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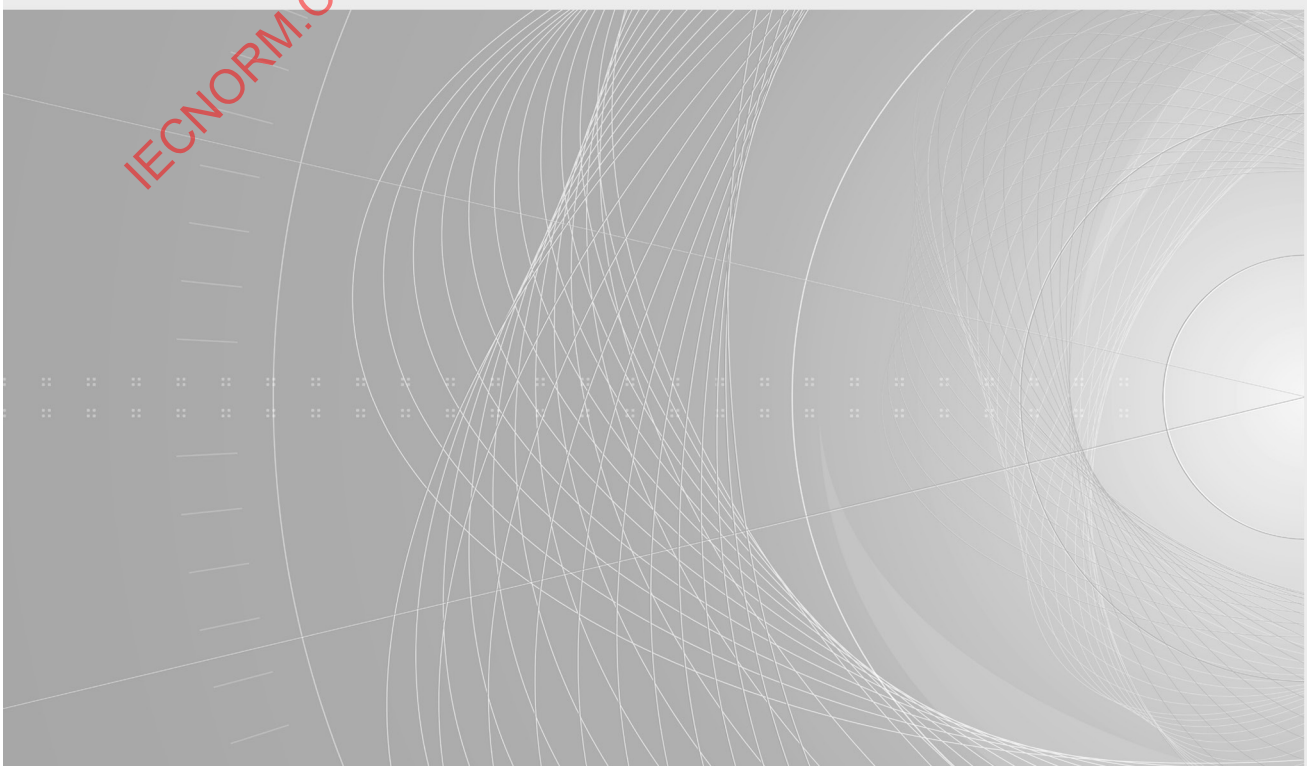
TECHNICAL SPECIFICATION

High-voltage switchgear and controlgear – Part 315: Direct current (DC) transfer switches



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HIGH-VOLTAGE SWITCHGEAR AND CONTROLGEAR –

Part 315: Direct current (DC) transfer switches

FOREWORD

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IEC TS 62271-315 has been prepared by subcommittee 17A: Switching devices, of IEC technical committee 17: High-voltage switchgear and controlgear. It is a Technical Specification.

The text of this Technical Specification is based on the following documents:

Draft	Report on voting
17A/1412/DTS	17A/1417/RVDTS

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 Technical Specification 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/publications.

This document is to be read in conjunction with IEC TS 62271-5:2024, 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 TS 62271-5. Amendments to these clauses and subclauses are given under the same references whilst additional subclauses are numbered from 101.

A list of all parts of IEC 62271 series, 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,
- withdrawn, or
- revised.

HIGH-VOLTAGE SWITCHGEAR AND CONTROLGEAR –

Part 315: Direct current (DC) transfer switches

1 Scope

This part of IEC 62271 is applicable to direct current (DC) transfer switches designed for indoor or outdoor installation and for operation on HVDC transmission systems having direct voltages of 100 kV and above.

DC transfer switches normally include metallic return transfer switches (MRTS), earth return transfer switches (ERTS), neutral bus switches (NBS) and neutral bus earthing switches (NBES).

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 60060-1:2010, *High-voltage test techniques – Part 1: General definitions and test requirements*

IEC 60068-2-1:2007, *Environmental testing – Part 2-1: Tests – Test A: Cold*

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

IEC 60068-2-30:2005, *Environmental testing – Part 2-30: Tests – Test Db: Damp heat, cyclic (12 h + 12 h cycle)*

IEC 60071-11:2022, *Insulation co-ordination – Part 11: Definitions, principles and rules for HVDC system*

IEC 60076-6, *Power transformers– Part 6: Reactors*

IEC 60099-9, *Surge arresters – Part 9: Metal-oxide surge arresters without gaps for HVDC converter stations*

IEC 60255-21-1:1988, *Electrical relays – Part 21: Vibration, shock, bump and seismic tests on measuring relays and protection equipment – Section One: Vibration tests (sinusoidal)*

IEC 60270:2000, *High-voltage test techniques – Partial discharge measurements*

IEC 60633, *High-voltage direct current (HVDC) transmission – Vocabulary*

IEC 60871-1, *Shunt capacitors for a.c. power systems having a rated voltage above 1 000 V – Part 1: General*

IEC 61000-4-18:2019, *Electromagnetic compatibility (EMC) – Part 4-18: Testing and measurement techniques – Damped oscillatory wave immunity test*

IEC TS 62271-5:2024, *High-voltage switchgear and controlgear – Part 5: Common specifications for direct 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 62271-207, *High-voltage switchgear and controlgear – Part 207: Seismic qualification for gas-insulated switchgear assemblies for rated voltages above 52 kV*

IEC TS 63014-1, *High-voltage direct current (HVDC) power transmission – System requirements for DC-side equipment Part 1: Using line-commutated converters*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in in IEC 60633, IEC TS 63014-1 and the following apply.

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

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

3.1 General terms and definitions

Subclause 3.1 of IEC TS 62271-5:2024 is applicable.

3.2 Assemblies of switchgear and controlgear

Subclause 3.2 of IEC TS 62271-5:2024 is applicable.

3.3 Parts of assemblies

Subclause 3.3 of IEC TS 62271-5:2024 is applicable.

3.4 Switching devices

Subclause 3.4 of IEC TS 62271-5:2024 is applicable with the following additions:

3.4.101
active DC transfer switch
DC transfer switch with charging device in oscillating branch, installed in parallel to the commutation switch

3.4.102
blank DC transfer switch
DC transfer switch with a sole commutation switch only, without any additional external branches or components

Note 1 to entry: Some commutation switches use internal components to increase voltage drop across the switching units during transfer operation.

3.4.103
passive DC transfer switch
DC transfer switch without charging device in oscillating branch, installed in parallel to the commutation switch

3.4.104
earth return transfer switch
ERTS
DC transfer switch used to transfer direct current from a metallic return path to an earth return path

Note 1 to entry: "DC transfer switch" is used instead of "DC commutation switch" to refer to whole switch, including oscillating branch and energy dissipation branch.

Note 2 to entry: Although the term "earth return transfer breaker" (ERTB) has been widely used in the industry for many years, it is misleading since such switches have no ability to interrupt fault current.

[SOURCE: IEC 60633:2019, 9.23, modified – The terms "earth return transfer breaker" and "ERTB" have been removed, "DC commutation switch" has been replaced by "DC transfer switch", DC current is replaced by direct current, Note 1 to entry and reference to Figure 7 have been deleted.]

3.4.105
metallic return transfer switch
MRTS
DC transfer switch used to transfer direct current from an earth return path to a metallic return path

Note 1 to entry: "DC transfer switch" is used instead of "DC commutation switch" to refer to whole switch, including oscillating branch and energy dissipation branch.

Note 2 to entry: Although the term "metal return transfer breaker" (MRTB) has been widely used in the industry for many years, it is misleading since such switches have no ability to interrupt fault current.

[SOURCE: IEC 60633:2019, 9.22, modified – The terms "metallic return transfer breaker" and "MRTB" have been removed, "DC commutation switch" has been replaced by "DC transfer switch", DC current is replaced by direct current, Note 1 to entry is moved to Note 2, and reference to Figure 7 has been deleted.]

3.4.106
neutral bus switch
NBS
DC transfer switch connected in series with the neutral bus on a bipolar HVDC scheme, designed to commutate current out of the pole conductor or neutral bus and into the electrode line or dedicated metallic return conductor or earth e.g. in response to a fault in a converter or neutral bus

Note 1 to entry: "DC transfer switch" is used instead of "DC commutation switch" to refer to whole switch, including oscillating branch and energy dissipation branch.

[SOURCE: IEC 60633:2019, 9.26, modified, "DC commutation switch" has been replaced by "DC transfer switch" and Note 1 has been replaced by a new Note 1.]

3.4.107
neutral bus earthing switch
NBES
DC transfer switch connected from the neutral bus to the station earth mat on a bipolar HVDC scheme, designed to provide a temporary earth connection, e.g. in the event of an open circuit fault on the electrode line until the imbalance of current between the two poles can be reduced to a safe minimum level or the electrode line connection can be restored

Note 1 to entry: Although the term “Neutral Bus Grounding Switch” (NBGS) has been widely used in the industry for many years.

Note 2 to entry: In some applications, NBES and high-speed earthing switch (HSES) are used in series.

[SOURCE: IEC 60633:2019, 9.27, modified – The terms “neutral bus grounding switch” and “NBGS” have been removed, “DC commutation switch” has been replaced by “DC transfer switch”, Note 1 and Note 2 have been replaced by new notes.]

3.5 Parts of switchgear and controlgear

Subclause 3.5 of IEC TS 62271-5:2024 is applicable with the following additions:

3.5.101
commutation switch
mechanical switching device used in the main current path of DC transfer switches

Note 1 to entry: A single pole of an AC circuit-breaker or its modification was often used as commutation switch in DC transfer switch.

Note 2 to entry: Some commutation switches use internal components to increase voltage drop across the switching units during transfer operation.

3.5.102
oscillating branch
circuit in parallel with the commutation switch in DC transfer switches, consisting of

– capacitors and reactors, in case of passive DC transfer switches;
– capacitors including a charging device and a making switch, in case of active DC transfer switches.

Note 1 to entry: The oscillating branch forces a current oscillation between itself and the commutation switch branch in order to produce current zeros in the last one.

Note 2 to entry: Depending on the stray inductance of the arrangement reactors are not necessarily needed to be installed.

Note 3 to entry: Passive DC transfer switches having a making device in series with the oscillating branch are also known.

3.5.103
current zero device
oscillating circuit in case of passive DC transfer switch or current impulse generator in case of active DC transfer switch

3.5.104
energy dissipation branch
impedance circuit in parallel with the commutation switch of DC transfer switches which dissipates the energy stored in the energy storage components (e.g. reactors, stray inductance, stray capacitance, etc.) in DC system after successful commutation of current from commutation switch branch to oscillating branch

Note 1 to entry: In real transfer switch, metal oxide surge arrester commonly is used as energy dissipation device.

3.5.105
charging device
device used in active DC transfer switches to charge capacitors in current zero device

3.5.106
making switch
mechanical switch in series with oscillating branch or current injection branch, designed for fast closing

Note 1 to entry: A making switch is used to close the oscillation branch to excite oscillation during current transfer operation.

3.5.107
platform
support for the oscillating branch and the energy dissipation branch

Note 1 to entry: Two versions are known:

– insulated platform with certain insulation level to earth;

– earthed platform.

3.6 Operational characteristics of DC transfer switches

Subclause 3.6 of IEC TS 62271-5:2024 is applicable.

3.7 Characteristic quantities

Subclause 3.7 of IEC TS 62271-5:2024 is applicable with the following additions:

3.7.101
initiation of (opening or closing) operation
instant of receipt of command for operation at the control circuit

[SOURCE: IEC 62271-100:2021, 3.7.153]

3.7.102
opening time
<of mechanical switching device> interval of time between the specified instant of initiation of the opening operation and the instant when the arcing contacts have separated

[SOURCE: IEC 60050-441:1984, 441-17-36, modified – “in all poles” and the Note to entry have been deleted.]

3.7.103
arcing time
interval of time between the instant of the initiation of the arc and the instant of final arc extinction

[SOURCE: IEC 60050-441:1984, 441-17-37, modified – The words “(of a pole or a fuse)” has been removed from the term and from the definition itself.]

3.7.104
commutation time
interval of time between the beginning of the opening time of the commutation switch and the end of the arcing time

3.7.105
closing time
interval of time between the initiation of the closing operation and the instant when the contacts touch

[SOURCE: IEC 60050-441:1984, 441-17-41, modified – The words “in all poles” have been removed at the end of the definition.]

3.7.106
open-close time
interval of time between the instant when the arcing contacts have separated and the instant when the contacts touch during a reclosing cycle

3.7.107
arcing withstand capability
maximum duration of commutation switches capable of withstanding an arc with specified current in case of an unsuccessful commutation

Note 1 to entry: This time shall include the open-close time of commutation switch and the time delay of control and protection system.

3.7.108
continuous current
direct current flowing through DC transfer switches with the DC transmission system operating

3.7.109
transfer current
direct current which the DC transfer switch is able to transfer in an adjacent return path

3.7.110
commutation voltage
transient voltage across the terminals of a DC transfer switch during the current commutation process, describing the time development of the voltage

Note 1 to entry: The commutation voltage depends mainly on the characteristics of the DC transfer switch and is characterised by two effects. Until arc extinguishing in the commutation switch the commutation voltage is equal to its arcing voltage, after arc extinguishing the commutation voltage is equal to the charging voltage of current zero device and will be limited in peak by the energy dissipation device.

Note 2 to entry: The value of commutation voltage at the end of commutation process depends on the HVDC transmission system and is equal to the voltage drop across the current path to which the current was transferred.

3.8 Index of definitions

A

B

4 Normal and special service conditions

Clause 4 of IEC TS 62271-5:2024 is applicable.

5 Ratings

5.1 General

Subclause 5.1 of IEC TS 62271-5:2024 is applicable with the following additions:

j) rated direct voltage of transfer switch (U_{rts});

k) rated transfer current (I_t);

l) rated commutation voltage (U_c);

m) rated dissipated energy during transfer operation (E_{rd});

n) rated operating sequence;

o) rated open-close time.

