

TECHNICAL SPECIFICATION



High-voltage switchgear and controlgear –
Part 314: Direct current disconnectors and earthing switches

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**High-voltage switchgear and controlgear –
Part 314: Direct current disconnectors and earthing switches**

INTERNATIONAL
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CONTENTS

FOREWORD.....	8
1 Scope.....	10
2 Normative references	10
3 Terms and definitions	11
3.1 General terms and definitions	11
3.2 Assemblies of switchgear and controlgear	11
3.3 Parts of assemblies	12
3.4 Switching devices	12
3.5 Parts of switchgear and controlgear	13
3.6 Operational characteristics of switchgear and controlgear.....	16
3.7 Characteristic quantities	18
3.8 Index of definitions.....	21
4 Normal and special service conditions	23
5 Ratings.....	23
5.1 General.....	23
5.2 Rated direct voltage (U_{rd}).....	24
5.3 Rated insulation level (U_{dd} , U_p , U_s).....	24
5.4 Rated continuous current (I_{rd})	27
5.5 Rated values of short-time withstand current.....	27
5.5.1 Typical waveform of short-circuit current.....	27
5.5.2 Rated short-time withstand current (I_{kd})	27
5.5.3 Rated peak withstand current (I_{pd})	27
5.5.4 Rated duration of short circuit (t_{kd}).....	27
5.6 Rated supply voltage of auxiliary and control circuits (U_a)	27
5.7 Rated supply frequency of auxiliary circuits and control circuits	27
5.8 Rated pressure of compressed gas supply for controlled pressure systems	27
5.101 Rated contact zone.....	28
5.102 Rated static mechanical terminal load.....	28
5.103 Classification of disconnectors for mechanical endurance.....	29
5.104 Classification of earthing switches for mechanical endurance	30
5.105 Rated ice-coating.....	30
5.106 Rated cable discharge current making capability	30
6 Design and construction	31
6.1 Requirements for liquids in disconnectors and earthing switches	31
6.2 Requirements for gases in disconnectors and earthing switches	31
6.3 Earthing of disconnectors and earthing switches.....	31
6.4 Auxiliary and control equipment and circuits	31
6.5 Dependent power operation	31
6.6 Stored energy operation.....	31
6.7 Independent unlatched operation (independent manual or power operation)	32
6.8 Manually operated actuators	32
6.9 Operation of releases.....	32
6.10 Pressure/level indication	32
6.11 Nameplates.....	32
6.12 Locking devices	33

6.13	Position Indication	34
6.14	Degree of protection provided by enclosures	34
6.15	Creepage distances for outdoor insulators	34
6.16	Gas and vacuum tightness	34
6.17	Tightness for liquid systems	34
6.18	Fire hazard (flammability)	34
6.19	Electromagnetic compatibility (EMC)	34
6.20	X-ray emission	34
6.21	Corrosion	34
6.22	Filling levels for insulation, switching and/or operation	34
6.101	Particular requirements for earthing switches	35
6.102	Requirements in respect of the isolating distance of disconnectors	35
6.103	Mechanical strength	35
6.104	Operation of disconnectors and earthing switches – Position of the movable contact system and its indicating and signalling devices	35
6.104.1	Securing of position	35
6.104.2	Additional requirements for power-operated mechanisms	35
6.104.3	Indication and signalling of position	36
6.104.3.1	General requirements	36
6.104.3.2	Indication of position	37
6.104.3.3	Signalling of position by auxiliary contacts	37
6.105	Maximum force required for manual (dependent or independent) operation	37
6.105.1	General	37
6.105.2	Operation requiring more than one revolution	37
6.105.3	Operation requiring up to one revolution	37
6.106	Dimensional tolerances	37
6.107	Earthing switches with short-circuit making current capability	38
7	Type tests	38
7.1	General	38
7.1.1	Basics	38
7.1.2	Information for identification of test objects	39
7.1.3	Information to be included in type test reports	39
7.2	Dielectric tests	40
7.2.1	General	40
7.2.2	Ambient air conditions during tests	40
7.2.3	Wet test procedure	40
7.2.4	Arrangement of the equipment	40
7.2.5	Criteria to pass the test	40
7.2.6	Application of the test voltage and test conditions	40
7.2.7	Test of disconnectors and earthing switches	41
7.2.8	Artificial pollution tests for outdoor insulators	41
7.2.9	Partial discharge tests	41
7.2.10	Dielectric tests on auxiliary and control circuits	42
7.2.11	Voltage test as condition check	42
7.3	Resistance measurement	42
7.4	Continuous current tests	42
7.5	Short-time withstand current and peak withstand current tests	42
7.5.1	General	42

7.5.2	Arrangement of the disconnectors and earthing switches and of the test circuit	42
7.5.3	Test current and duration.....	48
7.5.4	Conditions of disconnectors and earthing switches after test	48
7.6	Verification of the protection	48
7.7	Tightness tests	48
7.8	Electromagnetic compatibility tests (EMC)	48
7.9	Additional tests on auxiliary and control circuits	49
7.10	X-ray radiation test for vacuum interrupters.....	49
7.101	Capacitive current making test – Cable discharging test	49
7.101.1	General	49
7.101.2	Classification of earthing switches with cable discharging current making capability	49
7.101.3	Discharging making tests	49
7.101.3.1	Arrangement of the earthing switch for tests	49
7.101.3.2	Earthing of the test circuit	50
7.101.3.3	Test procedure	50
7.101.3.4	Test duty 1 (without current limiting resistor).....	50
7.101.3.4.1	General.....	50
7.101.3.4.2	Alternative test method for test-duty 1.....	50
7.101.3.4.3	Test frequency test duty 1.....	50
7.101.3.4.4	Test current test duty 1	51
7.101.3.4.5	Test voltage test duty 1.....	51
7.101.3.4.6	Tests at reduced voltage test duty 1	51
7.101.3.4.7	Test circuits test duty 1	51
7.101.3.5	Test duty 2 (with current limiting resistor)	53
7.101.3.5.1	General.....	53
7.101.3.5.2	Alternative test method for test duty 2.....	53
7.101.3.5.3	Test frequency test duty 2.....	54
7.101.3.5.4	Test current test duty 2	54
7.101.3.5.5	Test voltage test duty 2.....	54
7.101.3.5.6	Tests at reduced voltage at test duty 2.....	54
7.101.3.5.7	Test circuits test duty 2	54
7.101.4	Behaviour of the earthing switch during tests	55
7.101.5	Condition of earthing switch after tests	56
7.101.6	Test reports	56
7.102	Operating and mechanical endurance tests	56
7.102.1	General test conditions	56
7.102.2	Contact zone test.....	57
7.102.3	Mechanical endurance test	59
7.102.3.1	Test procedure	59
7.102.3.2	Verification of successful operation.....	60
7.102.4	Operation during the application of rated static mechanical terminal loads.....	61
7.102.5	Extended mechanical endurance tests	61
7.102.6	Testing of mechanical interlocking devices	62
7.103	Operation under severe ice conditions	62
7.103.1	General	62
7.103.2	Test arrangement	63
7.103.3	Test procedure	63

7.103.3.1	Checks before the formation of ice coating	63
7.103.3.2	Formation of ice coating	63
7.103.3.3	Checks after the formation of ice coating	64
7.104	Low- and high-temperature tests	65
7.104.1	General	65
7.104.2	Measurement of ambient air temperature	65
7.104.3	Low-temperature test	65
7.104.4	High-temperature test	67
7.105	Tests to verify the proper functioning of the position-indicating device	68
7.105.1	General	68
7.105.2	Tests on the power kinematic chain and the position-indicating kinematic chain	69
8	Routine tests	69
8.1	General	69
8.2	Dielectric test on the main circuit	70
8.3	Tests on auxiliary and control circuits	70
8.4	Measurement of the resistance of the main circuit	70
8.5	Tightness test	70
8.6	Design and visual checks	70
8.101	Mechanical operating tests	70
8.102	Verification of earthing function	71
9	Guide to the selection of disconnectors and earthing switches (informative)	71
9.1	General	71
9.2	Selection of rated values	71
9.2.101	General	72
9.2.102	Selection of rated voltage and preferred rated insulation level	72
9.2.103	Selection of rated continuous current	72
9.2.104	Selection of rated contact zone	72
9.2.105	Selection of rated static mechanical terminal load	72
9.2.106	Selection of rated short-time withstand current and of rated duration of short-circuit	73
9.2.107	Selection of rated peak withstand current	73
9.3	Cable-interface considerations	73
9.4	Continuous or temporary overload due to changed service conditions	73
9.5	Environmental aspects	73
9.5.101	Local environmental conditions	73
10	Information to be given with enquiries, tenders and orders	74
10.1	General	74
10.2	Information with enquiries and orders	74
10.3	Information with tenders	75
11	Transport, storage, installation, operating instructions, and maintenance	76
11.1	General	76
11.2	Conditions during transport, storage and installation	76
11.3	Installation	76
11.4	Operating instruction	76
11.5	Maintenance	76
12	Safety	77
12.1	General	77
12.2	Precautions by manufacturers	77

