)	Rated power-frequency recovery voltage ($^{+10}_{-0}$ %)	First TRV peak ($^{+10}_{-0}$ %)	Time to first peak ($^{+10}_{-0}$ %)	Rated induced current ($^{+10}_{-0}$ %)	Rated induced voltage ($^{+10}_{-0}$ %)
kV(RMS)	A (RMS)	kV (RMS)	kV(peak)	ms	A (RMS)	kV (RMS)
550	6 800	240	580	0,6	120	115
800	6 800	240	580	0,6	170	170
1 100 / 1 200	6 800	240	580	0,6	230	235

NOTE 1 For Table 2, the rated induced voltages by electrostatic recovery voltage have a “1-cos” wave shape based on the applied power frequency voltage.

NOTE 2 For networks with up to two faults (categories 0 and 1 as described in Clause B.2), the corresponding values are presented in Table B.3.

NOTE 3 For networks with delayed current zero crossing occurrence (category 3 as described in Clause B.2), the corresponding values are presented in Table B.1.

NOTE 4 For networks with multi-phase faults (category 4 as described in Clause B.2), the corresponding values are presented in Table B.2.

NOTE 5 The prospective TRV wave shape for electromagnetic coupling may be of a triangular or “1-cos” form. The time to peak is valid for either wave shape type.

Subclause 7.107 of IEC 62271-102:2018 is applicable with the following additions and modifications.

Number of tests both for electromagnetic and electrostatic coupling:

– 10 times C and O.

Measurement of travel characteristics shall be in accordance with 7.102.4.1 of IEC 62271-100:2021.

Test circuits are those shown in Figure 12 and Figure 13 of IEC 62271-102:2018.

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For electrostatic induced current test independent of the rated voltage of the HSES, the test circuit parameters shall be:

– capacitance value C_1 = 1,56 μF;

– surge impedance: 245 Ω;

NOTE 6 This test condition corresponds to line length 200 km.

The HSES shall preferably be tested at rated frequency; however, for convenience of testing, tests at 50 Hz cover the requirement for 60 Hz and vice versa.

These tests cover the classes of A and B described in 5.109 of IEC 62271-102:2018.

7.105.2 Induced current switching details

Type tests for HSES having a rated induced current making and breaking capability shall include tests to prove the electromagnetically and/or electrostatically induced current making and breaking capability under minimum control voltage.

The test currents shall be within a tolerance of ($^{+10}_{-0}$ %) of the rated induced currents as shown in Table 2.

For convenience of testing, the control voltage of the HSES can be either the rated or maximum of the auxiliary supply voltage if the control voltage does not affect the making and breaking capability of HSES. This condition is considered to be satisfied if the travel characteristics of that condition are within a range of ($^{+5}_{-5}$ %) of those obtained with a minimum control voltage.

Induced current making and breaking tests shall be conducted without maintenance.

7.105.3 Arrangement of the HSES before the test

The HSES under test shall be completely mounted on its own support or on a mechanically equivalent test support. Its operating device shall be operated in the manner prescribed and, in particular, if it is electrically, hydraulically or pneumatically operated, it shall be operated either at the minimum supply voltage or at the minimum functional pressure for operation, respectively.

Before commencing making and breaking tests, no-load operations shall be made and details of the operating characteristics of the HSES, such as travel characteristics, closing time and opening time, shall be recorded.

If applicable, tests shall be performed at the minimum functional pressure for interruption and insulation.

7.105.4 Behaviour of the HSES during the test

The HSES shall perform successfully without undue mechanical or electrical distress.

During tests, the HSES shall not

– show signs of distress;

– show harmful interaction with adjacent laboratory equipment;

– exhibit behaviour which could endanger an operator.

Outward emission of gases, flames or metallic particles from the switch during operation is permitted, if this does not impair the insulation level of the earthing switch or prove to be harmful to an operator or other person in the vicinity, or prove to be harmful to an operator or other person in the vicinity.

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Should doubt exist after an operation, the testing is to be continued or repeated with indicators as specified in IEC 62271-200:2011 mounted in the most onerous position likely for personnel to stand during the operation of the HSES.

7.105.5 Condition after the test

Comparison of mechanical characteristics before and after the test shall be done according to 7.102.3.2 of IEC 62271-102:2018.

Subclause 7.108.9 of IEC 62271-102:2018 is applicable.

8 Routine tests

Clause 8 of IEC 62271-1:2017 is applicable with the following additions.

For mechanical operating test, refer to 8.101 of IEC 62271-100:2021.

Mechanical travel characteristics shall be recorded and acceptance criteria are referred to 7.102.4.1 of IEC 62271-100:2021 with the modification of the tolerance to

20 % (for example $^{+20}_{-0}$ % or $^{+10}_{-10}$ % or $^{+0}_{-20}$ %).

Timing test of close and open with rated and minimum conditions of auxiliary supply shall be verified.

9 Guide to the selection of HSESs (informative)

For the selection of HSESs described in Table 2 and also in Table B.1 and Table B.2 if necessary, the following conditions and requirements at site should be considered:

– existing fault conditions;
– number of circuits;
– auto-reclosing scheme (single or multi auto-reclosing scheme);
– required operating sequence (the operating sequence is linked to circuit-breaker operating sequence);
– consideration on successive faults and other special conditions such as delayed current zero phenomena during HSES operations;
– required operational performance (mechanical endurance);
– switching requirements (making and short-circuit breaking capability);
– class M1 is mainly for applications where the HSES is operated in special requirement where frequent lightning strokes occur.

10 Information to be given with enquiries, tenders and orders (informative)

Clause 10 of IEC 62271-1:2017 is applicable.

11 Transport, storage, installation, operating instructions and maintenance

Clause 11 of IEC 62271-1:2017 is applicable.

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12 Safety

Clause 12 of IEC 62271-1:2017 is applicable.

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