5.2 Rated direct voltage (U_{rd})

Subclause 5.2 of IEC TS 62271-5:2024 is not applicable and is replaced by 5.101: Rated direct voltage of transfer switch (U_{rts}).

5.3 Rated insulation level (U_{dd}, U_p, U_s)

Subclause 5.3 of IEC TS 62271-5:2024 is not applicable.

The insulation levels for transfer switches shall be selected from the values given in Table 1.

Withstand values given in Table 1 cover the application of transfer switches under normal service conditions defined in 4.1 of IEC TS 62271-5:2024 including altitudes from sea level up to 1 000 m. However, for testing purposes to verify a rating or capability, they shall be considered as insulation values at the standardized reference atmosphere temperature (20 °C), pressure (101,3 kPa) and humidity (11 g/m^3) specified in IEC 60071-11:2022. For special service conditions, refer to IEC TR 62271-306 [1][1].

NOTE According to IEC 60071-11:2022 the insulation levels in Table 1 cover the temperature range of −40 °C up to 40 °C.

The rated withstand voltage values for direct voltage (U_{dd}) and lightning impulse voltage (U_p) shall be selected without crossing the horizontal marked lines in Table 1.

1 Numbers in square brackets refer to the Bibliography.

Table 1 – Rated insulation levels for transfer switches

Rated direct voltage of transfer switch U_{rts} kV	Rated direct withstand voltage U_{dd} kV	Rated lightning impulse withstand voltage U_p kV
	Terminal-to-earth and across open transfer switch	Terminal-to-earth and across open transfer switch
(1)	(2)	(3)
5	7,5	60
10	15	95
25	37,5	200
50	75	325
75	112,5	450
100	150	550
150	225	650
200	300	750

5.4 Rated continuous current (I_{rd})

Subclause 5.4 of IEC TS 62271-5:2024 is applicable.

5.5 Rated values of short-time withstand current

5.5.1 Typical waveform of short-circuit current

Subclause 5.5.1 of IEC TS 62271-5:2024 is applicable.

5.5.2 Rated short-time withstand direct current (I_{kd})

Subclause 5.5.2 of IEC TS 62271-5:2024 is applicable.

5.5.3 Rated peak withstand current (I_{pd})

Subclause 5.5.3 of IEC TS 62271-5:2024 is applicable.

5.5.4 Rated duration of short circuit (t_{kd})

Subclause 5.5.4 of IEC TS 62271-5:2024 is applicable.

5.6 Rated supply voltage of auxiliary and control circuits (U_a)

5.6.1 General

Subclause 5.6.1 of IEC TS 62271-5:2024 is applicable.

5.6.2 Rated supply voltage (U_a)

Subclause 5.6.2 of IEC TS 62271-5:2024 is applicable.

5.7 Rated supply frequency of auxiliary and control circuits

Subclause 5.7 of IEC TS 62271-5:2024 is applicable.

5.8 Rated pressure of compressed gas supply for controlled pressure systems

Subclause 5.8 of IEC TS 62271-5:2024 is applicable.

5.101 Rated direct voltage of transfer switch (U_{rts})

The rated direct voltage of transfer switch (U_{rts}) is the highest direct voltage terminal-to-earth that includes harmonics for which the transfer switch is designed in respect of its insulation as well as other characteristics, to operate as specified for indefinite period of time (lifetime).

NOTE The term "rated maximum voltage" used in most IEEE switchgear standards has the same meaning as the term "rated direct voltage" as used in this document.

The rated direct voltages of transfer switch are 5 kV – 10 kV – 25 kV – 50 kV – 75 kV – 100 kV – 150 kV – 200 kV.

5.102 Rated transfer current (I_t)

The values of rated transfer current should be selected from the R10 series, specified in IEC 60059 [2].

NOTE 1 The R10 series comprises the numbers 1 – 1,25– 1,6 – 2 – 2,5 – 3,15 – 4 – 5 – 6,3 – 8 and their products by 10^n.

NOTE 2 For certain projects or special applications other values than from R10 series could be chosen by agreement between manufacturer and user.

5.103 Rated commutation voltage (U_c)

The rated commutation voltage is the highest voltage which the transfer switch shall be capable of withstanding after commutating the current into the oscillating branch or after extinguishing the arc inside of the commutation switch.

NOTE 1 The rated commutation voltage of a transfer switch will be defined by its energy dissipation branch.

NOTE 2 Specific ratings can generally not be assigned because they are specific parameters to each project. The commutation voltage for each transfer switch in a specific project will be defined by system studies.

As an estimation the rated commutation voltage could be calculated from the rated voltage of transfer switch (U_{rts}) multiplied with a factor of 1,2.

NOTE 3 The rated commutation voltage is the determining factor for successful current commutation. Lower or higher factors than 1,2 between U_c and the U_{rts} at location of installation could arise for specific applications. In existing projects, this factor is mostly between 0,6 and 2,5. Further information can be found in Clause 9.

5.104 Rated dissipated energy during transfer operation (E_{rd})

The rated dissipated energy during transfer operation is the highest amount of energy which the energy dissipation device inside the DC transfer switch can manage in a single operating sequence without sustained deterioration. The value will be stated by the manufacturer of DC transfer switch according to the requirements at location of installation, usually based on system studies.

NOTE 1 The rated dissipated energy during transfer operation of a DC transfer switch normally regards to the energy dissipation device or the current limitation branch.

NOTE 2 The rated dissipated energy during transfer operation should be higher than the maximum energy which the transmission system could supply during current transfer operation at location of installation of DC transfer switch.

NOTE 3 Depending on the margin between the rated dissipated energy during transfer operation and the maximum energy which the transmission system could supply during current transfer operation at location of installation of DC transfer switch, specific cooling time between two transfer operations has to be considered. Further information should be supplied by the manufacturer.

5.105 Rated operating sequence

The rated operating sequence of direct current transfer switches are as follows:

a) O – t – C: for ERTS, MRTS and NBES

b) C – 0,1 s – O – t – C: for NBS

NOTE 1 sequence b) gives a typical operating sequence when NBS is used to connect converter neutral to an already energized current return path in a bipolar or DC grid system.

NOTE 2 The final closing operation in each operation sequence is to protect the commutation switch itself in case of unsuccessful transfer operation.

with:

t is more than the rated open-close time and less than T_{aw} (see 6.102.7).

where

– O represents an opening operation;

– C represents a closing operation.

5.106 Rated open-close time

This value shall be provided by manufacturer.

NOTE All ratings except subclause 5.104 are applicable for commutation switches also.

6 Design and construction

6.1 Requirements for liquids in switchgear and controlgear

Subclause 6.1 of IEC TS 62271-5:2024 is applicable.

6.2 Requirements for gases in switchgear and controlgear

Subclause 6.2 of IEC TS 62271-5:2024 is applicable.

6.3 Earthing of switchgear and controlgear

Subclause 6.3 of IEC TS 62271-5:2024 is applicable.

6.4 Auxiliary and control equipment and circuits

Subclause 6.4 of IEC TS 62271-5:2024 is applicable with the following additions:

– where shunt opening and closing releases are used, appropriate measures shall be taken in order to avoid damage on the releases when permanent orders for closing or opening are applied. For example, those measures can be the use of series control contacts arranged so that when the transfer switch is closed, the close release control contact ("b" contact or break contact) is open and the open release control contact ("a" contact or make contact) is closed, and when the transfer switch is open, the open release control contact is open and the close release control contact is closed;

– where auxiliary switches are used as position indicators, they shall indicate the end position of the transfer switch at rest, open or closed. The signal shall be sustained;

– connections shall withstand the stresses imposed by the transfer switch, especially those due to mechanical forces during operations;

– where special items of control equipment are used, they shall operate within the limits specified for supply voltages of auxiliary and control circuits, making and commutating and/or insulating and operating media, and be able to switch the loads which are stated by the transfer switch manufacturer;

– special items of auxiliary equipment such as liquid indicators, pressure indicators, relief valves, filling and draining equipment, heating and interlock contacts shall operate within the limits specified for supply voltages of auxiliary and control circuits and/or within the limits of use of making and commutating and/or insulating and operating media;

– where anti-pumping devices are part of the transfer switch control scheme, they shall act on each control circuit, if more than one is installed.

6.5 Dependent power operation

Subclause 6.5 of IEC TS 62271-5:2024 is applicable with the following addition:

A transfer switch arranged for dependent power operating with external energy supply shall also be capable of closing immediately following the opening according to its rated operating sequence.

6.6 Stored energy operation

Subclause 6.6. of IEC TS 62271-5:2024 is applicable with the following addition:

A transfer switch arranged for stored energy operating shall also be capable of closing immediately following the opening according to its rated operating sequence.

6.7 Independent unlatched operation (independent manual or power operation)

Subclause 6.7 of IEC TS 62271-5:2024 is applicable.

6.8 Manually operated actuators

Subclause 6.8 of IEC TS 62271-5:2024 is not applicable.

6.9 Operation of releases

Subclause 6.9 of IEC TS 62271-5:2024 is applicable.

6.10 Pressure/level indication

Subclause 6.10 of IEC TS 62271-5:2024 is applicable.

6.11 Nameplates

Subclause 6.11 of IEC TS 62271-5:2024 is applicable with the following additions:

The nameplates for all assemblies of the DC transfer switch should be in accordance with their relevant standards. The nameplate of the DC transfer switch, commutation switch and making switch shall be provided at least as the following (see Table 2):

Table 2 – Nameplate information

Item		Symbol	Unit	(**)			Condition: Marking only required if
				Transfer switch	Commutation switch	Making switch	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1	Name of manufacturer			X	X	X	
2	Type designation and serial number			X	X	X	
3	Rated direct voltage of transfer switch	U_{rts}	kV	X	X	X	
4	Rated direct withstand voltage	U_{dd}	kV	X	X	X	
5	Rated lightning impulse withstand voltage	U_p	kV	X	X	X	
6	Rated continuous current	I_{rd}	A	X	X		
7	Rated short-time withstand direct current	I_{kd}	kA	X	X		
8	Rated peak withstand current	I_{pd}	kA	X	X		
9	Rated duration of short-circuit	t_{kd}	s	X	X		
10	Rated transfer current	I_t	A	X			
11	Rated commutation voltage	U_c	kV	X	X		
12	Rated dissipated energy during transfer operation	E_{rd}	MJ	X			
13	Filling pressure for insulation(*)	p_e	MPa	X	X	X	
14	Filling pressure for operation(*)	p_m	MPa	X	X	X	
15	Rated supply voltage(s) of auxiliary and control circuits. Specify DC / AC (with rated frequency)	U_a	V	X	X	X	
16	Rated operating sequence			X	X	X	
17	Rated open-close time		ms	X	X		
18	Closing time		ms	X	X	X	
19	Type and mass of fluid (liquid or gas) for insulation	M_f	kg	X	X	X	
20	Mass of switchgear and controlgear (including any fluid)	M	kg	Y	Y	Y	more than 300 kg
21	Year of manufacture			X	X	X	
22	Minimum and maximum ambient air temperature		°C	Y	Y	Y	If different from –5 °C and/or 40 °C

(*) Absolute pressure (abs.) or relative pressure (rel.) to be stated on the nameplate

(**) X = the marking of these values is mandatory, where applicable.

Y = conditions for marking of these values are given in column (8).

NOTE 1 The symbol in column (3) can be used instead of the terms in column (2) to be stated on the nameplate.

NOTE 2 When terms in column (2) are used, the word “rated” can be omitted appear.

6.12 Locking devices

Subclause 6.12 of IEC TS 62271-5:2024 is applicable.

6.13 Position indication

Subclause 6.13 of IEC TS 62271-5:2024 is applicable.

6.14 Degrees of protection by enclosures

Subclause 6.14 of IEC TS 62271-5:2024 is applicable.

6.15 Creepage distances for outdoor insulators

Subclause 6.15 of IEC TS 62271-5:2024 is applicable.

6.16 Gas and vacuum tightness

Subclause 6.16 of IEC TS 62271-5:2024 is applicable.

6.17 Tightness for liquid system

Subclause 6.17 of IEC TS 62271-5:2024 is applicable.

6.18 Fire hazard (flammability)

Subclause 6.18 of IEC TS 62271-5:2024 is applicable.

6.19 Electromagnetic compatibility (EMC)

Subclause 6.19 of IEC TS 62271-5:2024 is applicable.

6.20 X-ray emission

Subclause 6.20 of IEC TS 62271-5:2024 is applicable.

6.21 Corrosion

Subclause 6.21 of IEC TS 62271-5:2024 is applicable.

6.22 Filling levels for insulation, switching and operation

Subclause 6.22 of IEC TS 62271-5:2024 is applicable.

6.101 Seismic requirement for operation

DC transfer switch shall be able to withstand the specified seismic stress and meet the requirements in IEC 62271-207.

6.102 Commutation switch

Subclauses 6.1 to 6.101 of this specification are applicable with the following additions:

6.102.1 General requirement for operation

A commutation switch, including its operating devices, shall be capable of completing its rated operating sequence 5.105 in accordance with the relevant provisions of 6.5 to 6.10 and 6.102.2 for the whole range of ambient temperatures within its minimum and maximum air temperature as defined in Clause 4 of IEC TS 62271-5:2024.

Commutation switches provided with heaters shall be designed to permit an opening operation at the minimum ambient air temperature when the heaters are not operational for a minimum time of 2 h.

6.102.2 Pressure limits of fluids for operation.

The manufacturer shall state the maximum and minimum pressures of the fluid for operation at which the commutation switch is capable of performing according to its ratings and at which the appropriate low- and high-pressure interlocking devices shall be set (see 6.10).

The manufacturer can specify pressure limits at which the commutation switch is capable of each of the following performances:

– a “C” operation;
– an “OC” operating cycle;

The commutation switch shall be provided with energy storage of sufficient capacity for satisfactory performance of the appropriate operations at the corresponding minimum pressures stated.

6.102.3 Vent outlets

Vent outlets of commutation switches shall be so situated that a discharge of oil or gas or both will not cause electrical breakdown and is directed away from any location where persons can be present. The necessary safety distance shall be stated by the manufacturer.

The construction shall be such that gas cannot collect at any point where ignition can be caused, during or after operation, by sparks arising from normal operation of the commutation switch or its auxiliary equipment.

6.102.4 Time quantities

Subclause 6.105 of IEC 62271-100:2021 is applicable with the following modifications:

Values may be assigned to the following time quantities:

– opening time;
– closing time;
– open-close time.