12.3	Precautions by users	77
13	Influence of the product on the environment	77
Annex A	(normative) Identification of test objects	78
Annex B	(informative) Induced current switching tests on earthing switches	79
Annex C	(normative) Tolerances on test quantities for type tests	80
Annex D	(informative) Cable discharging test	81
D.1	General	81
D.2	Surge impedance	82
D.3	Cable capacity of single-core cable with radial electrical field	82
D.4	Cable inductance of single-core cable	82
D.5	Time constant of high-voltage cables	84
D.6	Example and formulas according to Table D.3	84
Annex E	(informative) Extension of validity of type tests	86
E.1	General	86
E.2	Dielectric tests	87
E.3	Short-time withstand current tests	87
E.4	Operating and mechanical endurance tests	87
E.4.1	General	87
E.4.2	Operation under severe ice condition test	88
E.4.3	Low and high temperature test	88
E.5	Cable charging / Discharging current making test	88
Annex F	(informative) Example of location of neutral bus disconnector for one pole in an HVDC substation	89
Bibliography	91
Figure 1	– Position indicating/signalling device(s)	36
Figure 2	– Examples of test arrangement from a) to g) of different type of disconnectors (horizontal and vertical) with and without earthing switch combined	46
Figure 3	– Typical test circuit of oscillating RLC discharge	52
Figure 4	– Example of damped oscillating discharge of 525 kV XLPE cable of 300 km length, cross-section 2 000 mm ² and with a residual voltage of $U_{res} = 100$ kV	52
Figure 5	– Alternative test circuit of test duty 1	53
Figure 6	– Typical test circuit with damped RLC discharging oscillation (aperiodic)	55
Figure 7	– Example of discharging impulse (damped discharging oscillation, aperiodic) of 525 kV XLPE cable of 300 km length at system voltage by using a discharge resistor of 5 kΩ	55
Figure 8	– Fixed contact parallel to support	57
Figure 9	– Fixed contact perpendicular to support	58
Figure 10	– Example of the application of rated static mechanical terminal loads to a (divided support) pantograph disconnector (or earthing switch)	58
Figure 11	– Example of the application of rated static mechanical terminal loads to a two-column disconnector	59
Figure 12	– Test sequences for low and high temperature tests	66
Figure D.1	– Oscillation with parameters of 525 kV XLPE cable	85
Figure D.2	– Oscillation with parameters of 525 kV XLPE cable and residual voltage values	85
Figure F.1	– Location of (NBD) neutral bus disconnector	89

Table 1 – Multiterminal – Preferred rated insulation levels	24
Table 2 – Two-terminal – Preferred rated insulation levels	26
Table 3 – Preferred contact zones for "fixed" contacts supported by flexible conductors – outdoor installation	28
Table 4 – Preferred contact zones for "fixed" contacts supported by rigid conductors outdoor installation	28
Table 5 – Preferred static mechanical terminal loads –outdoor.....	29
Table 6 – Classification of disconnectors for mechanical endurance	29
Table 7 – Classification of earthing switches for mechanical endurance.....	30
Table 8 – Discharge classes based on energy amounts related to test duty 1	30
Table 9 – Discharge classes based on energy amounts related to test duty 2	30
Table 10 – Product information	32
Table 11 – List of type tests	38
Table 12 – Test voltages.....	41
Table C.1 – Tolerances on test quantities for type tests	80
Table D.1 – Common values of electrical characteristics of HV single-core copper cables (type XLPE)	81
Table D.2 – Common values of electrical characteristics of HV overhead lines	82
Table D.3 – Calculations regarding energy classification relating to test duty 1 (direct cable discharge) of earthing switches cable type: XLPE.....	83
Table E.1 – List of type tests valid according to IEC 62271-102	86
Table F.1 – Neutral bus disconnector – Preferred rated insulation levels for rated voltages.....	90

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

HIGH-VOLTAGE SWITCHGEAR AND CONTROLGEAR –

Part 314: Direct current disconnectors and earthing switches

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IEC TS 62271-314 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/1377/DTS	17A/1388B/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 this document. In order to simplify the indication of corresponding requirements, the same numbering of clauses and subclauses is used as in IEC TS 62271-5. Modifications 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

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HIGH-VOLTAGE SWITCHGEAR AND CONTROLGEAR –

Part 314: Direct current disconnectors and earthing switches

1 Scope

This part of IEC 62271, which is a Technical Specification, applies to high-voltage direct current disconnectors and earthing switches, designed for indoor and outdoor installations and for operation on HVDC transmission systems having direct voltages of 100 kV and above.

It also applies to the operating devices of these disconnectors and earthing switches and their auxiliary equipment.

NOTE Disconnectors in which the fuse forms an integral part are not covered by this document.

2 Normative references

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

IEC 60050-151, *International Electrotechnical Vocabulary (IEV) – Part 151: Electrical and magnetic devices*

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

IEC 60050-471, *International Electrotechnical Vocabulary (IEV) – Part 471: Insulators*

IEC 60050-614, *International Electrotechnical Vocabulary (IEV) – Part 614: Generation, transmission and distribution of electricity – Operation*

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

IEC 60529:1989, *Degrees of protection provided by enclosures (IP Code)*

IEC 60529:1989/AMD1:1999

IEC 60529:1989/AMD2:2013

IEC 62262:2002, *Degrees of protection provided by enclosures for electrical equipment against external mechanical impacts (IK code)*

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

IEC 62271-1:2017/AMD1:2021

IEC TS 62271-5:2024, *High-voltage switchgear and controlgear – Part 5: Common specifications for direct current switchgear and controlgear*

IEC 62271-200:2021, *High-voltage switchgear and controlgear – Part 200: AC metal-enclosed switchgear and controlgear for rated voltages above 1 kV and up to and including 52 kV*

IEC 62271-201:2014, *High-voltage switchgear and controlgear – Part 201: AC solid-insulation enclosed switchgear and controlgear for rated voltages above 1 kV and up to and including 52 kV*

IEC 62271-203:2022, *High-voltage switchgear and controlgear – Part 203: AC gas-insulated metal-enclosed switchgear for rated voltages above 52 kV*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60050-151, IEC 60050-441, IEC 60050-471, IEC 60050-614, and IEC TS 62271-5, as well as 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

3.1.101

indoor switchgear and controlgear

switchgear and controlgear designed solely for installation within a building or other housing, where the switchgear and controlgear is protected against wind, rain, snow, abnormal dirt deposits, abnormal condensation, ice and hoar frost

[SOURCE: IEC 60050-441:2000, 441-11-04]

3.1.102

outdoor switchgear and controlgear

switchgear and controlgear suitable for installation in the open air, i.e. capable of withstanding wind, rain, snow, dirt deposits, condensation, ice and hoar frost

[SOURCE: IEC 60050-441:2000, 441-11-05]

3.1.103

user

person or legal entity using the disconnectors or earthing switches

Note 1 to entry: This can include the purchaser (for example an electricity supplier), but it can also include the contracting company, the staff responsible for erection of installation, the maintenance or operating staff or anybody else temporarily or permanently responsible for the disconnector, earthing switch or electrical installation, or even the operation of the switchgear.

3.2 Assemblies of switchgear and controlgear

3.2.101

test object

equipment needed to represent the switchgear and controlgear for a particular type test

[SOURCE: IEC 62271-1:2017, 3.2.1]

3.3 Parts of assemblies

3.3.101

transport unit

part of switchgear and controlgear intended for transportation without being dismantled

[SOURCE: IEC 62271-1:2017, 3.3.1]

3.3.102

busbar

low-impedance conductor to which several electric circuits can be connected at separate points

Note 1 to entry: In many cases, the busbar consists of a bar.

[SOURCE: IEC 60050-151:2001, 151-12-30]

3.4 Switching devices

3.4.101

disconnecter

mechanical switching device which provides, in the open position, an isolating distance in accordance with specified requirements

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

Note 2 to entry: "Negligible current" implies residual currents such as the capacitive currents of converter stations, cables, DC filter capacitors, bushings, connections, and currents of permanently connected grading elements of circuit-breakers and voltage dividers (see applications indicated in Annex A of IEC TS 62271-5:2024). The currents may be $\leq 1A$ according to CIGRE TB-683.

[SOURCE: IEC 60050-441:2000, 441-14-05, modified – Note 2 to entry has been added]

3.4.102

divided support disconnecter (or earthing switch)

disconnecter (or earthing switch) in which the fixed and moving contacts of each pole are not supported by a common base or frame

Note 1 to entry: A typical example is the pantograph or semi-pantograph disconnecter (or earthing switch).

[SOURCE: IEC 60050-441:2000, 441-14-06 and –07, modified – The term "earthing switch" is completed with "divided support" and the term "disconnecter" substituted by "earthing switch" in Note 1 to entry when appropriate; Note 2 to entry deleted.]

3.4.103

centre-break disconnecter

disconnecter in which both contacts of each pole are movable and engage at a point substantially midway between their supports

Note 1 to entry: This term applies to high-voltage disconnecters only.

[SOURCE: IEC 60050-441:2000, 441-14-08]

3.4.104

double-break disconnecter

disconnecter that opens a circuit at two points

[SOURCE: IEC 60050-441:2000, 441-14-09]

3.4.105**resistor-fitted disconnecter**

disconnecter fitted with resistor in series or in parallel to the switching contacts in order to mitigate the very fast transient overvoltage (VFTO) during both the opening and closing operation in metal-enclosed gas-insulated switchgear

3.4.106**earthing switch**

mechanical switching device for earthing parts of a circuit, capable of withstanding for a specified time currents under abnormal conditions such as those of short-circuit, but not required to carry current under normal conditions of the circuit

Note 1 to entry: An earthing switch may have a short-circuit making capacity.

Note 2 to entry: These devices may sometimes be operated against short-circuit. The different classes of earthing switches are related to the number of short-circuit making operations.

Note 3 to entry: In some cases, earthing switches are used as fault-initiating devices.

[SOURCE: IEC 60050-441:2000, 441-14-11, modified – Notes 2 and 3 to entry have been added]

3.4.107**combined function earthing switch**

earthing switch having a common contact system for earthing and disconnecting

3.4.108**converter hall bushing earthing switch**

earthing switch that usually earths the bushing in the valve hall

Note 1 to entry: Usually, converter hall bushing earthing switch is defined as a separate element because is composed by only fix contact and movable contacts and frame.

3.4.109**converter earthing switch**

earthing switch or group of earthing switches that usually earths module by module all the VSC valve levels

Note 1 to entry: One single converter earthing switch can include several terminals to connect to the earth several VSC valve levels at the same time.

Note 2 to entry: Converter earthing switches can be operated as a single earthing switch with several terminals to be operated by on single control.

3.4.110**capacitive discharging earthing switch**

earthing switch that is used to put earth on a cable or a line partially charged at U_{rd} (capability to discharge the energy stored in cable or line)

3.5 Parts of switchgear and controlgear**3.5.101****pole of a switching device**

portion of a switching device associated exclusively with one electrically separated conducting path of its main circuit and excluding those portions which provide a means for mounting and operating all poles together

Note 1 to entry: A switching device is called single-pole if it has only one pole. If it has more than one pole, it may be called multipole (two-pole, three-pole, etc.) provided the poles are or can be coupled in such a manner as to operate together.

[SOURCE: IEC 60050-441:2000, 441-15-01]

3.5.102**main circuit <of a switching device>**

all the conductive parts of a switching device included in the circuit which it is designed to close or open

[SOURCE: IEC 60050-441:2000, 441-15-02]

3.5.103**contact <of a mechanical switching device>**

conductive parts designed to establish circuit continuity when they touch and which, due to their relative motion during an operation, open or close a circuit or, in the case of hinged or sliding contacts, maintain circuit continuity

[SOURCE: IEC 60050-441:2000, 441-15-05]

3.5.104**main contact**

contact included in the main circuit of a mechanical switching device, intended to carry, in the closed position, the current of the main circuit

[SOURCE: IEC 60050-441:2000, 441-15-07]

3.5.105**control contact**

contact included in a control circuit of a mechanical switching device and mechanically operated by this device

[SOURCE: IEC 60050-441:2000, 441-15-09]

3.5.106**"a" contact****make contact**

control or auxiliary contact that is closed when the main contacts of the mechanical switching device are closed and open when they are open

[SOURCE: IEC 60050-441:2000, 441-15-12]

3.5.107**"b" contact****break contact**

control or auxiliary contact that is open when the main contacts of a mechanical switching device are closed and closed when they are open

[SOURCE: IEC 60050-441:2000, 441-15-13]

3.5.108**position-indicating device**

part of a mechanical switching device that indicates whether it is in the open, closed, or where appropriate, earthed position

[SOURCE: IEC 60050-441:2000, 441-15-25]

3.5.109**position-signalling device**

part of a disconnector or earthing switch which uses auxiliary energy to indicate whether the contacts of the main circuit are in the open or closed position

**3.5.110
terminal**

conductive part of a device, electric circuit, or electric network, provided for connecting that device, electric circuit or electric network to one or more external conductors

[SOURCE: IEC 60050-151:2014, 151-12-12, modified – the note has been deleted.]

**3.5.111
contact zone <for divided support disconnectors and earthing switches>**

spatial region of positions the fixed contact may take up for correct engagement with the moving contact

**3.5.112
power kinematic chain**

mechanical connecting system between the operating mechanism and the moving contacts

Note 1 to entry: Refer to Figure 1.

**3.5.113
position-indicating kinematic chain**

mechanical connecting system between the moving contacts and the position-indicating device(s)

**3.5.114
position-signalling kinematic chain**

mechanical connecting system between the moving contacts and the position of the signalling device(s)

**3.5.115
connecting point**

most upstream point (i.e. the closest to the source of energy) of the common part of the power and position-indicating/signalling kinematic chains

**3.5.116
strain limiting device**

device that limits to a defined value the torque or force transmitted to the downstream side of the device irrespective of the torque or force applied to the upstream side

**3.5.117
torque (force) controlling system**

system that monitors and controls the torque (force) transmitted to the downstream side of the device in comparison with defined value

**3.5.118
bushing**

device that enables one or several conductors to pass through a partition such as a wall or a tank, and insulate the conductors from it

[SOURCE: IEC 60050-471:2007, 471-02-01, modified – Notes 1 and 2 to entry deleted]

**3.5.119
source of energy**

origin of the energy released or of the force/torque applied to the power kinematic chain of a switching device during an operation or at any stable position of it

Note 1 to entry: The origin of the energy or force/torque can be human, electrical, hydraulics, pneumatics and mechanics i.e. springs, weights, etc. alone or in combination.

3.5.120**arcing contact**

contact on which the arc is intended to be established

Note 1 to entry: An arcing contact may serve as a main contact; it may be a separate contact so designed that it opens after and closes before another contact which it is intended to protect from injury.

[SOURCE: IEC 60050-441:2000, 441-15-08]

3.6 Operational characteristics of switchgear and controlgear**3.6.101****operation**

<of a mechanical switching device>

transfer of the moving contact(s) from one position to an adjacent position

Note 1 to entry: For disconnector or earthing switch, this may be a closing operation or an opening operation.

Note 2 to entry: If distinction is necessary, an operation in the electrical sense, e.g. make or break, is referred to as a switching operation, and an operation in the mechanical sense, e.g. close or open, is referred to as a mechanical operation.

[SOURCE: IEC 60050-441:2000, 441-16-01]

3.6.102**operating cycle**

<of a mechanical switching device>

succession of operations from one position to another and back to the first position through all other positions, if any

[SOURCE: IEC 60050-441:2000, 441-16-02]

3.6.103**closing operation**

<of a mechanical switching device>

operation by which the device is brought from the open position to the closed position

[SOURCE: IEC 60050-441:2000, 441-16-08]

3.6.104**opening operation**

<of a mechanical switching device>

operation by which the device is brought from the closed position to the open position

[SOURCE: IEC 60050-441:2000, 441-16-09]

3.6.105**dependent manual operation**

<of a mechanical switching device>

operation solely by means of directly applied manual energy, such that the speed and force of the operation are dependent upon the action of the operator

Note 1 to entry: Dependent manual operation may be performed by a crank or by a swing lever (horizontal or vertical).

Note 2 to entry: Switching devices with dependent manual operation have not any inherent switching capability.

[SOURCE: IEC 60050-441:2000, 441-16-13, modified – Notes 1 and 2 to entry have been added]

3.6.106**dependent power operation**

<of a mechanical switching device>

operation by means of energy other than manual, where the completion of the operation is dependent upon the continuity of the power supply (to solenoids, electric or pneumatic motors, etc.)