Time quantities are based on

– rated supply voltages of closing and opening devices and of auxiliary and control circuits (see 5.6);
– rated supply frequency of closing and opening devices and of auxiliary circuits (see 5.7);
– filling pressure for controlled pressure systems (see 5.8);
– filling levels for insulation and/or operation (see 6.22);
– an ambient air temperature of 20°C±5°C.

6.102.5 Static mechanical loads

6.102.5.1 General

Commutation switches shall be designed to withstand static forces such as those from connected conductors, wind, etc. and dynamic forces (for example caused by short-current and operation of the commutation switch).

These forces can occur simultaneously.

6.102.5.2 Static mechanical loads

This capability is demonstrated by calculation.

When calculating the stresses resulting from ice and wind, the ice coating and wind pressure shall be in accordance with 4.1.3 of IEC TS 62271-5:2024.

Commutation switches may be equipped with suitable terminal. The capability of its mechanical load should be not less than:

– horizontal longitudinal: 2 000 N;
– horizontal transversal: 1 500 N;
– vertical: 1 500 N.

6.102.5.3 Dynamic loads

This capability is demonstrated by calculation.

NOTE A calculation method of the effects of short-circuit current on rigid and flexible conductors is given in IEC 60865-1:2011

6.102.6 Classification

The classification of DC transfer switch normally regards to the commutation switch.

The commutation switch (and the making switch, if applicable) can be classified according to the performance of mechanical endurance as Table 3.

Table 3 – Classification of commutation switches and making switches

Class	Number of operating cycles	Mechanical endurance
M0	1 000	Normal
M1	2 000	Extended

6.102.7 Arcing withstand capability

In the case of DC transfer switches with oscillation branches, the commutation switch shall withstand arc of transfer current for time (T_{aw}) without causing obvious damage (for example, explosion of porcelain insulator).

Here:

$$T_{aw} \geq T_b + T_2 + T_c$$

T_b is contact separating time, which is the time interval from the instant that arc contact separates to the instant that moving contact reaches its final open position;

T_2 is the time delay of control and protection system during which it determines commutation succeed or not, if not, send a signal to commutation switch to close. It depends on the judgment strategy. In the case of a CT is installed inside of the DC transfer switch, direct in series with the commutation switch, 20 ms is preferred. In the case of the commutation switch branch without a CT, T_2 can be up to 40 ms and shall be discussed between manufacture and user;

T_c is closing time.

NOTE After a reclosing operation with arcing (in case of failed commutation operation), the current commutation capability can be impaired due to the internal pollution. In such cases, early maintenance becomes necessary. This issue can be agreed between manufacture and user.

6.103 Insulated platform

The insulated platform shall be able to support all the devices installed on it and without mechanical damage under specified conditions.

The insulated platform also should fulfil the dielectric requirement.

Each metallic support of insulated platform shall have a point through where it can be earthed reliably.

6.104 Commutation capacitor

The capacitor used in oscillating branch shall meet the requirements of IEC 60871-1, and it shall withstand the rated commutation voltage (U_c).

6.105 Energy dissipation device

The energy dissipation device used in the energy absorption branch shall meet the requirements of IEC 60099-9. Some measures shall be taken to ensure that the current sharing between parallel columns of energy dissipation device within manufacture's specification.

6.106 Reactor

The reactor used in the oscillating branch shall meet the requirements in IEC 60076-6.

6.107 Making switch (if applicable)

Subclause 6.102 is applicable except 6.102.7.

6.108 Charging device (if applicable)

To ensure successful current transfer operation, the charging device has to keep the commutation capacitor always charged excepted the short period of re-charging time after a transfer operation.

The re-charging time shall be as short as possible, should be agreed by manufacturer and user and has to be mentioned in the relevant documents.

NOTE If there is no requirement to perform two transfer operations within a few min, this re-charging time could be considered as neglectable.

7 Type tests

7.1 General

7.1.1 Basics

Subclause 7.1.1 of IEC TS 62271-5:2024 is applicable with the following additions:

Type tests shall be performed on a complete assembled DC transfer switch, except when it is otherwise noted in the relevant subclause.

For test situations which are aligned to one specific component of the DC transfer switch, or the test result is only affected by this component, the specified test may be performed only on this component.

NOTE 1 For example, the mechanical test can be performed on a commutation switch only.

If specific product standards are available for components of DC transfer switches, like reactors, capacitors, energy dissipation devices and so on, these components shall be tested according to their relevant product standards as far as applicable.

In this specific application of DC transfer switches, not all requirements specified in IEC 60871-1 for capacitors, IEC 60076-6 for reactors and IEC 60099-9 for arrester apply.

NOTE 2 For example, there is no continuous current in the oscillating branch, thus the temperature rise test on reactor and thermal stability test for capacitors are not necessary.

Generally, tests on components of DC transfer switches should be carried out in accordance with their relevant product standards unless a specified test specification or condition is defined in this specification. For such cases, the condition given in this specification should be considered.

Each component of DC transfer switches, like reactors, capacitors, energy dissipation devices and so on, shall pass the tests specified in Annex A.

The type tests for transfer switches are listed in Table 4 and can be performed on a new or refurbished transfer switch.

Table 4 – Type tests

Type test	Condition	Subclauses
Dielectric tests	[a]	7.2
Resistance measurement	[a]	7.3
Continuous current test	[a]	7.4
Short-time withstand current and peak withstand current tests	[a]	7.5
Additional tests on auxiliary and control circuits	[a]	7.9
Mechanical operation test at ambient temperature (class M0)	[a]	7.101.2
Direct current commutation test	[a]	7.103
Direct arc withstand tests	[a]	7.104
Verification of the protection	Assigned IP and IK class [b]	7.6
Tightness test	Controlled, sealed or closed pressure systems [b]	7.7
EMC tests	Electronic equipment or components are included in the secondary system [b]	7.8
X-ray radiation test	Vacuum interrupters [b]	7.10
Extended mechanical operation test at ambient temperature	Class M1 specified [b]	7.101.2
Low and high temperature tests	If ambient air temperature is different from −5 ^{0}C and/or +40 ^{0}C [b]	7.101.3
Humidity test	Insulation subject to voltage stress and condensation [b]	7.101.4
Test to prove operation under severe ice conditions	Outdoor transfer switches ‘(or all mechanical switching devices) with moving external parts [b]	7.101.5
Seismic tests	[b]	7.102

[a] Mandatory type tests required for all transfer switches regardless of rated voltage, design or intended use.

[b] Other type tests, shown in the lower part of the table, are required for all transfer switches where the associated rating or requirement is specified, for example X-ray radiation test is required only for vacuum interrupters.

If a pole of a type tested AC circuit-breaker is used as commutation switch, the existing test documentation could be used as far as applicable.

Tolerances on test quantities are given in Annex C and Table C.1.

Information regarding the extension of validity of type tests is given in Annex E.

The responsibility of the manufacturer is limited to the declared values and not to those values achieved during the type tests.

7.1.2 Information for identification of test objects

Subclause 7.1.2 of IEC TS 62271-5:2024 is applicable.

7.1.3 Information to be included in type-test reports

Subclause 7.1.3 of IEC TS 62271-5:2024 is applicable with the following addition:

Further details relating to records and reports of type tests are given in Annex D.

7.2 Dielectric tests

7.2.1 General

Subclause 7.2.1 of IEC TS 62271-5:2024 is applicable with the following addition:

Test on a complete DC transfer switch can be omitted if any component of the DC transfer switch was tested in accordance with Annex A and the air clearance between the components and between each component to earth comply with the requirements of Annex B of IEC 60071-11:2022.

7.2.2 Ambient air conditions during tests

Subclause 7.2.2 of IEC TS 62271-5:2024 is applicable.

7.2.3 Wet test procedure

Subclause 7.2.3 of IEC TS 62271-5:2024 is applicable.

7.2.4 Arrangement of the equipment

Subclause 7.2.4 of IEC TS 62271-5:2024 is applicable.

7.2.5 Criteria to pass the test

Subclause 7.2.5 of IEC TS 62271-5:2024 is applicable.

7.2.6 Application of the test voltage and test conditions

Subclause 7.2.6 of IEC TS 62271-5:2024 is applicable with the following addition:

– Only the general case, sub-clause 7.2.6.2 of IEC TS 62271-5:2024, is applicable for DC transfer switches
– Subclause 7.2.6.3 of IEC TS 62271-5:2024 is not applicable.

7.2.7 Tests of switchgear and controlgear

7.2.7.1 General

Subclause 7.2.7.1 of IEC TS 62271-5:2024 is not applicable.

The tests shall be performed with the test voltage equal to the rated withstand voltages selected from Table 1.

7.2.7.2 Direct voltage tests

Subclause 7.2.7.2 of IEC TS 62271-5:2024 is applicable with the following addition:

For DC transfer switches comprising a non-switchable oscillating branch (commutation switches using a non-switchable oscillating branch in parallel) direct withstand voltage test will be performed with the transfer switch in the closed position, with voltage applied between the switch terminals and earth only.

NOTE If an oscillating branch is fixed connected in parallel to the commutation switch, the complete DC transfer switch has to be disconnected from neutral system after commutation switch is opened. Otherwise, the energy dissipation device could be overloaded by repeatedly discharging the capacitor inside the oscillating branch, which will be charged by the neutral system.

To demonstrate the direct voltage withstand capability across such transfer switches, the direct voltage test across open transfer switch can be limited in time (e.g. to 1 min) by agreement between manufacturer and user.

To demonstrate the direct voltage withstand capability across the commutation switch of such transfer switches, the direct voltage test across open transfer switch can be performed on the commutation switch only (similar to test on a blank DC transfer switch) by agreement between manufacturer and user.

7.2.7.3 Switching impulse voltage tests

Subclause 7.2.7.3 of IEC TS 62271-5:2024 is not applicable.

7.2.7.4 Lightning impulse voltage tests

Subclause 7.2.7.4 of IEC TS 62271-5:2024 is applicable with the following addition:

For DC transfer switches comprising a non-switchable oscillating branch (commutation switches using a non-switchable oscillating branch in parallel) lightning impulse voltage tests will be performed with the transfer switch in the closed position, with voltage applied between the switch terminals and earth only.

During lightning impulse voltage test across DC transfer switch, the test voltage will usually be limited by the internal energy dissipation device Therefore, lightning impulse voltage test across DC transfer switch with reduced test voltage could be performed by agreement between manufacturer and user.

To demonstrate the full lightning impulse voltage withstand capability across DC transfer switch, the lightning impulse voltage test across open transfer switch can be performed with disconnected energy dissipation device by agreement between manufacturer and user.

To demonstrate the lightning impulse voltage withstand capability across the commutation switch of such transfer switches, the lightning impulse voltage test across open transfer switch can be performed on the commutation switch only (similar to test on a DC blank transfer switch) by agreement between manufacturer and user.

7.2.7.5 Superimposed impulse voltage tests

Subclause 7.2.7.5 of IEC TS 62271-5:2024 is not applicable.

7.2.7.6 Polarity reversal tests

Subclause 7.2.7.6 of IEC TS 62271-5:2024 is applicable.

7.2.8 Artificial pollution tests for outdoor insulators

Subclause 7.2.8 of IEC TS 62271-5:2024 is applicable.

7.2.9 Partial discharge tests

Subclause 7.2.9 of IEC TS 62271-5:2024 is applicable with the following addition:

Partial discharge tests are normally not required on transfer switches. However, in the case of a transfer switch using components for which a relevant IEC standard exists, including partial discharge measurements (for example, bushings, see IEC/IEEE 65700-19-03:2014 [3]), evidence shall be produced by the manufacturer showing that those components have passed the partial discharge tests as laid down in the relevant IEC standard.

7.2.10 Dielectric tests on auxiliary and control circuits

Subclause 7.2.10 of IEC TS 62271-5:2024 is applicable.

7.2.11 Voltage test as condition check

Subclause 7.2.11 of IEC TS 62271-5:2024 is applicable with the following addition:

Any component of a DC transfer switch shall be tested in accordance with its relevant product standard. As an alternative, for the commutation switch and making switch (if any), a direct voltage test in dry conditions according to subclause 7.2.7.2 can be applied.

7.3 Resistance measurement

7.3.1 Measurement of the resistance of auxiliary contacts class 1 and class 2

Subclause 7.3.1 of IEC TS 62271-5:2024 is applicable.

7.3.2 Measurement of the resistance of auxiliary contacts class 3

Subclause 7.3.2 of IEC TS 62271-5:2024 is applicable.

7.3.3 Electrical continuity of earthed metallic parts test

Subclause 7.3.3 of IEC TS 62271-5:2024 is applicable.

7.3.4 Resistance measurement of contacts and connections in the main circuit as a condition check

Subclause 7.3.4 of IEC TS 62271-5:2024 is applicable with the following addition:

7.3.4.1 Resistance measurement test procedure

Subclause 7.3.4.1 of IEC TS 62271-5:2024 is applicable with the following addition:

This test is only applicable for the commutation switch and any accessory that is connected between both terminals of transfer switch and direct in series with the commutation switch.

7.4 Continuous current tests

Subclause 7.4 of IEC TS 62271-5:2024 is applicable with the following addition:

7.4.1 Condition of the test object

Subclause 7.4.1 of IEC TS 62271-5:2024 is applicable with the following addition:

This test is only applicable for the commutation switch and any accessory that is connected between both terminals of transfer switch, including these terminals and its supports, and direct in series with the commutation switch.

NOTE Accessory means any component connected between the terminals of the commutation switch and the outer terminals of the transfer switch, e.g.: shielding, clamps, wires…

7.4.3.1 Test on main circuit

Subclause 7.4.3.1 of IEC TS 62271-5:2024 is applicable with the following addition:

For convenience of testing, alternating current may be used alternatively without any correction.

A test with alternating current of arbitrarily frequency without any correction is more severe than a test with direct current and should only apply upon approval of manufacturer.

7.5 Short-time withstand current and peak withstand current tests

7.5.1 General

Subclause 7.5.1 of IEC TS 62271-5:2024 is applicable with the following addition:

This test is only applicable for the commutation switch and any accessory which is connected between both terminals of transfer switch, including these terminals and its supports, and direct in series with the commutation switch.

NOTE Accessory means any component connected between the terminals of the commutation switch and the outer terminals of the transfer switch, for example: shielding, clamps, wires.

7.5.2 Arrangement of the equipment and of the test circuit

Subclause 7.5.2 of IEC TS 62271-5:2024 is applicable with the following addition:

The use of insulating fluid is not mandatory for short-time withstand current and peak withstand current tests. Air or N_2 may be used as an alternative to gases with high global warming potential. There is also no requirement of minimum pressure for insulating fluid.

7.5.3 Test current and duration

Subclause 7.5.3 of IEC TS 62271-5:2024 is applicable.