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

3.6.107**stored energy operation**

<of a mechanical switching device>

operation by means of energy stored in the mechanism itself prior to the completion of the operation and sufficient to complete it under predetermined conditions

Note 1 to entry: This kind of operation may be subdivided according to:

- the manner of storing the energy (spring, weight, etc.);
- the origin of the energy (manual, electric, etc.);
- the manner of releasing the energy (manual, electric, etc.).

[SOURCE: IEC 60050-441:2000, 441-16-15]

3.6.108**independent manual operation**

<of a mechanical switching device>

stored energy operation where the energy originates from manual power, stored and released in one continuous operation, such that the speed and force of the operation are independent of the action of the operator

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

3.6.109**closed position**

<of a mechanical switching device>

position in which the predetermined continuity of the main circuit of the device is secured

Note 1 to entry: Predetermined continuity means that the contacts are fully closed to carry the rated continuous and the rated short-circuit currents, as applicable.

[SOURCE: IEC 60050-441:2000, 441-16-22, modified – Note to entry has been added]

3.6.110**open position**

<of a mechanical switching device>

position in which the predetermined clearance between open contacts in the main circuit of the device is secured

[SOURCE: IEC 60050-441:2000, 441-16-23]

3.6.111**toggle point**

point beyond which any further movement of the charging mechanism causes the stored energy to be released

3.6.112**mechanical endurance**

<of a disconnecter or earthing switch>

capability of a disconnecter or earthing switch to perform a defined number of operations without voltage on or current through the circuit under specified operation conditions

3.7 Characteristic quantities**3.7.101****peak current**

peak value of current during the transient period following initiation

3.7.102**short-time withstand current**

current that a circuit or a switching device in the closed position can carry during a specified short time under prescribed conditions of use and behaviour

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

3.7.103**peak withstand current**

value of peak current that a circuit or a switching device in the closed position can withstand under prescribed conditions of use and behaviour

[SOURCE: IEC 60050-441:2000, 441-17-18]

3.7.104**insulation level**

set of withstand voltages specified which characterize the dielectric strength of the insulation

[SOURCE: IEC 60050-614:2016, 614-03-23]

3.7.105**lightning impulse withstand voltage**

peak value of the lightning impulse voltage which the insulation of the disconnecter or earthing switch withstands under specified test conditions

3.7.106**switching impulse withstand voltage**

peak value of the switching impulse voltage which the insulation of the disconnecter or earthing switch withstands under specified test conditions

3.7.107**external insulation**

distances in atmospheric air, and along the surfaces in contact with atmospheric air of solid insulation of the equipment which are subject to dielectric stresses and to the effects of atmospheric and other environmental conditions from the site

Note 1 to entry: Examples of environmental conditions are pollution, humidity, vermin, etc.

Note 2 to entry: External insulation is either weather-protected or non-weather-protected, designed to operate inside or outside closed shelters, respectively.

[SOURCE: IEC 60050-614:2016, 614-03-02, modified – Note 2 to entry has been added]

3.7.108**internal insulation**

internal distances of the solid, liquid or gaseous insulation of equipment which are protected from the effects of atmospheric and other external conditions

[SOURCE: IEC 60050-614:2016, 614-03-03]

3.7.109**self-restoring insulation**

insulation which completely recovers its insulating properties after a disruptive discharge caused by the application of a test voltage

[SOURCE: IEC 60050-614:2016, 614-03-04, modified ("witing a short time interval" removed, "caused by the application of a test voltage" added)]

3.7.110**non-self-restoring insulation**

insulation which loses its insulating properties, or does not recover them completely, after a disruptive discharge caused by the application of a test voltage

Note 1 to entry: In high-voltage apparatus, parts of both self-restoring and non-self-restoring insulation are always operating in combination and some parts may be degraded by repeated or continued voltage applications. The behaviour of the insulation in this respect should be taken into account by the relevant Technical Committee when specifying the test procedures to be applied.

[SOURCE: IEC 60050-614:2016, 614-03-05, modified ("caused by the application of a test voltage" added, Note 1 to entry added)]

3.7.111**parallel insulation**

insulator arrangement with two insulators in parallel where the distance between the two insulators might influence the dielectric strength

Note 1 to entry: With open terminal disconnectors and earthing switches, parallel insulation is used when a drive insulator is situated next to a support insulator.

3.7.112**disruptive discharge**

failure of insulation under electric stress, in which the discharge completely bridges the insulation under test, reducing the voltage between electrodes to practically zero

Note 1 to entry: Non-sustained disruptive discharge in which the test object is momentarily bridged by a spark or arc may occur. During these events the voltage across the test object is momentarily reduced to zero or to a very small value. Depending on the characteristics of the test circuit and the test object, a recovery of dielectric strength may occur and may even allow the test voltage to reach a higher value. Such an event should be interpreted as a disruptive discharge unless otherwise specified by the relevant technical committee.

Note 2 to entry: A disruptive discharge in a solid dielectric produces permanent loss of dielectric strength; in a liquid or gaseous dielectric the loss may be only temporary.

[SOURCE: IEC 60060-1:2010, 3.1.1]

3.7.113**clearance**

distance between two conductive parts along a string stretched the shortest way between these conductive parts

[SOURCE: IEC 60050-441:2000, 441-17-31]

3.7.114**clearance between poles**

clearance between any conductive parts of adjacent poles

[SOURCE: IEC 60050-441:2000, 441-17-32]

3.7.115**clearance to earth**

clearance between any conductive parts and any parts which are earthed or intended to be earthed

[SOURCE: IEC 60050-441:2000, 441-17-33]

3.7.116**clearance between open contacts**

total clearance between the contacts, or any conductive parts connected thereto, of a pole of a mechanical switching device in the open position

Note 1 to entry: The total clearance is the sum of the clearances existing between the contacts.

[SOURCE: IEC 60050-441:2000, 441-17-34, modified – Note to entry has been added]

3.7.117**mechanical terminal load**

external load acting on each terminal

Note 1 to entry: The external load is the result of the combined mechanical forces which may be applied to the terminals of the switching device. Wind forces acting on the equipment itself are not included as they do not contribute to the external load acting on terminals.

Note 2 to entry: A disconnector or earthing switch can be subjected to several mechanical forces different in value, direction and point of action.

Note 3 to entry: The terminal loads as defined here do not usually apply to enclosed switchgear.

Note 4 to entry: The terminal loads as defined here do not usually apply indoor application.

3.7.118**static mechanical terminal load**

static mechanical terminal load at each terminal equivalent to the mechanical force to which this terminal of the disconnector or earthing switch is subjected by the flexible or rigid conductor connected to this terminal

Note 1 to entry: The static mechanical terminal load includes forces resulting from ice, wind and connected conductors.

3.7.119**dynamic mechanical terminal load**

combination of the static mechanical load and the electromagnetic forces under short-circuit conditions

3.7.122**transient voltage to earth**

U_{TVE}

voltage to earth which appears at the first prestrike during a closing operation of a disconnector

3.7.123**filling pressure (or density) for insulation and/or switching**

pressure in Pascal (Pa) for insulation and/or for switching, referred to the standard atmospheric air conditions of +20 °C and 101,3 kPa (or density), which may be expressed in relative or absolute terms, to which the assembly is filled before being put into service, or automatically replenished

[SOURCE: IEC 62271-1:2017, 3.6.5.1]

3.7.124**minimum functional pressure (or density) for insulation and/or switching**

pressure (Pa) for insulation and/or for switching, referred to the standard atmospheric air conditions of +20 °C and 101,3 kPa (or density), which may be expressed in relative or absolute terms, at which and above which rated characteristics of switchgear and controlgear are maintained and at which a replenishment becomes necessary

[SOURCE: IEC 62271-1:2017, 3.6.5.5]

3.8 Index of definitions

A – B

"a" contact	3.5.106
arcing contact	3.5.120
"b" contact	3.5.107
Busbar	3.3.102
Bushing	3.5.118

C

Capacitive discharging earthing switch	3.4.110
Centre-break disconnecter	3.4.103
Clearance	3.7.113
Clearance between open contacts	3.7.116
Clearance between poles	3.7.114
Clearance to earth	3.7.115
Closed position	3.6.109
Closing operation	3.6.103
Combined function earthing switch	3.4.107
Connecting point	3.5.115
Contact (of a mechanical switching device)	3.5.103
Contact zone (for divided support disconnectors and earthing switches)	3.5.111
Control contact	3.5.105
Converter earthing switch	3.4.109
Converter hall bushing earthing switch	3.4.108

D

Dependent manual operation (of a mechanical switching device)	3.6.105
Dependent power operation (of a mechanical switching device)	3.6.106
Disconnecter	3.4.101
Disruptive discharge	3.7.112
Divided support disconnecter	3.4.102
Divided support earthing switch	3.4.102
Double-break disconnecter	3.4.104
Dynamic mechanical terminal load	3.7.119

E

Earthing switch	3.4.106
External insulation	3.7.107

I

Independent manual operation (of a mechanical switching device)	3.6.108
Indoor switchgear and controlgear	3.1.101
Insulation level	3.7.104
Internal insulation	3.7.108

L – N

Lightning impulse withstand voltage	3.7.105
Main circuit (of a switching device)	3.5.102
Main contact	3.5.104
Mechanical endurance of a disconnecter or earthing switch	3.6.112
Mechanical terminal load	3.7.117
Minimum functional density for insulation	3.7.124
Minimum functional pressure for insulation	3.7.124
Non-self-restoring insulation	3.7.110

O

Open position (of a mechanical switching device)	3.6.110
Opening operation (of a mechanical switching device)	3.6.104
Operation (of a mechanical switching device)	3.6.101
Operating cycle (of a mechanical switching device)	3.6.102
Outdoor switchgear and controlgear	3.1.102

P

Parallel insulation	3.7.111
Peak current	3.7.101
Peak withstand current	3.7.103
Pole of a switching device	3.5.101
Position-indicating device	3.5.108
Position-indicating kinematic chain	3.5.113
Position-signalling device	3.5.109
Position-signalling kinematic chain	3.5.114

Power kinematic chain	3.5.112
R – U	
Rated filling density for insulation	3.7.123
Rated filling pressure for insulation	3.7.123
Resistor-fitted disconnecter	3.4.105
Self-restoring insulation	3.7.109
Short-time withstand current	3.7.102
Source of energy	3.5.119
Static mechanical terminal load	3.7.118
Stored energy operation (of a mechanical switching device)	3.6.107
Strain limiting device	3.5.116
Switching impulse withstand voltage	3.7.106
Terminal	3.5.110
Test object	3.2.101
Toggle point	3.6.111
Torque (force) controlling system	3.5.117
Transient voltage to earth	3.7.122
Transport unit	3.3.101
User	3.1.103

4 Normal and special service conditions

Clause 4 of IEC TS 62271-5:2024 is applicable, except point e) of 4.1.3, which is modified as follows:

- e) ice coating does not exceed 10 mm;

5 Ratings

5.1 General

Clause 5 of IEC TS 62271-5:2024 is applicable for a disconnecter or earthing switch, including their operating devices and auxiliary equipment. The list of ratings is complemented with the following items:

- a) rated contact zone (only if applicable);
- b) rated static mechanical terminal load;
- c) rated ice-coating;
- d) mechanical endurance class;
- e) rated cable discharging class (for earthing switches only if applicable).

Ratings for making and breaking capabilities cannot be assigned to disconnectors or earthing switches with only manual dependent operation.

In the case of disconnectors and earthing switches with both dependent power and dependent manual operation, any making and breaking capability is not valid for dependent manual operation.

5.2 Rated direct voltage (U_{rd})

Subclause 5.2 of IEC TS 62271-5:2024 is applicable.

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

Subclause 5.3 of IEC TS 62271-5:2024 is applicable with the following addition:

For disconnectors rated voltage of 105 kV and above and disconnectors having an isolating distance in parallel to the base of the disconnector and having integrated earthing switches, the insulation level between moving parts of the earthing switch and the opposite live parts, during operation of the earthing switch, shall be at least the short-duration direct voltage or power frequency peak withstand voltage for the smallest gap between them specified in 7.2.6.

If safety regulations specify higher withstand values for earthing switches that have manual operating mechanisms only, this has to be agreed upon between the user and the manufacturer.

Preferred rated insulation levels of IEC TS 62271-5:2024 are presented subdivided in Table 1 and Table 2 in order to make clear the direct voltage applied to the opposite terminal of the line disconnector. For line disconnectors installed on multiterminal HVDC transmission systems (both LCC and VSC technology), the direct voltage that shall be applied at the opposite terminal is the full voltage (U_{rd}), instead for line disconnectors installed on two-terminal HVDC transmission systems (both LCC and VSC technology) the direct voltage that shall be applied is 10 % of U_{rd} . For the other types of disconnectors, no direct voltage shall be applied at the opposite terminal in case of dielectric test.

For neutral bus disconnectors, information is given in Annex F.

Superimposed voltage is not applicable to disconnectors or earthing switches.

Table 1 – Multiterminal – Preferred rated insulation levels

Rated direct voltage U_{rd} kV (NOTE 1)	Rated direct withstand voltage U_{dd} kV	Rated switching impulse withstand voltage U_s kV (peak value)		Rated lightning impulse withstand voltage U_p kV (peak value)	
	Pole-to-earth Across open switching device and/or isolating distance (NOTE 2)	Pole-to-earth and across open switching device (NOTE 3)	Across isolating distance ^a	Pole-to-earth (NOTE 3)	Across open switching device and/or isolating distance ^a
(1)	(2)	(3)	(4)	(5)	(6)
105	160	--	--	380	380(+105)
160	240	--	--	450	450(+160)
210	315	550	550(+210)	550	550(+210)
				650	650(+210)
265	395	550	550(+265)	550	550(+265)
				650	650(+265)
		650	650(+265)	650	650(+265)
				750	750(+265)

Rated direct voltage U_{rd} kV (NOTE 1)	Rated direct withstand voltage U_{dd} kV	Rated switching impulse withstand voltage U_s kV (peak value)		Rated lightning impulse withstand voltage U_p kV (peak value)	
	Pole-to-earth Across open switching device and/or isolating distance (NOTE 2)	Pole-to-earth and across open switching device (NOTE 3)	Across isolating distance ^a	Pole-to- earth (NOTE 3)	Across open switching device and/or isolating distance ^a
(1)	(2)	(3)	(4)	(5)	(6)
340	505	650	650(+340)	650	650(+340)
				750	750(+340)
		850	850(+340)	850	850(+340)
				950	950(+340)
420	630	850	850(+420)	850	850(+420)
				950	950(+420)
		950	950(+420)	950	950(+420)
				1 050	1 050(+420)
		1 175	1 175(+420)	1 175	1 175(+420)
				1 175	1 175(+420)
525 ^b	790	950	950(+525)	950	950(+525)
				1 050	1 050(+525)
		1 175	1 175(+525)	1 175	1 175(+525)
				1 300	1 300(+525)
		1 425	1 425(+525)	1 425	1 425(+525)
				1 425	1 425(+525)
630	945	1 175	1 175(+630)	1 175	1 175(+630)
				1 300	1 300(+630)
		1 425	1 425(+630)	1 425	1 425(+630)
				1 550	1 550(+630)
840	1 260	1 550	1 550(+840)	1 550	1 550(+840)
				1 675	1 675(+840)
		1 675	1 675(+840)	1 675	1 675(+840)
				1 800	1 800(+840)
		1 950	1 950(+840)		

NOTE 1 The rated direct voltage U_{rd} takes into account 5 % of ripple and harmonics to the typical system direct voltage, based on that the ripples and harmonics are in the range of 2 % to 5 % of the typical system direct voltage. Reference is made to CIGRE Technical Brochure 684 [70]¹.

NOTE 2 The rated direct withstand voltage U_{dd} is 150 % of the rated direct voltage, reference is made to IEC TS 63014-1.

NOTE 3 The values in columns (3) and (5) are referred to IEC 60071-11:2022, Annex C.

^a In columns (4) and (6), values in brackets are the rated direct voltage applied to the opposite terminal (combined voltage) only applicable to line disconnectors. For equipment not subjected to direct voltage at the opposite terminal, columns (4) and (6) are not applicable.

^b Instead of $U_{rd} = 525$ kV rated direct voltage, $U_{rd} = 550$ kV may also be reasonable. Reference is made to IEC 60071-11:2022, Annex C. In this case, the values in brackets of columns (4) and (6) have to be adapted to the higher value of U_{rd} and the rated direct withstand voltage in column (2) has to be re-calculated according to NOTE 1.

¹ Numbers in square brackets refer to the bibliography.