7.5.4 Conditions of the test object after test

Subclause 7.5.4 of IEC TS 62271-5:2024 is applicable.

7.6 Verification of the protection

Subclause 7.6 of IEC TS 62271-5:2024 is applicable.

7.7 Tightness tests

Subclause 7.7 of IEC TS 62271-5:2024 is applicable.

7.8 Electromagnetic compatibility tests (EMC)

Subclause 7.8 of IEC TS 62271-5:2024 is applicable with following modification:

Subclause 7.8.1.1 is not applicable.

7.9 Additional tests on auxiliary and control circuits

Subclause 7.9 of IEC TS 62271-5:2024 is applicable.

7.10 X-radiation test for vacuum interrupters

Subclause 7.10 of IEC TS 62271-5:2024 is applicable.

7.101 Mechanical and environmental tests

7.101.1 Miscellaneous provisions for mechanical and environmental tests

7.101.1.1 Mechanical characteristics

The mechanical characteristic shall be only established for the commutation switch and all other mechanical switching devices inside the DC transfer switch.

At the beginning of the type tests, the mechanical characteristics of the DC transfer switch shall be established individually on all mechanical switching devices. IEC TR 62271-306 [1] gives examples on how to measure the mechanical characteristics. The mechanical characteristics will serve as the reference for the purpose of characterizing the mechanical behaviour of the DC transfer switch. Furthermore, the mechanical characteristics shall be used to confirm that the different test samples used during the mechanical and commutation type tests behave mechanically in a similar way. The reference mechanical characteristics are also used to confirm that production units behave mechanically in a similar way compared to the test samples used during type tests.

Following are examples of operating characteristics that can be recorded:

– no-load travel curves;
– closing and opening times.

The mechanical characteristics shall be produced during a no-load test made with a single O operation and a single C operation at rated supply voltage of operating devices and of auxiliary and control circuits, filling pressure for operation and, for convenience of testing, at the minimum functional pressure for insulation.

7.101.1.2 Component tests

When testing of a complete mechanical switching device is not practicable, component tests may be accepted as type tests as far as applicable. The manufacturer should determine the components which are suitable for testing.

Components are separate functional sub-assemblies which can be operated independently of the complete mechanical switching device (example given: part of a pole, switching unit, operating mechanism).

When component tests are made, the manufacturer shall prove that the mechanical and environmental stresses on the component during the tests are not less than those applied to the same component when the complete mechanical switching device is tested. Component tests shall cover all different types of components of the complete mechanical switching device, provided that the particular test is applicable to the component. The conditions for the component type tests shall be the same as those which could be employed for the complete mechanical switching devices.

Parts of auxiliary and control equipment which have been manufactured in accordance with relevant standards shall comply with these standards. The proper function of such parts in connection with the function of the other parts of the commutation switch shall be verified.

7.101.1.3 Characteristics and settings of the mechanical switching device to be recorded before and after the tests

Before and after the tests, the following operating characteristics or settings shall be recorded and evaluated:

a) closing time;
b) opening time;
c) time spread between units of one pole;
d) recharging time and consumption of the operating device;
e) consumption of the control circuit, if applicable;
f) consumption of the auxiliary circuit;
g) duration of opening and closing command;
h) tightness, if applicable;
i) gas densities or pressures, if applicable;
j) resistance of the main circuit;
k) mechanical travel, if applicable;
l) other important characteristics or settings as specified by the manufacturer.

The above operating characteristics shall be recorded at

– rated supply voltage and filling pressure for operation;
– maximum supply voltage and filling pressure for operation;
– maximum supply voltage and minimum functional pressure for operation;
– minimum supply voltage and minimum functional pressure for operation;
– minimum supply voltage and filling pressure for operation.

7.101.1.4 Condition of the mechanical switching device during and after the tests

During and after the tests, the mechanical switching device shall be in such a condition that it is capable of operating normally, carrying its rated continuous current and withstanding the voltage values according to its rated insulation level.

In general, these requirements are fulfilled if

– during the tests, the mechanical switching device operates on command and does not operate without command;
– after the tests, the characteristics measured according to 7.101.1.3 are within the tolerances given by the manufacturer;
– after the tests, coated contacts are such that a layer of coating material remains at the contact area. If this is not the case, the contacts shall be regarded as bare and the test requirements are fulfilled only if the temperature rise of the contacts during the continuous current (according to 7.4) does not exceed the value permitted for bare contacts;
– during and after the tests, it shall be possible to fit any defined replacement part according to the manufacturer's instructions;
– after the tests the insulating properties of the mechanical switching device in the open position shall be in essentially the same condition as before the tests. Visual inspection of the mechanical switching device after the tests is usually sufficient for verification of the insulating properties. In the case of mechanical switching device with sealed-for-life

interrupters, a voltage test as a condition check in accordance with 7.2.11 replaces this visual inspection;

– for sealed-for-life interrupters, the increase of the resistance of the main circuit shall be less than or equal to 20 %. If the increase in resistance exceeds 20 % then a continuous current test according to 7.4 is applicable to determine if the test object can carry its rated continuous current without exceeding the temperature limits given in Table 10 of IEC TS 62271-5:2024 by more than 10 K;
– for other types of mechanical switching devices, the resistance condition check of the test object is satisfactory if the resistance determined in 7.3.4 is not greater than 20 % and that the visual inspection of the contact system does confirm that the contact system complies with the requirements stated above in this subclause. If the resistance increase exceeds 20 % then also a visual inspection shall be performed to see if the contact system is complying the requirements stated above in this subclause.

7.101.1.5 Condition of the auxiliary and control equipment during and after the tests

During and after the tests, the following conditions for the auxiliary and control equipment shall be fulfilled:

– during the tests, care should be taken to prevent undue heating;
– during the tests, a set of contacts (both make and break auxiliary contacts) shall be arranged to switch the current of the circuits to be controlled (see 6.4);
– during and after the tests, the auxiliary and control equipment shall fulfil its functions;
– during and after the tests, insulation capability of the auxiliary circuits, of the auxiliary switches and of the control equipment shall not be impaired. In case of doubt, the dielectric tests according to 7.9.5 of IEC TS 62271-5:2024 shall be performed;
– during and after the tests, the contact resistance of the auxiliary switches shall not be affected adversely.

7.101.2 Mechanical operation tests at ambient air temperature

7.101.2.1 General

The mechanical operation test shall be performed on the commutation switch and all other mechanical switching devices inside the DC transfer switch only at the ambient air temperature of the test location. The ambient air temperature shall be recorded in the test report. Auxiliary equipment forming part of the operating devices shall be included.

In cases where a making switch is used in series with the oscillation branch in parallel to the commutation switch the mechanical operation test shall be performed on the making switch also.

In accordance with 7.101.2.3 the mechanical operation test shall consist of:

– 1 000 operating cycles for DC transfer switches of endurance class M0;
– 2 000 operating cycles for DC transfer switches of endurance class M1.

Mechanical switching device design can be fitted with several variants of auxiliary equipment (shunt releases and motors) in order to accommodate the various rated control voltages and frequencies as stated in 5.6 and 5.7. These variants do not need to be tested if they are of similar designs and if the resulting no-load mechanical characteristics are within the tolerance given in Annex C.

7.101.2.2 Condition of the mechanical switching device before the test

The mechanical switching device for test shall be mounted on its own support and its operating mechanism shall be operated in the specified manner. It shall be tested according to its type as follows.

A multicolumn mechanical switching device actuated by a single operating device and/or with all columns mounted on a common frame shall be tested as a complete unit.

Tests shall be conducted at the filling pressure for insulation.

A multicolumn mechanical switching device in which each column is actuated by a separate operating device should be tested preferably as a complete multicolumn commutation switch. However, for convenience, or owing to limitations of the dimensions of the test bay, one single-column unit of the mechanical switching device may be tested, provided that it is equivalent to, or not in a more favourable condition than, the complete multicolumn mechanical switching device over the range of tests, for example in respect of

– reference mechanical travel characteristics;
– power and strength of closing and opening mechanism;
– rigidity of structure.

7.101.2.3 Operating sequence

The commutation switch shall be tested in accordance with Table 5 if it is intended to be used in DC transfer switches with mechanical endurance class M0.

For commutation switches intended to be used in DC transfer switches with mechanical endurance class M1 the numbers given in Table 5 shall be doubled.

In cases where a making switch is used in series with the oscillation branch in parallel to the commutation switch, this switch normally will operate single close and single open operation.

The making switch shall be tested in accordance with Table 6 if it is intended to be used in DC transfer switches with mechanical endurance class M0.

For making switches intended to be used in DC transfer switches with mechanical endurance class M1 the numbers given in Table 6 shall be doubled.

Table 5 – Number of operating sequences for commutation switches

Operating sequence	Supply voltage	Operating pressure	ERTS, MRTS, NBES	NBS
O – t_a – C – t_a	Minimum	Minimum functional	250	250
	Rated	Filling pressure	250	250
	Maximum	Filling pressure	250	250
O – t –C – t_a	Rated	Filling pressure	250	-
C – 0,1 s – O – t –C – t_a – O – t_a	Rated	Filling pressure	-	125
O = opening; C = closing; t is less than or equal to the rated open-close time (5.106); t_a = time between two operations which is necessary to restore the initial conditions and/or to prevent undue heating of parts of the commutation switch (this time can be different according to the type of operation).				
NOTE 1 The sequences and numbers given for NBS will also cover the requirements for commutation switches which are intended to operate in ERTS, MRTS or NBES as agreed by manufacturer and user. NOTE 2 Operating sequence shall be in line with application, see subclause 5.105.				

Table 6 – Number of operating sequences for making switches

Operating sequence	Supply voltage	Operating pressure	
O – t_a – C – t_a	Minimum	Minimum functional	250
	Rated	Filling pressure	500
	Maximum	Filling pressure	250
O = opening; C = closing; t_a = time between two operations which is necessary to restore the initial conditions and/or to prevent undue heating of parts of the making switch (this time can be different according to the type of operation).			

During the test, lubrication of parts outside of the main circuit is allowed in accordance with the manufacturer's instructions, but no mechanical adjustment or other kind of maintenance is allowed.

7.101.2.4 Acceptance criteria for the mechanical operation tests

a) Before and after the total test program, the following operations shall be performed:

- five open-close operating cycles at the rated supply voltage of closing and opening devices and of auxiliary and control circuits and/or the filling pressure for operation;
- five open-close operating cycles at the minimum supply voltage of closing and opening devices and of auxiliary and control circuits and/or the minimum functional pressure for operation;
- five open-close operating cycles at the maximum supply voltage of closing and opening devices and of auxiliary and control circuits and/or the filling pressure for operation.

During these operating cycles, the operating characteristics (see 7.101.1.3) shall be recorded. It is not necessary to publish all the oscillograms recorded. However, at least one oscillogram for each set of conditions given above shall be included in the test report.

In addition, the following checks and measurements shall be performed:

- measurements of characteristic operating fluid pressures and consumption during operations, if applicable;
- verification of the rated operating sequence;
- checks of certain specific operations, if applicable.

The variation between the mean values of each parameter measured before and after the mechanical operation tests shall be within the tolerances given by the manufacturer.

b) After the total test program, the condition of the mechanical switching devices shall be in accordance with 7.101.1.4.

The DC transfer switch is considered to pass the mechanical operation tests if the mechanical switching devices fulfil the criteria detailed above.

7.101.3 Low and high temperature tests

7.101.3.1 General requirements

The low and high temperature test should be performed on a fully assembled DC transfer switch as far as possible.

If a test on a fully assembled DC transfer switch is not possible for dimensional reasons in testing station, tests on single component of DC transfer switch should be performed as agreed between manufacturer and client.

Low and high temperature test shall be performed always on the commutation switch and all other mechanical switching devices inside the DC transfer switch.

In cases where a making switch is used in series with the oscillation branch in parallel to the commutation switch, the low and high temperature test shall also be performed on this switch. Other as described in the following test procedure below a making switch shall operate with single close or open operations only.

Other components like capacitors, reactors, resistors, or energy dissipation devices shall be tested in accordance with their relevant standards.

It is permitted to store this component in a climatic test cell during the low and high temperature test to demonstrate its performance as agreed by manufacturer and client.

In cases when the component is tested individually, the DC transfer switch is deemed having passed the test if all components pass these tests individually.

The two tests need not be performed in succession, and the order in which they are made is arbitrary. If the minimum ambient air temperature of indoor and outdoor DC transfer switches is higher than or equal to −5 °C, no low temperature test is required. If maximum ambient air temperature is not higher than +40 °C, no high temperature test is required.

If heat sources are required, they shall be in operation.

Liquid or gas supplies for transfer switch operation are to be at the test air temperature unless the transfer switch design requires a heat source for these supplies.

No maintenance, replacement of parts, lubrication or readjustment of the transfer switch is permissible during the tests.

The transfer switch has passed the test if the conditions stated in 7.101.1.4 and 7.101.1.5 are fulfilled. Furthermore, the conditions in 7.101.3.3 and 7.101.3.4 shall be fulfilled and the leakage rates recorded shall not exceed the limits given in Table 11 of IEC TS 62271-5:2024. In the test report the testing conditions and the condition of the transfer switch before, during and after the test shall be reported. The recorded quantities shall be presented. To reduce the number of oscillograms in the test report, a single representative oscillogram of every relevant type of operation under each specified testing condition shall be included.

A transfer switch design may be fitted with several variants of auxiliary equipment (shunt releases and motors) to accommodate the various rated control voltages and frequencies as stated in 5.6 and 5.7. These variants do not need to be tested if they are of similar designs and if the resulting no-load mechanical characteristics are within the tolerance given in 7.101.1.1.

The conditions during and after the tests are given in 7.101.1.4.

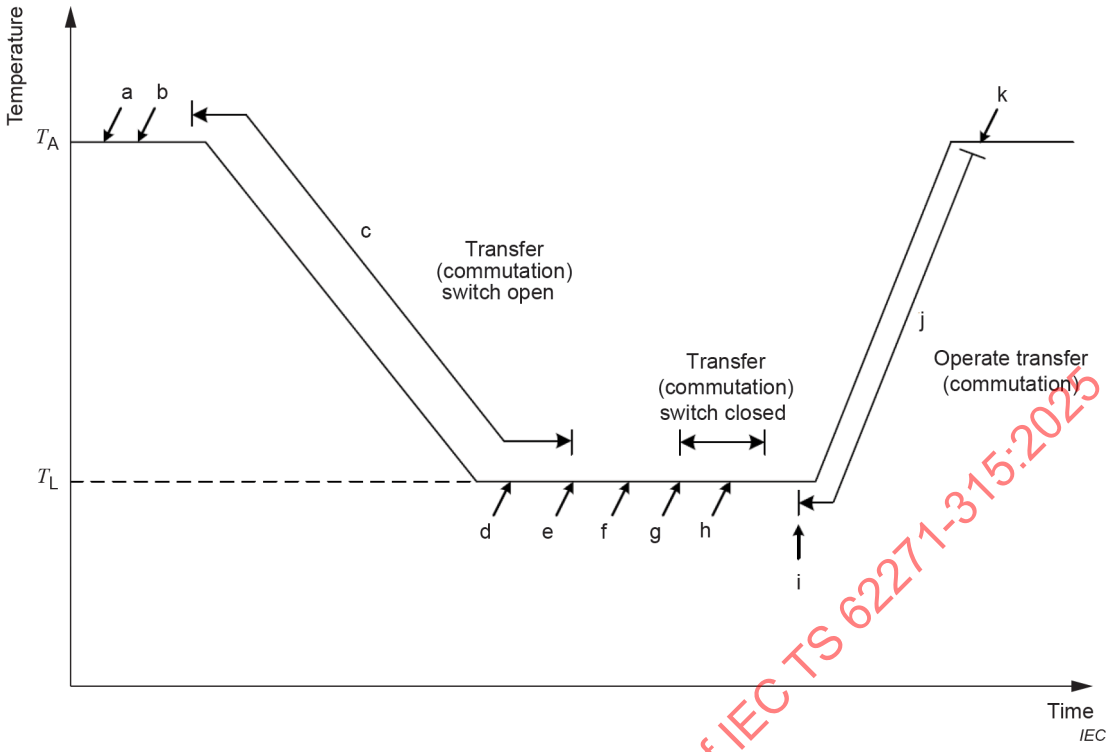
7.101.3.2 Measurement of ambient air temperature

The ambient air temperature of the immediate test environment shall be measured at half the height of the transfer switch and at a distance of 1 m from the transfer switch.

The maximum temperature deviation over the height of the transfer switch shall not exceed 5 K.

7.101.3.3 Low-temperature test

The diagram of the test sequences and identification of the application points for the tests specified are given in Figure 1.



NOTE Letters a through k identify application points of tests specified in 7.101.3.3.

Figure 1 – Test sequence for low temperature test

If the low temperature test is performed immediately after the high temperature test, the low temperature test can proceed after completion of item u) of the high temperature test. In this case items a) and b) are omitted.

a) The test transfer switch shall be prepared and adjusted in accordance with the manufacturer's instructions;

b) Characteristics and settings of the transfer switch shall be recorded in accordance with 7.101.1.3 and at an ambient air temperature of 20 °C ±5 °C (T_A). The tightness test (if applicable) shall be performed according to 7.7;

c) With the transfer switch in the open position, the air temperature shall be decreased to the appropriate, minimum ambient air temperature (T_L), according to the minimum ambient temperature specified as given in 4.1.2, 4.1.3 and 4.2.4 of IEC TS 62271-5:2024. The transfer switch shall be kept in the open position for 24 h after the ambient air temperature stabilizes at T_L;

d) During the 24 h period with the transfer switch in the open position at temperature T_L, a tightness test shall be performed (if applicable). An increased leakage rate is acceptable, provided that it returns to the original value when the transfer switch is restored to the ambient air temperature T_A and is thermally stable. The increased temporary leakage rate shall not exceed the permissible temporary leakage rate of Table 11 of IEC TS 62271-5:2024;

e) After 24 h at temperature T_L, the transfer switch shall be closed and opened at rated values of supply voltage and operating pressure. The mechanical characteristics shall be recorded and shall be within the manufacturer's specified tolerances;

f) The low temperature behaviour of the transfer switch and its alarms and lock-out systems shall be verified by disconnecting the supply of all heating devices, including also the anti-condensation heating elements, for a duration t_x. During this interval, occurrence of an alarm is acceptable but lock-out is not. At the end of the interval t_x, a closing order, at rated values of supply voltage and operating pressure, shall be given. The mechanical characteristics shall be recorded and shall within the manufacturer's specified tolerances.

The manufacturer shall state the value of t_x (not less than 2 h) up to which the transfer switch is still operable without auxiliary power to the heaters. In the absence of such a statement, the default value shall be equal to 2 h;

g) The transfer switch shall be left in the closed position for 24 h;

h) During the 24 h period with the transfer switch in the closed position at temperature T_L, a tightness test shall be performed (if applicable). An increased leakage rate is acceptable, provided that it returns to the original value when the transfer switch is restored to the ambient air temperature T_A and is thermally stable. The increased temporary leakage rate shall not exceed the permissible temporary leakage rate of Table 11 of IEC TS 62271-5:2024;

i) At the end of the 24 h period, 50 opening and 50 closing operations shall be made at rated values of supply voltage and operating pressure with the transfer switch at temperature T_L. At least a 3 min interval shall be allowed for each cycle or sequence. The first opening and closing operation shall be recorded. The mechanical characteristics shall be recorded and shall be within the manufacturer's specified tolerances. Following the first opening operation (O) and the first closing operation (C) three OC operating cycles shall be performed. The additional operations shall be made by performing O – t_a – C –t_a operating sequences (t_a is defined in Table 5);

j) After completing the 50 opening and 50 closing operations, the air temperature shall be increased to ambient air temperature T_A at a rate of change of approximately 10 K per hour;

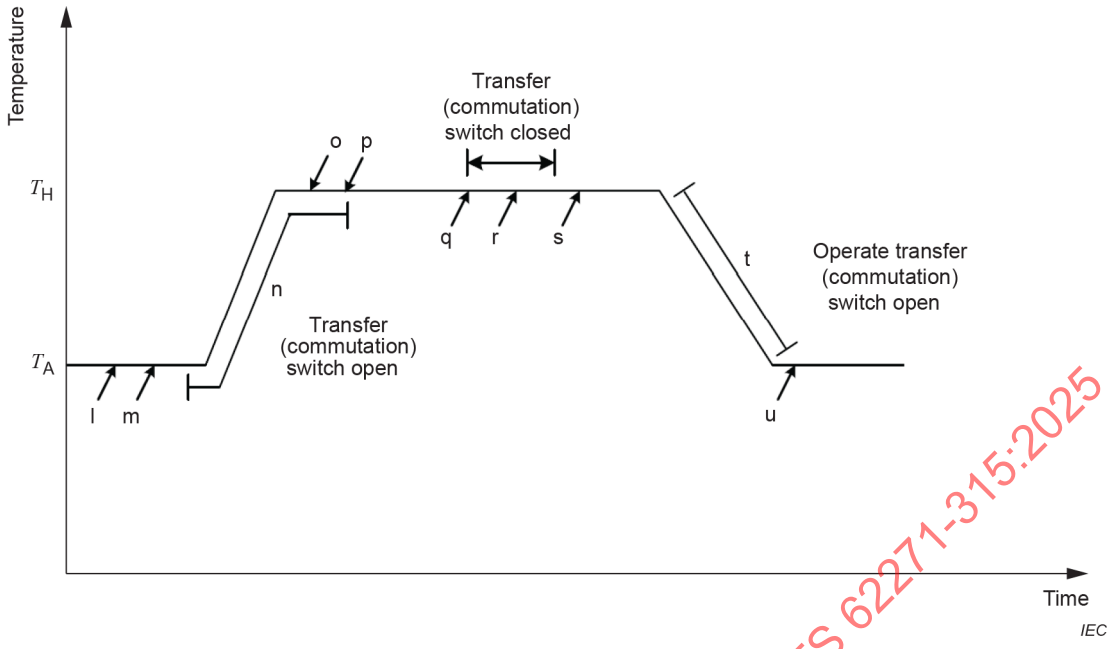
During the temperature transition period the transfer switch shall be subjected to alternate O – t_a – C –t_a – O and C – t_a – O – t_a – C operating sequences at rated values of supply voltage and operating pressure. The alternate operating sequences should be made at 30 min intervals so that the transfer switch will be in closed and open positions for 30 min periods between the operating sequences;

k) After the transfer switch has stabilized thermally at ambient air temperature T_A, a recheck shall be made of the transfer switch settings. The mechanical characteristics shall be recorded and shall be within the manufacturer's specified tolerances. The tightness test shall be repeated as in Item b) and the leakage rate shall remain the limits stated in 7.7.

The accumulated leakage during the complete low temperature test sequence from item b) to item j) shall not be such that lock-out pressure is reached (reaching alarm pressure is allowed).

7.101.3.4 High-temperature test

The diagram of the test sequence and identification of the application points for the tests specified are given in Figure 2.



NOTE Letters l through u identify application points of tests specified in 7.101.3.4.

Figure 2 – Test sequence for high temperature test

If the high temperature test is performed immediately after the low temperature test, the high temperature test can proceed after completion of item j) of the low temperature test. In this case, items l) and m) below are omitted.

a) The test transfer switch shall be prepared and adjusted in accordance with the manufacturer's instructions;

b) Characteristics and settings of the transfer switch shall be recorded in accordance with 7.101.1.3 and at an ambient air temperature of 20 °C ± 5 °C (T_A). The tightness test (if applicable) shall be performed according to 7.7;

c) With the transfer switch in the open position, the air temperature shall be increased to the appropriate, maximum ambient air temperature (T_H), according to the upper limit of ambient air temperature as given in 4.1.2, 4.1.3 and 4.2.4 of IEC TS 62271-5:2024. The transfer switch shall be kept in the open position for 24 h after the ambient air temperature stabilizes at T_H;

d) During the 24 h period with the transfer switch in the open position at the temperature T_H, a tightness test shall be performed (if applicable). An increased leakage rate is acceptable, provided that it returns to the original value when the transfer switch is restored to the ambient air temperature T_A and is thermally stable. The increased temporary leakage rate shall not exceed the permissible temporary leakage rate of Table 11 of IEC TS 62271-5:2024;

e) After 24 h at the temperature T_H, the transfer switch shall be closed and opened at rated values of supply voltage and operating pressure. The mechanical characteristics shall be recorded and shall be within the manufacturer's specified tolerances;

f) The transfer switch shall be closed and left closed for 24 h at the temperature T_H;

g) During the 24 h period with the transfer switch in the closed position at the temperature T_H, a tightness test shall be performed (if applicable). An increased leakage rate is acceptable, provided that it returns to the original value when the transfer switch is restored to the ambient air temperature T_A and is thermally stable. The increased temporary leakage rate shall not exceed the permissible temporary leakage rate of Table 11 of IEC TS 62271-5:2024;

h) At the end of the 24 h period, 50 opening and 50 closing operations shall be made at rated values of supply voltage and operating pressure with the transfer switch at the temperature T_H. An interval of at least 3 min shall be allowed for each cycle or sequence. The first opening and closing operation shall be recorded. The mechanical characteristics shall be recorded and shall be within the manufacturer's specified tolerances;

   Following the first opening operation (O) and the first closing operation (C) three OC operation cycles shall be performed. The additional operations shall be made by performing O – t_a – C –t_a operating sequences (t_a is defined in Table 5);

i) After completing the 50 opening and 50 closing operations, the air temperature shall be decreased to ambient air temperature T_A, at a rate of change of approximately 10 K/h;

   During the temperature transition period, the transfer switch shall be subjected to alternate O – t_a – C –t_a – O and C – t_a – O – t_a – C operating sequences at rated values of supply voltage and operating pressure. The alternate operating sequences should be made at 30 min intervals so that the transfer switch will be in the closed and open positions for 30 min periods between the operating sequences;

j) After the transfer switch has stabilized thermally at ambient air temperature T_A, a recheck shall be made of the transfer switch settings. The mechanical characteristics shall be recorded and shall be within the manufacturer's specified tolerances. The tightness test shall be repeated as in item m) and the leakage rate shall remain the limits stated in 7.7.

The accumulated leakage during the complete high temperature test sequence from item l) to item t) shall not be such that lock-out pressure is reached (reaching alarm pressure is allowed).

7.101.4 Humidity test

7.101.4.1 General

The humidity test does not apply to equipment, which is designed to be directly exposed to precipitation, for example primary parts of outdoor DC transfer switches. The test shall be performed on DC transfer switches or its component, where due to sudden changes of the temperature, condensation may occur on insulating surfaces which are continuously stressed by voltage. This is mainly the insulation of the secondary wiring of indoor installed DC transfer switches. It is also not necessary where effective means against condensation are provided, for example control cubicles with anti-condensation heaters.

Applying the test procedure described in 7.101.4.2, the withstand of the test object, primarily components of transfer switch or of active current injection circuit, to humidity effects, which may produce condensation on the surface of the test object, is determined in an accelerated manner.

7.101.4.2 Test procedure

The test object shall be arranged in a test chamber containing circulating air and in which the temperature and humidity shall follow the cycle given below:

During about half of the cycle the surfaces of the test object shall be wet, and dry during the other half. To obtain this result the test cycle consists of a period t_4 with low air temperature (T_{min} = 25 °C ±3 °C) and a period t_2 with high air temperature (T_{max} = 40 °C ±2 °C) inside the test chamber. Both periods shall be equal in time. The generation of fog shall be maintained for that half of the cycle (see Figure 3) in which the low air temperature is applied.

The beginning of fog generation coincides in principle with the beginning of the low air temperature period. However, to wet the vertical surfaces of materials with a high thermal time constant, it may be necessary to start the fog generation later within the low air temperature period.