Table 2 – Two-terminal – Preferred rated insulation levels

Rated direct voltage U_{rd} kV (NOTE 1)	Rated direct withstand voltage U_{dd} kV	Rated switching impulse withstand voltage U_s kV (peak value)		Rated lightning impulse withstand voltage U_p kV (peak value)	
	Pole-to-earth Across open switching device and/or isolating distance (NOTE 2)	Pole-to-earth and across open switching device (NOTE 3)	Across isolating distance ^a	Pole-to-earth (NOTE 3)	Across open switching device and/or isolating distance ^a
(1)	(2)	(3)	(4)	(5)	(6)
105	160	--	--	380	380(+11)
160	240	--	--	450	450(+16)
210	315	550	550(+21)	550	550(+21)
				650	650(+21)
265	395	550	550(+27)	550	550(+27)
				650	650(+27)
				650	650(+27)
				750	750(+27)
340	505	650	650(+34)	650	650(+34)
				750	750(+34)
				850	850(+34)
				950	950(+34)
420	630	850	850(+42)	850	850(+42)
				950	950(+42)
				950	950(+42)
				1 050	1 050(+42)
				1 175	1 175(+42)
525 ^b (NOTE 3)	790	950	950(+53)	950	950(+53)
				1 050	1 050(+53)
				1 175	1 175(+53)
				1 300	1 300(+53)
				1 425	1 425(+53)
630	945	1 175	1 175(+63)	1 175	1 175(+63)
				1 300	1 300(+63)
				1 425	1 425(+63)
				1 550	1 550(+63)
840	1260	1 550	1 550(+84)	1 550	1 550(+84)
				1 675	1 675(+84)
				1 675	1 675(+84)
				1 800	1 800(+84)
				1 950	1 950(+84)

NOTE 1 The rated direct voltage U_{rd} takes into account 5 % of ripple and harmonics to the typical system direct voltage, based on that the ripples and harmonics are in the range of 2 % to 5 % of the typical system direct voltage. Reference is made to CIGRE Technical Brochure 684 [70].

NOTE 2 The rated direct withstand voltage U_{dd} is 150 % of the rated direct voltage, reference is made to IEC TS 63014-1.

NOTE 3 The values in columns (3) and (5) are referred to IEC 60071-11:2022, Annex C.

^a In columns (4) and (6), values in brackets are the rated direct voltage applied to the opposite terminal (combined voltage) only applicable to line disconnectors. For equipment not subjected to direct voltage at the opposite terminal, columns (4) and (6) are not applicable.

^b Instead of $U_{rd} = 525$ kV rated direct voltage, $U_{rd} = 550$ kV may also be reasonable. Reference is made to IEC 60071-11:2022, Annex C. In this case, the values in brackets of column (4) and (6) has to be adapted to the higher value of U_{rd} and the rated direct withstand voltage in column (2) has to be re-calculated according to NOTE 1.

5.4 Rated continuous current (I_{rd})

Subclause 5.4 of IEC TS 62271-5:2024 is applicable. This subclause applies only to disconnectors.

5.5 Rated values of short-time withstand current 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 current (I_{kd})

Subclause 5.5.2 of IEC TS 62271-5:2024 is applicable with the following addition:

An earthing switch may be assigned a rating different from the rating of the related main circuit (if applicable).

An earthing switch forming an integral part of a combined function earthing switch may be assigned a rating different from the rating of its main circuit.

5.5.3 Rated peak withstand current (I_{pd})

Subclause 5.5.3 of IEC TS 62271-5:2024 is applicable with the following addition:

An earthing switch may be assigned a rating different from the rating of the related main circuit (if applicable).

An earthing switch forming an integral part of a combined function earthing switch may be assigned a rating different from the rating of its main circuit.

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

Subclause 5.5.4 of IEC TS 62271-5:2024 is applicable with the following addition:

An earthing switch may be assigned a rating different from the rating of the related main circuit (if applicable).

An earthing switch forming an integral part of a combined function earthing switch may be assigned a rating different from the rating of its main circuit.

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

Subclause 5.6 of IEC TS 62271-5:2024 is applicable.

5.7 Rated supply frequency of auxiliary circuits 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 contact zone

In case of divided support disconnectors and divided support earthing switches the manufacturer shall state the rated values of the contact zone (indicated by x_r , y_r and z_r). Preferred values are given in Table 3 and Table 4. The rated values shall be specified by the manufacturer. This refers also to a tolerable angular displacement of the fixed contact.

Table 3 – Preferred contact zones for "fixed" contacts supported by flexible conductors – outdoor installation

Rated direct voltage U_{rd} kV	x mm	y mm	z_1 mm	z_2 mm
105	100	300	200	300
160		350		
210		400		
265	200	500	250	450
340			300	
420			500	
525		600	400	500
630				550
840	250	650	450	550

x = total amplitude of longitudinal movement of the supporting conductor (temperature)
 y = total horizontal deflection (perpendicular to supporting conductor) (wind)
 z = vertical deflection (ice and temperature).
 NOTE z_1 are values for short-span, z_2 are values for long-span of the flexible conductors to which the fixed contacts are mounted.

Table 4 – Preferred contact zones for "fixed" contacts supported by rigid conductors outdoor installation

Rated direct voltage U_{rd} kV	x mm	y mm	z mm
105; 160	100	100	100
210; 265; 340; 420	150	150	150
525; 630	175	175	175
840	200	200	200

x = total amplitude of longitudinal movement of the supporting conductor (temperature).
 y = total horizontal deflection (perpendicular to supporting conductor) (wind).
 z = vertical deflection (ice).

5.102 Rated static mechanical terminal load

When disconnectors or earthing switches are intended to be directly connected to lines, i.e. flexible or rigid conductors, the rated static mechanical terminal load of each terminal shall be assigned, indicating the directions of application.

The maximum static mechanical terminal load to which a terminal of a disconnector or earthing switch is allowed to be subjected under the most disadvantageous conditions is the rated static mechanical terminal load.

Preferred values of outdoor installation static mechanical terminal loads are given in Table 5 and are intended to be used as a guide. The static terminal load is not usually assigned for an indoor installation.

Table 5 – Preferred static mechanical terminal loads –outdoor

Rated voltage U_{rd} kV	Rated continuous current I_r A	Two- and three-column disconnectors or earthing switches		Divided support disconnectors or earthing switches		Vertical Force F_c^a N
		Straight load F_{a1} and F_{a2}	Cross-load F_{b1} and F_{b2}	Straight load F_{a1} and F_{a2}	Cross-load F_{b1} and F_{b2}	
		In Figure 9		In Figure 8		
		N	N	N	N	
105	≤ 1 600	400	130	800	200	500
	> 1 600	500	170	800	200	
160	≤ 1 600	500	170	800	200	1 000
	> 1 600	600	200	1 000	300	
210	≤ 1 600	600	200	1 000	300	
	> 1 600	800	250	1 250	400	
265	≤ 2 500	800	270	1 250	400	1 250
	> 2 500	1 000	330	1 600	500	
340; 420	≤ 2 500	1 000	400	1 600	500	1 500
	> 2 500	1 500	500	1 800	600	
525; 630	≤ 3 150	1 600	530	2 000	800	1 500
	> 3 150	2 000	660	4 000	1 600	
840	≤ 3 150	1 600	530	2 000	800	1 500
	> 3 150	2 000	660	4 000	1 600	

^a F_c simulates the downward forces caused by the weight of the connecting conductors. F_c does not apply to flexible conductors.

NOTE The static mechanical terminal load includes forces resulting from ice, wind and connected conductors.

5.103 Classification of disconnectors for mechanical endurance

The mechanical endurance of disconnectors shall correspond to one of the classes given in Table 6. The performance is associated to a maintenance program defined by the manufacturer.

Table 6 – Classification of disconnectors for mechanical endurance

Class	Number of operating cycle	Mechanical endurance
M0	1 000	Normal
M1	2 000	Extended
M2	10 000	Extended

5.104 Classification of earthing switches for mechanical endurance

The mechanical endurance of earthing switches shall correspond to one of the classes given in Table 7. The performance is associated to a programme of maintenance defined by the manufacturer.

Table 7 – Classification of earthing switches for mechanical endurance

Class	Number of operating cycles	Mechanical endurance
M0	1 000	Normal
M1	2 000	Extended
M2	10 000	Extended

5.105 Rated ice-coating

For disconnectors and earthing switches able to operate under ice-conditions a rated ice coating shall be assigned by the manufacturer.

Preferred ratings of ice-coating for normal service condition are 1 mm and 10 mm.

Preferred rating of ice-coating for special service condition is 20 mm.

5.106 Rated cable discharge current making capability

The discharging capability of a capacitive discharging earthing switch is classified according to the requirements of a direct discharge of a HVDC cable, mainly with stored residual discharge energy, and by using a limiting discharging device (resistor) to operate at full system voltage. Table 8 and Table 9 are classifying earthing switches with a cable discharge current switching rating to common energy classes to cover a range of discharge applications.