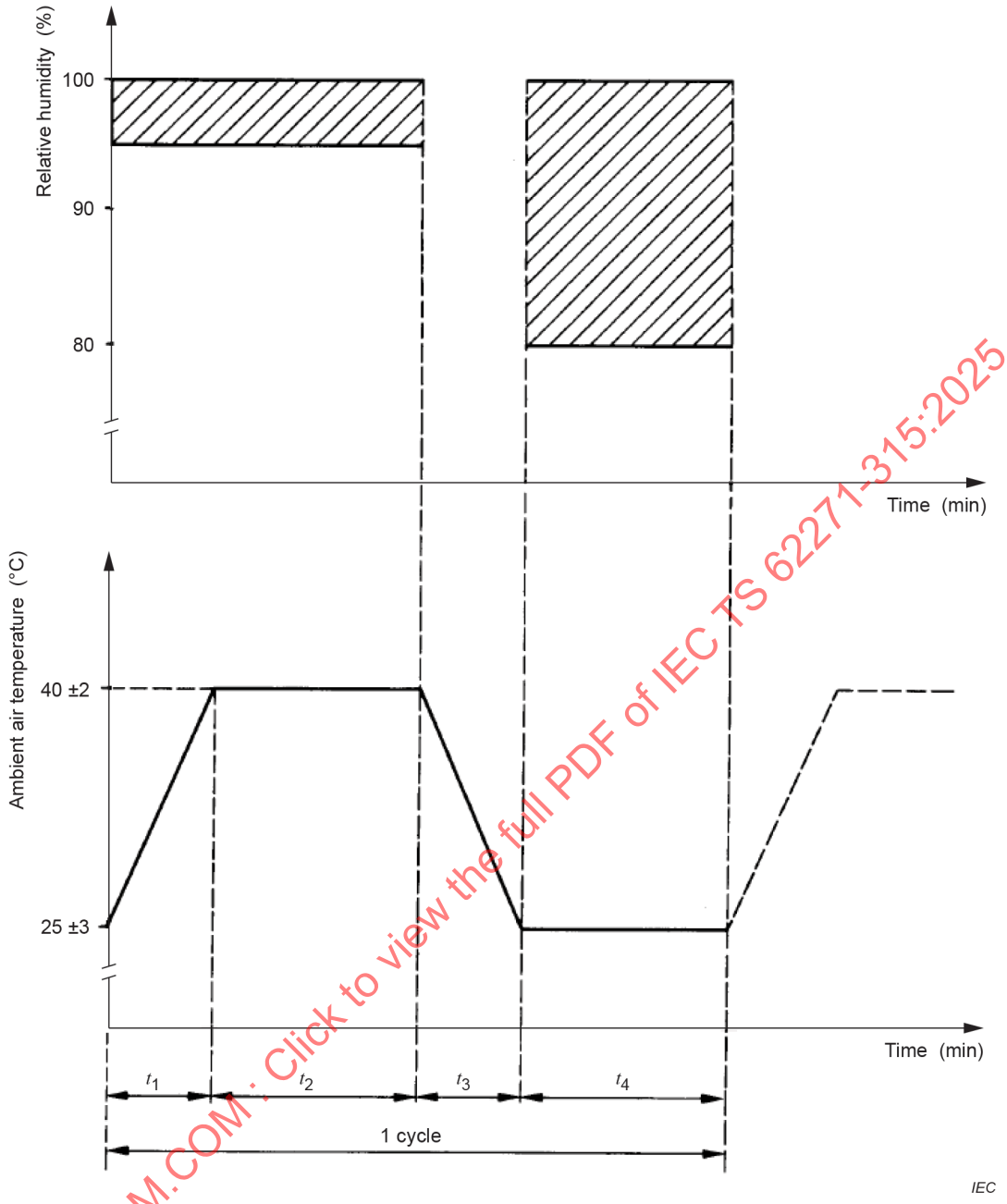


Figure 3 – Humidity test

The duration of the test cycle depends on the thermal characteristics of the test objects, and shall be sufficiently long, both at high and low temperature, to cause wetting and drying of all insulation surfaces. In order to obtain these conditions, steam should be injected directly into the test chamber or heated water should be atomized; the rise from 25 °C to 40 °C may be obtained with the provision of heat coming from the steam or atomized water or, if necessary, by additional heaters. Preliminary cycles shall be carried out with the test object placed in the test chamber in order to observe and to check these conditions.

For low-voltage components of transfer switches, usually having time constants smaller than 10 min, the duration of the time intervals given in Figure 3 are: t_1 = 10 min, t_2 = 20 min, t_3 = 10 min and t_4 = 20 min.

The fog is obtained by the continuous or periodical atomization of 0,2 l to 0,4 l of water (with the resistivity characteristics given below) per hour and per cubic meter of test chamber volume. The diameter of the droplets shall be less than 10 µm; such a fog can be obtained by mechanical

atomizers. The direction of the spraying shall be such that the surfaces of the test object are not directly sprayed. No water shall drop from the ceiling upon the test object. During the fog generation the test chamber shall be closed, and no additional forced air-circulation is permitted.

The water used to create the humidity shall be such that the water collected in the test chamber has a resistivity equal to or greater than 100 Ωm and contains neither salt (NaCl) nor any corrosive element.

The temperature and the relative humidity of the air in the test chamber shall be measured in the immediate vicinity of the test object and shall be recorded for the whole duration of the test. No value of relative humidity is specified during the drop in temperature; however, the humidity shall be above 80 % during the period when the temperature is maintained at 25 °C. The air shall be circulated to obtain uniform distribution of the humidity in the test chamber.

The number of cycles shall be 350.

During and after the test, the operating characteristics of the test objects shall not be affected. This is proven by the dielectric withstand test on the auxiliary and control circuits in accordance with 7.2.11. The degree of corrosion, if any, should be indicated in the test report.

7.101.5 Test to prove the operation under severe ice conditions

The test to prove the operation under severe ice conditions is applicable only to outdoor transfer switches having movable external parts. The test shall be performed according to IEC 62271-102:2018.

The test to prove the operation under severe ice conditions shall be established for the commutation switch and all other mechanical switching devices inside the DC transfer switch only.

In cases where a making switch is used in series with the oscillation branch in parallel to the commutation switch, the test to prove the operation under severe ice conditions shall performed for the making switch also.

7.102 Seismic tests

The seismic test should be performed on a fully assembled DC transfer switch as far as possible.

If a test on a fully assembled DC transfer switch is not possible for dimensional reasons in testing station, tests on single component of DC transfer switch should be performed as agreed between manufacturer and client.

The tests shall be performed in accordance with IEC 62271-207.

NOTE By agreement of manufacturer and client this test could be substituted by calculation.

7.103 Direct current commutation tests

7.103.1 General

The purpose of this test is to verify the specified direct current transfer capability of DC transfer switches.

NOTE 1 This test verifies whether the DC transfer switch can successfully transfer the direct current within the rated value, the DC transfer switch can withstand the specified voltage, having a specific rate of rise, across its open contacts and the capability of energy dissipation device.

NOTE 2 Simulations could be used for determination of the settings of oscillating branch, but they do not replace this test.

The value of transfer current as test result, is the current in the main test circuit, measured outside of the transfer switch, at the instant of arc extinction in the commutation switch.

7.103.2 Arrangement of the transfer switch during test

As preferred method direct current transfer tests should be performed on a fully assembled DC transfer switch. During the direct current commutation test, if the energy of the test circuit is insufficient to verify the capability of the energy dissipation device, it should be proofed/demonstrated in a different way like test on arrester discs.

NOTE 1 Due to limitations of testing stations full energy dissipation capability of energy dissipation device may not being tested sufficiently during test on a fully assembled DC transfer switch. Therefore, the energy dissipation device can be adapted to handle the energy of test circuit only.

As an alternative method for testing a passive DC transfer switch, the commutation switch can be tested in an arrangement of oscillation circuit, having same capacitance and inductance as the original one, and an energy dissipation device adapted to the test circuit.

NOTE 2 In passive DC transfer switches, the capability to transfer a direct current depends on the interaction between the arc voltage of commutation switch and the oscillation branch in parallel. Also, the voltage stress after arc extinction is defined by the oscillation branch. Therefore, only the capacitance and the inductance of the elements inside the oscillation branch are considered during the test.

Values for capacitance, inductance and resistance of the test setup or the transfer switch under test shall be established and mentioned in the test document.

NOTE 3 Stray inductances within the oscillating branch and between the DC switch and the oscillating branch can be significant for the DC current commutation performance. If an equivalent circuit having the same inductance and same capacitance is used, then the stray inductance of the oscillating circuit can be represented as close as possible (e.g. same cable lengths between the oscillating branch and the DC commutation switch).

If an energy dissipation device is used during current transfer test having a residual voltage less than the rated commutation voltage, the dielectric withstand capability of the commutation switch and current zero device will not be tested correctly. In this case the dielectric withstand capability of commutation switch and current zero device shall be demonstrated in additional tests. During these tests the peak value of test voltage shall not be less than the rated commutation voltage and its rate of rise shall not be less than the specified value calculated from circuit components. For the current zero device this can be an impulse voltage withstand test. For commutation switch an AC breaking test is recommended with same current peak value as during current transfer test. The current derivative (di/dt) at current zero should not be less than the current derivative obtained during current transfer tests.

For DC transfer switches using compressed fluids for insulation or commutation, the test shall be performed at minimum functional pressure (density) for insulation or commutation. The kind of fluid, its temperature and pressure during the test shall be noted and recorded in the test report.

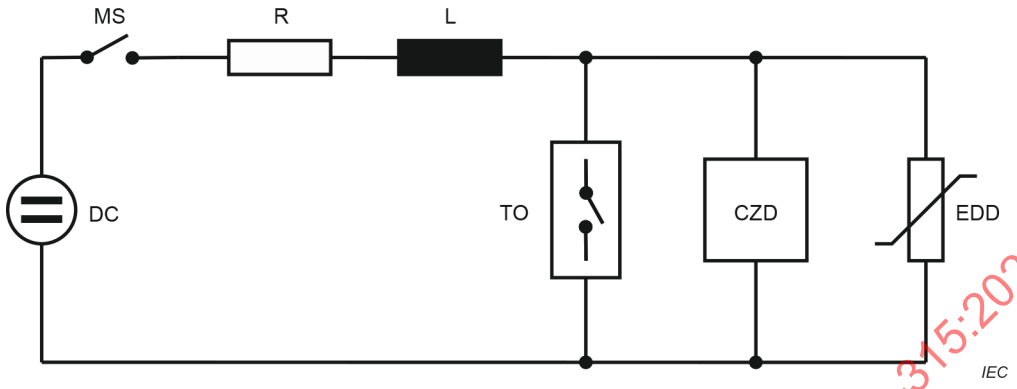
For separate commutation voltage withstand tests, it should be clear that these additional tests shall be performed with, at least, the maximum arcing time obtained during the commutation tests. Moreover, the number of additional tests demonstrating the commutation voltage withstand capability shall be the same number of tests as the number of tests specified for the commutation test.

For DC transfer switches using compressed fluids for operation, the test shall be performed at filling pressure for operation and minimum functional pressure for operation (refer to 7.103.4). The temperature and pressure of the fluid during the test shall be noted and recorded in the test report.

The supply voltage of opening and closing releases during the test shall be set to rated supply voltage.

7.103.3 Test circuit

The general layout of a test circuit for current transfer test is shown in Figure 4.



Key

DC DC source

MS Master switch

R Resistor

L Inductor

TO Test object (Commutation switch)

CZD Current zero device, will be

– an oscillation branch in case of passive DC transfer switch

– a current impulse generator in case of active DC transfer switch

EDD Energy dissipation device

Figure 4 – General layout of test circuit for direct current commutation test

NOTE 1 Further information on test circuits can be found in Annex B, Clause B.1.

If test facilities are limited, an equivalent low-frequency alternating current may be used for the test. In this case only one-half period of current shall be used and the interval of commutation (arcing time of commutation switch) should be close to the maximum current. The current in the main test circuit during the commutation time in the commutation switch, measured outside of the transfer switch, shall not be less than 100 % of the rated transfer current (see Figure 5).

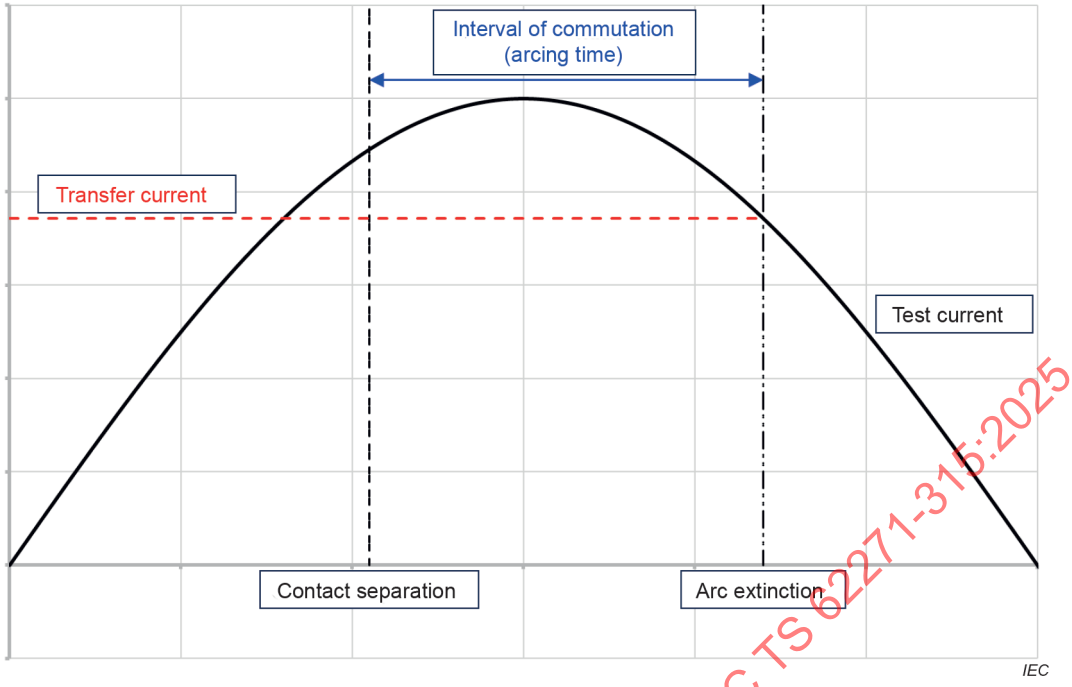


Figure 5 – Current commutation test with low-frequency alternating current

NOTE 2 Suitable frequency (wavelength of current) depends on needed arcing time, for example, 16 2/3 Hz could be used.

7.103.4 Test procedure

Before and after the direct current commutation test the mechanical characteristics and the resistance of the main circuit shall be established.

In the test series 15 commutation operations shall be performed consisting of:

– 5 operations at minimum functional pressure for operation;
– 10 operations at filling pressure for operation.

In case of active current injection transfer switches or transfer switches having a current limitation branch, test with reduced current shall be performed, also, the number of required commutation operations for each polarity is given as follows:

– 5 operations with 100 % of rated transfer current at minimum functional pressure for operation;
– 5 operations with 100 % of rated transfer current at filling pressure for operation;
– 5 operations with 50 % of rated transfer current at filling pressure for operation;
– 5 operations with 10 % of rated transfer current at filling pressure for operation;

In case of active current injection transfer switches with predetermined unipolar current impulse the number of required commutation operations is 20.

In case of active current injection transfer switches with bipolar injection current wave the number of required commutation operations is 40, that means 20 operations in each polarity.

7.103.5 Behaviour of DC transfer switch during test

During direct current commutation test, the DC transfer switch shall not

– show signs of distress;
– show harmful interaction to earth;
– show harmful interaction with adjacent laboratory equipment;
– exhibit behavior which could endanger an operator.

If faults occur that are neither persistent nor due to defect in design, but rather are due to errors in assembly or maintenance, the faults can be rectified and the DC transfer switch subjected to the repeated direct current transfer test concerned. In those cases, the test report shall include reference to the invalid tests.

7.103.6 Criteria to pass the test

The DC transfer switch shall pass the direct current transfer test if the required number of transfer operations have been performed successfully without damage (beside the usually acceptable wear of contacts), and it is capable of opening and closing normally after the tests. This will be confirmed by checks of mechanical characteristics, resistance of main circuit, dielectric withstand capability and a visual inspection of switching units.

The mechanical travel characteristic and the opening and closing time before and after test shall be compared.

– The difference of opening and closing time at rated condition after test is within the limits given by the manufacturer;
– The mechanical travel characteristic for opening and closing, before and after test shall be within an envelope of not more than 10 % around the mechanical reference curve.

The resistance of main circuit before and after test shall be compared.

– Difference of resistance of main circuit after test measured according to 7.3.4 is within not more than 100 % of before the test.

The dielectric withstand capability after direct current transfer test shall be demonstrated.

– Dielectric condition check, according to 7.2.11 shall be performed.

NOTE Dielectric condition check can be omitted if it will be performed after ‘Direct arc withstand test’.

The switching units of DC transfer switch shall be inspected.

For other than sealed for life switching units, visual inspection is usually sufficient for verification of the capability of the commutation switch to carry the rated continuous current.

– The main contacts shall be in such a condition, in particular with regard to wear, contact area, pressure and freedom of movement, that they are capable of carrying the rated normal current of the transfer switch without their temperature rise exceeding by more than 10 K the values specified for them in Table 10 of IEC TS 62271-5:2024.
– Contacts shall be considered as "silver-faced" only if there is still a layer of silver at the contact points after the test; otherwise, they shall be treated as "not silver-faced".

7.104 Direct arc withstand tests

7.104.1 General

The purpose of this test is to verify the arc withstand capability of the DC transfer switch should it fail to commutate the rated transfer current. The time duration of the direct arc is the interval of time between the instant when the contacts have separated during the opening operation and the instant when the contacts touch during the following closing operation.

For blank DC transfer switches which have an inherent arc quenching capability, it is not possible for the arc to be sustained for an extended period. Usually, the arc will be quenched by these commutation switches within the required time span. In these cases, the test shall be considered compliant, despite the arcing time achieved.

7.104.2 Arrangement of the transfer switch during test

The test shall only be performed on the commutation switch without auxiliary circuits fitted and the insulation platform.

For DC transfer switches using compressed fluids for insulation or commutation, the test shall be performed at minimum functional pressure (density) for insulation or commutation. The kind of fluid, its temperature and pressure during the test shall be noted and recorded in the test report.

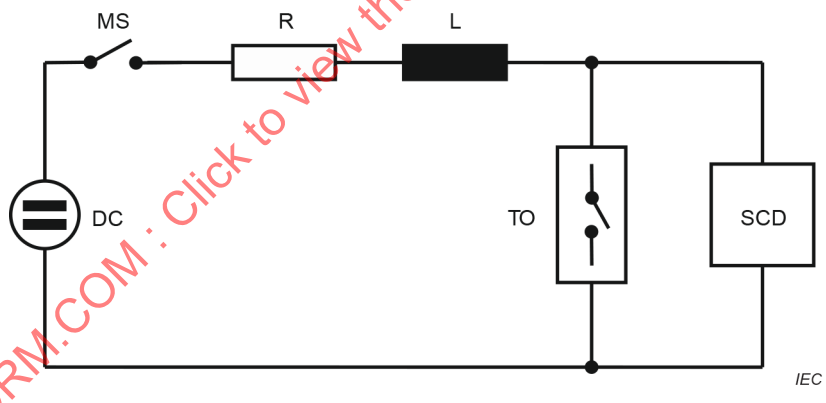
For DC transfer switches using compressed fluids for operation, the test shall be performed at filling pressure for operation and minimum functional pressure for operation (refer to sub-clause 7.104.4). The temperature and pressure of the fluid during the test shall be noted and recorded in the test report.

The supply voltage of opening and closing releases during the test shall be set to rated supply voltage.

7.104.3 Test circuit

The test circuit shall be equivalent to the actual service condition of DC transfer switches.

The general layout of a test circuit for direct arc withstand test is shown in Figure 6.



Key

DC	DC source
MS	Master switch
R	Resistor
L	Inductor
TO	Test object
SCD	Short circuit device, to by-pass test object in case of failed closing operation.

Figure 6 – General layout of test circuit for direct arc withstand test

NOTE Further information on test circuits can be found in Annex B, Clause B.2.

7.104.4 Test procedure

Before and after the direct arc withstand test the mechanical characteristics and the resistance of the main circuit shall be established.

The test requirements are as follows:

– Test current: rated transfer current;
– Operating sequence: O – t – C;
– Time intervals t: assigned by the manufacturer;
– Time duration of the arc: not less than T_{aw};
– 1 operation cycle (O – t – C) at minimum functional pressure for operation;
– 1 operation cycle (O – t – C) at filling pressure for operation;

7.104.5 Behaviour of DC transfer switch during test

During direct arc withstand test, the DC transfer switch shall not

– show signs of distress;
– show harmful interaction to earth;
– show harmful interaction with adjacent laboratory equipment;
– exhibit behavior which could endanger an operator.

If faults occur which are neither persistent nor due to defect in design, but rather are due to errors in assembly or maintenance, the faults can be rectified and the DC transfer switch subjected to the repeated direct arc withstand test concerned. In those cases, the test report shall include reference to the invalid tests.

7.104.6 Criteria to pass the test

The DC transfer switch shall pass the direct arc withstand test if the required number of opening operations were performed successfully without damage, and it is capable of opening and closing normally after the tests. This will be confirmed by checks of mechanical characteristics, resistant of main circuit, dielectric withstand capability and a visual inspection of switching units.

NOTE After the direct arc withstand tests, the current commutation capability can be impaired due to the internal pollution.

The mechanical travel characteristic and the opening and closing time before and after test shall be compared.

– The difference of opening and closing time at rated condition after test is within the limits given by the manufacturer.
– The mechanical travel characteristic for opening and closing, before and after test shall be within an envelope of not more than 10 % around the mechanical reference curve.

The resistance of main circuit before and after test shall be compared.

The difference of resistance of the main circuit after the test measured according to 7.3.4 shall be within 100 % of that measured before the test.

The dielectric withstand capability after the direct current transfer test shall be demonstrated.

Dielectric condition check, according to 7.2.11 shall be performed.

The switching units of DC transfer switch shall be inspected.

For other than sealed for life switching units, visual inspection is usually sufficient for verification of the capability of the commutation switch to carry the rated continuous current.

– The main contacts shall be in such a condition, in particular with regard to wear, contact area, pressure and freedom of movement, that they are capable of carrying the rated normal current of the transfer switch without their temperature rise exceeding by more than 10 K the values specified for them in Table 10 of IEC TS 62271-5:2024.
– Contacts shall be considered as "silver-faced" only if there is still a layer of silver at the contact points after the test; otherwise, they shall be treated as "not silver-faced".

8 Routine tests

8.1 General

Subclause 8.1 of IEC TS 62271-5:2024 is applicable with the following addition:

Each component of DC transfer switches, like commutation switches, reactors, capacitors, energy dissipation device, etc., shall pass the routine tests specified in Annex A or specific product standards (if available).

8.2 Dielectric test on the main circuit

Subclause 8.2 of IEC TS 62271-5:2024 is applicable.

8.3 Tests on auxiliary and control circuits

Subclause 8.3 of IEC TS 62271-5:2024 is applicable.

8.4 Measurement of the resistance of the main circuit

Subclause 8.4 of IEC TS 62271-5:2024 is applicable.

8.5 Tightness test

Subclause 8.5 of IEC TS 62271-5:2024 is applicable.

8.6 Design and visual checks

Subclause 8.6 of IEC TS 62271-5:2024 is applicable.

8.101 Mechanical operating tests

Mechanical operating tests shall include the following:

a) at maximum supply voltage of operating devices and of auxiliary and control circuits and filling pressure for operation (if applicable):
   – five closing operations;
   – five opening operations.
b) at specified minimum supply voltage of operating devices and of auxiliary and control circuits and minimum functional pressure for operation (if applicable):
   – five closing operations;
   – five opening operations.
c) at rated supply voltage of operating devices and of auxiliary and control circuits and filling pressure for operation (if applicable):
   – five open-close operating cycles with the closing mechanism energised by the auxiliary contacts.

The mechanical operation tests shall be performed on the commutation switch and all other mechanical switching devices inside the DC transfer switch only at the ambient air temperature of the test location. The ambient air temperature shall be recorded in the test report. Auxiliary equipment forming part of the operating devices shall be included.

Mechanical operating tests should be made on the complete switching devices. However, when these switching devices are assembled and shipped as separate units, routine tests may be performed on components according to 7.101.1.2. In such cases, the manufacturer shall produce a programme of commissioning tests for use at site to confirm the compatibility of such separate units and components when assembled as a complete switching devices.

For all required operating sequences the following shall be performed and records made of the closing and opening operations:

– measurement of operating times;
– where applicable, measurement of fluid consumption during operations, for example pressure difference.

Proof shall be given that the mechanical behaviour conforms to that of the test object used for type testing. For example, a no-load operating cycle, as described in 7.101.1.1, can be performed to record the no-load travel curves at the end of the routine tests. Where this is done, the curve shall be within the prescribed envelope of the reference mechanical travel characteristic, as defined in 7.101.1.1, from the instant of contact separation to the end of the contact travel for an opening operation and from start of movement to contact touch for a closing operation.

Where the mechanical routine tests are performed on sub-assemblies, the reference mechanical travel characteristics shall be confirmed to be correct, as above, at the end of the commissioning tests on site.

If the measurement is performed on site, the manufacturer shall state the preferred measuring procedure. If other procedures are used, the results may be different and the comparison of the instantaneous contact stroke may be impossible to achieve.

The mechanical travel characteristics can be recorded directly, using a travel transducer or similar device on the DC transfer switches contact system or at other convenient locations on the drive to the contact system where there is a direct connection, and a representative image of the contact stroke can be achieved. The mechanical travel characteristics shall be preferably a continuous curve. Where the measurements are taken on site, other methods may be applied which record points of travel during the operating period.

In these circumstances, the number of points recorded shall be sufficient to derive the time to, and contact speed at, contact touch and contact separation, together with the total travel time.

After completion of the required operating sequences, the following tests and inspections shall be performed (if applicable):

– connections shall be checked;
– the control and/or auxiliary switches shall correctly indicate the open and closed positions of the DC transfer switches;
– all auxiliary equipment shall operate correctly at the limits of supply voltage of operating devices and of auxiliary and control circuits and/or pressures for operation.

Furthermore, the following tests and inspections shall be made (if applicable):

– measurement of the resistance of heaters (if fitted) and of the control coils;
– inspections of the wiring of the control, heater and auxiliary equipment circuits and checking of the number of auxiliary contacts, in accordance with the order specification;
– inspection of the control cubicle (electrical, mechanical, pneumatic and hydraulic systems);
– recharging duration(s);
– functional performance of the pressure relief valve of the operating mechanism;
– operation of electrical, mechanical, pneumatic or hydraulic interlocks and signalling devices;
– operation of anti-pumping device;
– general performance of equipment within the required tolerance of the supply voltage;
– inspection of earthing terminals of the DC transfer switches.

9 Guide to the selection of DC transfer switches （informative）

9.1 General

Subclause 9.1 of IEC TS 62271-5:2024 is applicable with the following additions:

For the selection of DC transfer switches, the following conditions and requirements at site should be considered:

– application (MRTS, ERTS, NBS, NBES);
– continuous current load and overload conditions;
– existing fault conditions;
– environmental conditions (climate, pollution, etc.);
– altitude of the substation.

9.2 Selection of rated values

Subclause 9.2 of IEC TS 62271-5:2024 is applicable with the following additions:

9.2.101 General

All rated characteristics and classes of a DC transfer switch given in Clause 5 should be considered.

9.2.102 Selection of rated direct voltage of transfer switch and rated insulation level

The rated direct voltage of transfer switch should be chosen so as to be at least equal to the highest voltage of neutral bus system to be installed. The rated direct voltage of transfer switch and insulation level of the neutral bus for different converter station are different. The selected rated direct voltage of transfer switch and insulation level should meet the engineering requirements.

The rated direct voltage of transfer switch can be selected from the standard values in subclause 5.101 and their related insulation levels are given in 5.3.

For DC transfer switches installed at high altitudes, refer to 4.2.2 of IEC TS 62271-5:2024.

9.2.103 Selection of rated operating sequence

The operating sequence depends on the specific application of the DC transfer switch in the system. The rated operating sequence should be selected from those sequences given in 5.105.

9.2.104 Selection of rated continuous current

The rated continuous current of a DC transfer switch should be selected from the standard values given in 5.4 of IEC TS 62271-5:2024.

The overload requirements of the HVDC system should be considered when selecting the rated continuous current.

9.2.105 Selection of rated values of short time withstand current

The rated values of short time withstand current should be selected from those given in 5.5 of IEC TS 62271-5:2024.

9.2.106 Selection of rated transfer current

The rated transfer current should be selected in accordance with 5.102.

9.2.107 Selection of rated commutation voltage

The commutation voltage of a transfer switch at each location in the system is determined by its energy dissipation branch. This value can be determined by simulation of current commutation process.

The commutation voltage is normally lower than the protection level of the surrounding surge arresters where DC transfer switch is installed.

The rated commutation voltage for a specific DC transfer switch shall be equal to or higher than the maximum commutation voltage determined by simulation.

9.3 Cable-interface considerations

Subclause 9.3 of IEC TS 62271-5:2024 is applicable.

9.4 Continuous or temporary overload due to changed service conditions

Subclause 9.4 of IEC TS 62271-5:2024 is applicable.

9.5 Environmental aspects

Subclause 9.5 of IEC TS 62271-5:2024 is applicable.