Table 8 – Discharge classes based on energy amounts related to test duty 1

Class	Energy amount during discharging operation of test object E kJ	Peak current related to class I_p A	Duration of oscillation / impulse t s	Joule Integral related to class E_j kA ² s
A	≥ 10	1 500	≤ 0,1	25
B	≥ 50	3 200		130
C	≤ 100	4 500		250

NOTE 1 Test duty 1 of 7.101.2 usually describes a damped oscillating circuit. For example see Figure 4.

Table 9 – Discharge classes based on energy amounts related to test duty 2

Class	Test current related to class I A	Duration of oscillation / impulse t s	Joule Integral related to class E_j kA ² s
1	100	> 1 s	12,5
2	150		25
3	200		50

NOTE 2 Test duty 2 in 7.101.2 usually describes an aperiodic damped oscillating circuit. See example in Figure 7.

6 Design and construction

6.1 Requirements for liquids in disconnectors and earthing switches

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

6.2 Requirements for gases in disconnectors and earthing switches

Subclause 6.2 of IEC TS 62271-5:2024 is applicable with the following addition:

NOTE In general, the term "gas" for insulation and/or switching in this document refers to SF₆ and its mixtures. However, the principles expressed could be also used for other gases.

6.3 Earthing of disconnectors and earthing switches

Subclause 6.3 of IEC TS 62271-5:2024 is applicable with the following additions.

Metallic enclosures and operating mechanisms not mounted together with and not electrically connected to the metallic frame of the disconnector or earthing switch, shall be provided with an earthing terminal marked with the protective earth symbol.

If, for testing purposes after installation (e.g. cable testing, contact resistance measurement), a removable connection for earthing the main circuit through the earthing switch exists, it shall be able to withstand the rated peak and short-time withstand current. The relevant insulation level (DC and AC) of this external connection – when removed – shall be stated by the manufacturer.

6.4 Auxiliary and control equipment and circuits

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

Refer also to 6.104.

6.5 Dependent power operation

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

In the case of disconnectors and earthing switches with both dependent power and dependent manual operation, generally the switching device is not capable of making and breaking operation. If it is possible from safety point of view for the operator, it shall be clearly stated in the instruction manual and also displayed at the point of manual operation that they are capable of making and breaking when manually operated.

Disconnectors and earthing switches having a pneumatic or hydraulic operating device shall be capable of closing and opening when the supply pressure is between the minimum (85 %) and the maximum (110 %) of the rated pressure if not otherwise specified.

See also 6.105 for maximum manual operating forces.

6.6 Stored energy operation

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

See also 6.105 for maximum manual operating (storing energy) forces.

6.7 Independent unlatched operation (independent manual or power operation)

Subclause 6.7 of IEC TS 62271-5:2024 is applicable with the following addition:

See also 6.105 for maximum manual operating (storing energy) forces.

6.8 Manually operated actuators

Subclause 6.8 of IEC TS 62271-5:2024 is 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:

- Disconnectors, earthing switches and their operating devices that are designed to be:
 - used as stand alone or may be integrated as components for switchgear, shall be provided with nameplates that contain information in accordance with Table 10;
 - integrated in a particular family of switchgear and controlgear shall integrate the information on the nameplate(s) and/or in the manufacturer instruction manual of the switchgear and controlgear, as indicated in Table 10.

Table 10 – Product information

Information to be put on the nameplate	Abbreviation	Unit	Disconnector	Earthing switch ^a	Operating device
Manufacturer			x	x	x
Manufacturer's type designation			x	x	x
Mechanical endurance class			x ^b	x ^b	x
Instruction book reference			x	x	x
Year of manufacture			x	x	x
Reference of this standard			x	x	x
Serial number			x	x	x
Rated direct voltage	U_{rd}	kV	x	x	
Rated frequency	f_r	Hz			x
Rated lightning impulse withstand voltage	U_p	kV	x	x	
Rated switching impulse withstand voltage for $U_{rd} \geq 265$ kV	U_s	kV	x	x	
Rated direct voltage withstand	U_{dd}	kV	x	x	
Rated continuous current	I_{rd}	A	x		
Rated short-time withstand current	I_{kd}	kA	x	x	
Rated duration of short-circuit	t_{kd}	s	x ^c	x ^c	
Rated peak withstand current	I_{pd}	kA	x	x	
Insulating fluid and mass	M_f	kg	x ^d	x ^d	

Information to be put on the nameplate	Abbreviation	Unit	Disconnecter	Earthing switch ^a	Operating device
Minimum and maximum ambient air temperature		°C	x ^e	x ^e	x ^e
Value of the resistor	R	Ω	x ^f		
Rated filling pressure for operation	P_{rm}	MPa			x
Minimum functional pressure for operation	p_{mm}	MPa			x
Alarm pressure for operation	P_{am}	MPa			x
Rated filling pressure for insulation	P_{re}	MPa	x	x	
Minimum functional pressure for insulation	p_{me}	MPa	x	x	
Alarm pressure for insulation	P_{ae}	MPa	x	x	
Minimum functional pressure for switching	p_{sw}	MPa	x	x	
Rated supply voltage of auxiliary and control circuits	U_a	V			x ^g
Rated static mechanical terminal load	F	N	x	x	
Mass (including liquid)	M	kg	x	x	x
Rated ice-coating		mm	x	x	x
Rated contact zone	x_r, y_r and z_r	mm	x ^h	x ^h	
Cable discharge class				x	

NOTE 1 The marking of values indicated by x is mandatory (if applicable).

NOTE 2 The word "rated" does not need to appear on the nameplate.

^a One nameplate may be used for an earthing switch and disconnector assembled as a single unit.

^b The class marking is mandatory if different from M0 or E0. It may be included into the type designation to avoid additional space requirement.

^c Mandatory if t different from 0,5 s.

^d Chemical formula for gas or commercial name for liquid (if any of both) shall be indicated.

^e Mandatory if different from –5 °C and/or +40 °C.

^f For resistor-fitted disconnectors.

^g Rated supply voltages of auxiliary and control circuits may have separate values which have to be indicated. Manufacturer shall also indicate if the supply is direct voltage or ac source.

^h For divided support disconnectors and/or divided support earthing switches of $U_r > 100$ kV.

6.12 Locking devices

Subclause 6.12 of IEC TS 62271-5:2024 is applicable with the following addition:

Disconnectors and earthing switches to be mechanically interlocked by blocking the operating shaft or power kinematic chain of the disconnector or earthing switch shall be designed to withstand:

- during motor-operation, the strain produced by the motor starting torque at the maximum motor supply voltage, or, if a strain limiting device is present, to its limiting value, and

- during manual-operation, 3 times the value of the corresponding maximum force given for manual operation in 6.105 (without considering peak value) or, if a strain limiting device is present, to 1,5 times its limiting value.

6.13 Position Indication

Subclause 6.13 of IEC TS 62271-5:2024 is applicable with the following addition:

Refer also to 6.104 of this document.

6.14 Degree of protection provided by enclosures

Subclause 6.14 of IEC TS 62271-5:2024 is applicable with the following addition for enclosures containing auxiliary and control circuits:

The degree of protection provided by enclosures for outdoor installation shall be a minimum of IP3XDW of IEC 60529:2013.

For indoor installations the degree of protection shall be not less than IP2X of IEC 60529:2013.

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 62271-5:2024 is applicable.

6.17 Tightness for liquid systems

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/or operation

Subclause 6.22 of IEC TS 62271-5:2024 is applicable with the following addition:

The pressure in Pa (or density) or liquid mass shall be assigned by the manufacturer referred to atmospheric air conditions of 20 °C at which the gas- or liquid-filled switchgear is filled before being put into service.

For operating devices having their own compressor or pump integral to them and with their own supplying pressure tank, the limits of filling (operating) pressure shall be stated by the manufacturer.

6.101 Particular requirements for earthing switches

Any material and any cross-section are allowed for connections between movable parts of an earthing switch and its frame, provided that the connections are able to withstand the electrical, mechanical and environmental stresses that occur in service.

6.102 Requirements in respect of the isolating distance of disconnectors

When the insulation across the isolating distance may be subjected to pollution in service, care shall be taken to ensure the suitability of insulator design (e.g. creepage distance, hydrophobicity, orientation of insulator). IEC TS 60815 (all parts) [2] can be used for guidance selecting the appropriate insulator design. The satisfactory performance of the insulation across the isolating distance under polluted conditions should be verified with the appropriate voltage withstand level corresponding to the isolating distance for which the disconnector is intended.