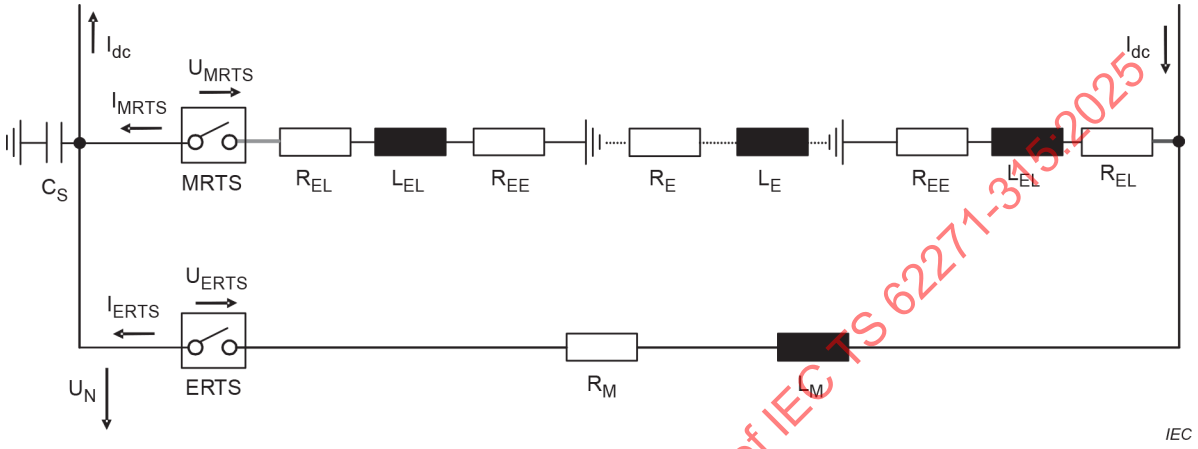
9.101 Selection of the application

9.101.1 MRTS

The MRTS forms part of the electrode line circuit (earth return) in a HVDC system with both earth and metallic returns. For current transfer purpose, it starts from the closed position and transfers current from earth return to metallic return through its coordinated opening operation with the ERTS. In the sequence, the ERTS closes first from its original open position, which results in current transfer from the earth return to the metallic return. After the current in the earth return reaches new steady state, the MRTS opens, which completes the current transfer from electrode line (earth return) to metallic return. Figure 7 shows the equivalent circuit where the MRTS is defined.

9.101.2 ERTS

The ERTS forms part of metallic return in a HVDC system with both earth and metallic returns. For current transfer purpose, it starts from the closed position and transfers current from metallic return to earth return through its coordinated opening operation with the MRTS. In the sequence, the MRTS closes first from its original open position, which results in current transfer from the metallic return to the earth return. After the current in the metallic return reaches new steady state, the ERTS opens, which completes the current transfer from metallic return to electrode line (earth return). Figure 7 shows the equivalent circuit where the ERTS is defined.



Key

EL electrode line

EE electrode earth

M metallic return

E earth return

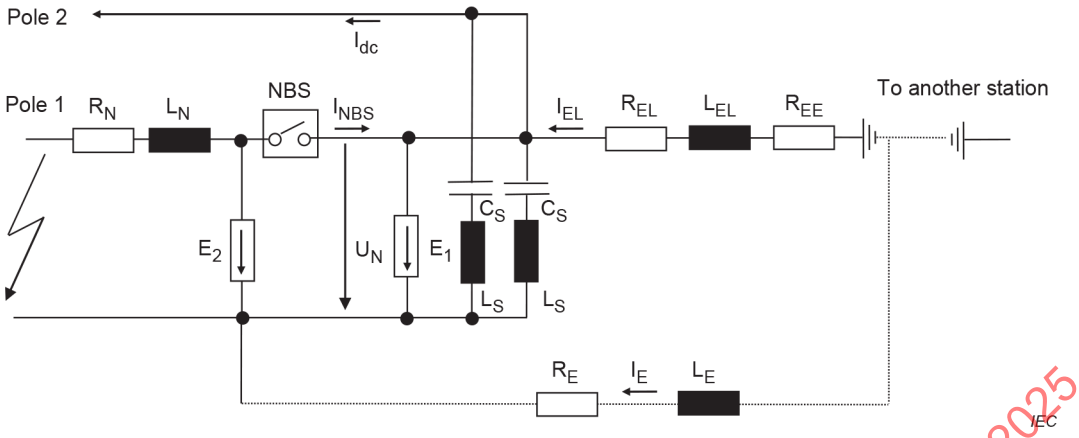
C_s surge capacitor

N Neutral bus

Figure 7 – Equivalent transfer circuit of MRTS and ERTS

9.101.3 NBS

At an earth fault within the converter in one pole during normal bipolar operation, the faulty pole is blocked with by-pass pairs. The NBS is used to transfer direct current which is generated by the operating pole flowing through the short-circuit point and the blocked pole to the electrode line. Figure 8 shows the equivalent transfer circuit of the NBS.



Key

EL electrode line

EE electrode earth

N neutral bus

E earth return

C_s surge capacitor

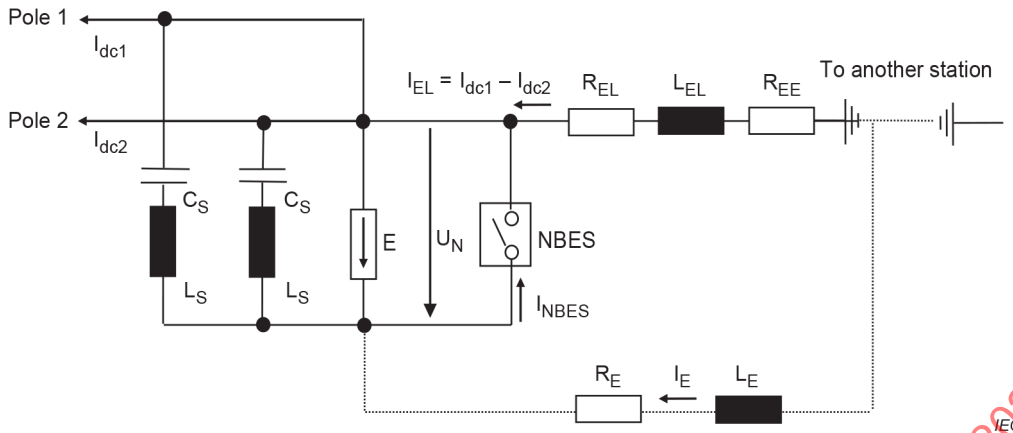
L_s leakage inductance of surge capacitor

Figure 8 – Equivalent transfer circuit of NBS

9.101.4 NBES

The NBES is used to prevent bipolar operation from stopping and blocked and improve the reliability of HVDC transmission system. When the electrode line is open, the neutral bus voltage rises because of the unbalanced current. The NBES is closed to provide converter station temporary earth. The system could continue operating in bipolar mode. When the electrode line can be used again, the NBES transfers the current from the converter station earth to the electrode line. Figure 9 shows the equivalent transfer circuit of the NBES.

NOTE The NBES can also be used when a fault occurs on one pole during bipolar operation and supports the NBS to isolate the faulted pole by sharing the current.



Key

EL electrode line

EE electrode earth

N neutral bus

E earth return

C_s surge capacitor

L_s leakage inductance of surge capacitor

Figure 9 – Equivalent transfer circuit of NBES

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

10.1 General

Subclause 10.1 of IEC TS 62271-5:2024 is applicable.

10.2 Information with enquiries and orders

Subclause 10.2 of IEC TS 62271-5:2024 is applicable with the following addition:

When enquiring for or ordering a transfer switch, the following particulars should be supplied by the enquirer:

a) particular of systems, i.e. normal and highest voltages, normal and maximum continuous currents. Unusual characteristics of the system in which the transfer switch is to be applied should be noted;

b) service conditions including minimum and maximum ambient air temperatures, altitude if over 1 000 m and any special conditions likely to exist or arise, for example unusual exposure to water vapour, moisture, fumes, explosive gases, excessive dust or salt air, seismic activity

c) characteristics of transfer switch.

The following information should be given:

1) indoor or outdoor installation;
2) type and class of transfer switch as defined in Clause 3;
3) current transferring capability: unidirectional or bidirectional;
4) rated direct voltage of transfer switch (5.101);
5) rated insulation level (5.3);
6) rated continuous current (5.4);
7) rated values of short-time withstand current (5.5);

8) rated transfer current (5.102);
9) rated commutation voltage (5.103)
10) rated dissipated energy during transfer operation (5.104)
11) rated operating sequence (5.105);
12) rated open-close time (5.106);
13) class of mechanical endurance (6.102.6);
14) the type tests required on special request.

d) characteristics of the operating mechanism of transfer switch and associated equipment, in particular:
1) method of operation;
2) number and type of spare auxiliary switches;
3) rated supply voltage and rated supply frequency;
4) number of releases for opening, if more than one;
5) number of releases for closing, if more than one.

e) requirements concerning the use of compressed fluids and requirements for design and test of pressure vessels.

The enquirer should give information of any special conditions not included above, that might influence the tender or order (see also the note in 9.101).

10.3 Information with tenders

Subclause 10.3 of IEC TS 62271-5:2024 is applicable with the following addition.

When the enquirer requests technical particulars of a transfer switch, the following information, if applicable, should be given by the manufacturer, with any explanatory text and drawings:

a) rated values and characteristics:
1) indoor or outdoor installation; type and class of transfer switch as defined in Clause 3
2) rated direct voltage of transfer switch (5.101);
3) rated insulation level (5.3);
4) rated continuous current (5.4);
5) rated values of short-time withstand current (5.5);
6) rated transfer current (5.102);
7) rated commutation voltage (5.103)
8) rated dissipated energy during transfer operation (5.104)
9) rated operating sequence (5.105);
10) rated open-close time (5.106);
11) class of mechanical endurance (6.102.6);
12) cooling down time of energy dissipation device.

b) type tests
List of certificates or report on request, including the special tests requested by the inquirer;

c) constructional features:

The following details are required where they are applicable to the design:

1) mass of complete transfer switch without fluids for insulation, and transfer switching operation;
2) mass/volume of fluid for insulation, its quality and operating range, including the minimum functional value;
3) mass/volume of fluid for transfer switching operation (where different fluid to items 2) and/or 4)), its quality and operating range, including the minimum functional value;
4) mass/volume of fluid for operation (where different fluid to items 2) and/or 3)), its quality and operating range, including the minimum functional value;
5) tightness qualification;
6) mass/volume of fluids per pole to fill to a level sufficient to prevent deterioration of internal components during storage and transportation;
7) number of units in series;
8) minimum clearances in air:
   - to earth
   - the safety boundaries during a switching operation for transfer switches with external exhaust for ionised gasses or flame;

d) operating mechanism of transfer switch and associated equipment:

1) type of operating mechanism;
2) whether the transfer switch is suitable for trip-free or fixed trip operation and whether it is provided with lock-out preventing closing;
3) rated supply voltage and/or pressure of closing mechanism, pressure limits where different to or expanding data required in c) 4) of 10.3;
4) current required at rated supply voltage to close the transfer switch;
5) energy expended to close the transfer switch, for example measured as a fall in pressure;
6) rated supply voltage of releases for opening;
7) current required at rated supply voltage for releases for opening;
8) number and type of spare auxiliary switches;
9) current required at rated supply voltage by other auxiliaries;
10) setting of high and low pressure interlocking devices;
11) number of releases for opening, if more than one;
12) number of releases for closing, if more than one.

e) overall dimensions and other information:

The manufacturer should give the necessary information as regards the overall dimensions of the transfer switch and details necessary for the design of the foundation.

General information regarding maintenance of the transfer switch and its connections should be given.

11 Transport, storage, installation, operating instructions and maintenance

Clause 11 of IEC TS 62271-5:2024 is applicable with following addition.

Subclause 11.5.1 of IEC TS 62271-5:2024 is applicable with following addition.

After a reclosing operation with arcing (in case of failed commutation operation), the current commutation capability may be impaired due to the internal pollution. In such cases, early maintenance becomes necessary.

12 Safety

Clause 12 of IEC TS 62271-5:2024 is applicable.

13 Influence of the product on the environment

Clause 13 of IEC TS 62271-5:2024 is applicable.

Annex A
(normative)

Test requirements for components of DC transfer switches

A.1 Commutation switch

The type test requirements given in Clause 7, except 7.103, are applicable for commutation switches.

NOTE DC commutation switch normally cannot complete DC commutation test alone.

The routine test requirements given in 8.2 to 8.101 are applicable for commutation switches.

A.2 Making switch

The type test requirements given in Clause 7, except those of 7.4, 7.103 and 7.104, are applicable for making switches.

The routine test requirements given in 8.2 to 8.101 are applicable for making switches.

A.3 Commutation capacitor

Test requirements in IEC 60871 are applicable for commutation capacitor with the following addition.

For the commutation capacitors in passive circuit which will not be exposed to any continuous voltage stresses, the equivalent AC rated voltage of commutation capacitors (U_R) could be calculated according to the following equation:

$$U_R = \frac{U_{LIWL}}{4{,}3 \times S}$$

where

U_{LIWL} is the lightning impulse withstand voltage level across open terminals of DC transfer swithces;

S is the number of capacitor units in series.

Since the capacitors in passive DC transfer switches are not subjected to any continuous duty, the following type tests as specified in IEC 60871-1 do not apply to commutation capacitors of passive DC transfer switches:

– thermal stability test;

– measurement of capacitance and tan δ at elevated temperature;

– aging test.

A.4 Energy dissipation device

Test requirements in IEC 60099-9 are applicable for energy dissipation devices in DC transfer switches with the following addition.

Since the energy dissipation device is not subjected to any continuous duty, the following type tests as specified in IEC 60099-9 do not apply to the energy dissipation device:

– steep current impulse residual voltage test;
– test to verify long term stability under continuous operating voltage;
– heat dissipation behaviour of test sample;
– test to verify the thermal energy rating, W_{th}.

The test to verify the repetitive charge transfer rating (Q_{rs}) for MRTS and ERTS arresters shall be made by applying two consecutive energy impulses per group. The time between each energy impulses in one group shall be less than 60 s and the time between groups shall be long enough for the test samples to cool down to ambient temperature. The tests shall be carried by applying a total of 200 impulses in 100 groups. In order to shorten the testing duration, the test energy can be raised to 120 % of the required energy in order to reduce the number of impulse groups to 50. The test should be performed on three prorated sections without failure.

A.5 Reactor

Test requirements in IEC 60076-6 are applicable for reactors in DC transfer switches with the following addition.

Since the reactor is not subjected to any continuous duty, temperature rise test as specified in IEC 60076-6 do not apply to the reactor in DC transfer switch.

A.6 Charging device

A.6.1 Type tests for charging device

A.6.1.1 General

The following type tests should be considered as minimum for charging device. If necessary, the supplier shall propose additional type tests and submit detailed test procedures for approval.

A.6.1.2 Lightning impulse voltage test between terminals and earth

The lightning impulse voltage test between terminals and earth should be performed with the standard lightning impulse 1,2/50 μs. The test includes three full voltage impulses and a reduced (50 %) voltage impulse with each polarity. If the waveforms of test voltage and current under full voltage are same as that of 50 % voltage, the device is considered to have passed the test successfully.

A.6.1.3 DC polarity reversal test (dry) with partial discharge measurement

During the test, positive polarity test voltage should be applied to the negative terminal and negative polarity should be applied to the positive terminal. As a result, the voltage on the unconnected terminal is equal to the test voltage plus the rated voltage between terminals.