The design has also to take into account the effects of contamination caused by wear and arcing by-products. The effectiveness of the design to withstand these effects is verified by the condition checks specified in Clause 7 after the relevant type tests.

NOTE 1 It is usual that the isolating gap of a disconnector is longer than the phase-to-ground insulating distance, since IEC 62271-1:2017 specifies higher voltage withstand levels across the isolating distance than for the phase-to-ground insulation. However, where a long creepage distance is required, the phase-to-ground insulation distance can become longer than the isolating gap of the disconnector. Consider this aspect for dielectric sizing to ground of HVDC station.

NOTE 2 Test method for insulators can be found in IEC TS 60815 (all parts) [2].

6.103 Mechanical strength

The disconnector and earthing switch, including the insulators used, installed according to the manufacturer's instructions shall be able to:

- open and close correctly the main contacts under its rated static mechanical terminal loads;
- carry the rated continuous current (when applicable) under its rated static mechanical terminal loads;
- withstand the dynamic forces on its terminals under short-circuit conditions.

The required cantilever strength of an insulator shall be calculated taking into consideration the height of the terminal above the top of the insulator as well as additional forces acting on the insulator (see 3.7.119 and 9.2.105).

6.104 Operation of disconnectors and earthing switches – Position of the movable contact system and its indicating and signalling devices

6.104.1 Securing of position

Disconnectors and earthing switches, including their operating mechanisms, shall be designed in such a way that they cannot come out of their open or closed position by gravity, wind pressure, vibrations, reasonable shocks or accidental touching of the connecting rods of their operating system according to their service conditions as defined in Clause 4.

Disconnectors and earthing switches shall permit temporary mechanical locking in at least the open position (for disconnectors) and closed position (for earthing switches) except for disconnectors or earthing switches whose contacts are directly moved by a hook-stick.

6.104.2 Additional requirements for power-operated mechanisms

Power operated mechanisms shall also provide a manual operating facility. Connecting a hand-operating device (for instance a hand crank) to the power-operated mechanism shall ensure safe interruption of the control energy to the power-operated mechanism.

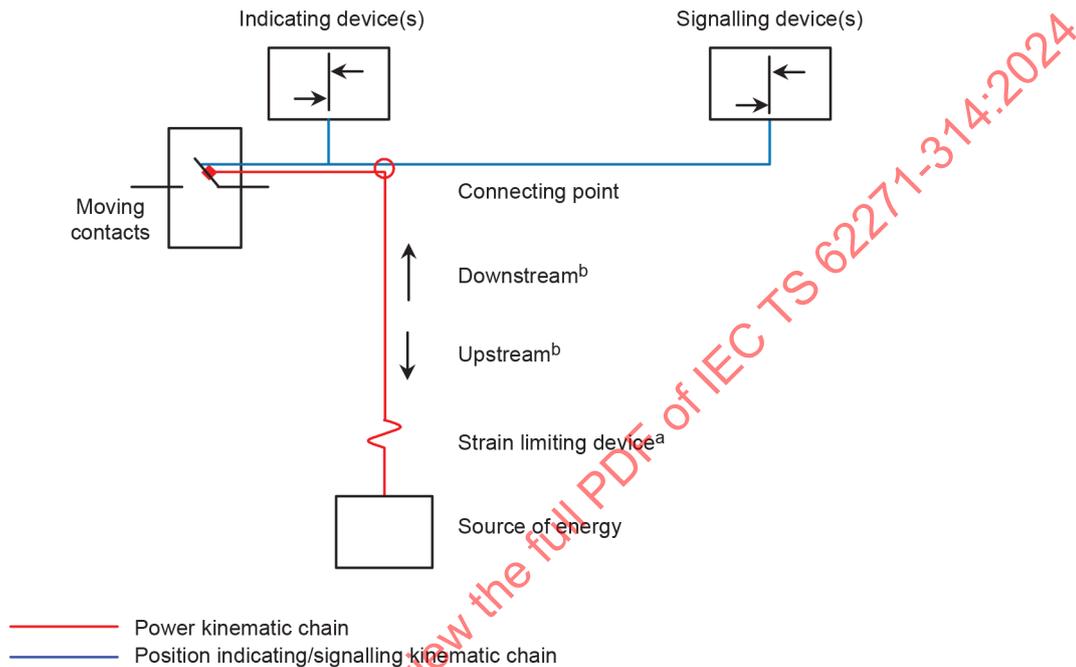
6.104.3 Indication and signalling of position

6.104.3.1 General requirements

Indication and signalling of the closed and open position shall not take place unless the moving contacts have reached their closed or open position, respectively.

NOTE For the definition of "closed" and "open" see 3.6.109 and 3.6.110.

Figure 1 represents the different elements involved in indication and signalling of positions, and some design conditions.



Key

- ^a The strain limiting device (if any) can be an external device or an internal as part of the source of energy, e.g. torque (force) controlling system.
- ^b Upstream is the direction towards the source of energy, downstream is the direction towards the contacts.

Figure 1 – Position indicating/signalling device(s)

The strain limiting device (if any) may be placed at any point along the power kinematic chain between the source of energy and the connecting point, but it shall not be along the position indicating/signalling kinematic chain. See 6.104.3.2 and 6.104.3.3.

The position-indicating device(s) shall be fixed directly on a mechanical part of the power kinematic chain or mechanically connected to it through a separate position indicating/signalling kinematic chain. If the position indicator is not directly fixed on the mechanical part of the power kinematic chain, then the position-indicating kinematic chain from the connecting point shall be placed inside an enclosure providing a minimum degree of protection equivalent to IP2XC of IEC 60529:1989 + AMD1:1999 + AMD2:2013, and with an impact level IK 07 of IEC 62262:2002.

The position-signalling kinematic chain shall be placed inside an enclosure with the same levels of protection as defined for the position-indicating kinematic chain.

6.104.3.2 Indication of position

It shall be possible to know the position of the disconnecter or earthing switch. The indication of the position of the disconnecter or earthing switch is given if one of the following conditions is fulfilled:

- at least the position of the moving contacts of equipment is visible for disconnectors in open position and for earthing switches in closed position;
- both the open and closed positions of the moving contacts of equipment are indicated by a reliable position-indicating device;

NOTE In some countries the design of the disconnecter is such that the isolating distance is visible (Canada).

The kinematic chain between the moving contacts and the position-indicating device shall be designed with sufficient mechanical strength to meet the requirements of the specified tests (7.105). The operation of the position-indicating kinematic chain shall be positively driven. The position-indicating device may be marked directly on a mechanical part of the power kinematic chain by suitable means. The strain-limiting device, if any, shall not form part of the position-indicating kinematic chain.

6.104.3.3 Signalling of position by auxiliary contacts

A common signal for a disconnecter or earthing switch shall be given only if the disconnecter or earthing switch are in a position in accordance with 6.104.3.1.

The kinematic chain between the moving contacts and the position-signalling device(s) shall be designed with sufficient mechanical strength to meet the requirements of the mechanical endurance tests. The position-signalling kinematic chain operation shall be positively driven. The strain-limiting device, if any, shall not form part of the position-signalling kinematic chain.

6.105 Maximum force required for manual (dependent or independent) operation

6.105.1 General

The values given in 6.105.2 and 6.105.3 also apply to maintenance manual operation of normally motor-operated disconnectors and earthing switches.

NOTE These values include ice-breaking, if applicable.

6.105.2 Operation requiring more than one revolution

The maximum force needed to operate or store energy in a disconnecter or earthing switch with more than one revolution (hand crank for example) shall not exceed 80 N during 90 % of the total required revolutions and never exceed 120 N.

6.105.3 Operation requiring up to one revolution

The force needed to operate or store energy in a disconnecter or earthing switch requiring up to one revolution (swing lever for example) should not exceed 250 N (refer to 6.6.4 of IEC 62271-5:2024). A maximum value of 450 N is accepted during a rotation of 15° maximum.

6.106 Dimensional tolerances

For disconnectors and earthing switches installed and/or connected by the user, the relevant mounting dimensions and the dimensions of high-voltage connections as well as the earthing connections of disconnectors and earthing switches, the tolerances given in ISO 2768-1 shall apply for linear and angular dimensions.

6.107 Earthing switches with short-circuit making current capability

Earthing switches assigned for short-circuit making current shall be capable of making at rated and lower voltage, any current up to and including the rated short-circuit making current.

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:

Disconnectors and earthing switches shall be tested to verify their rated characteristics, under the proper conditions of installation and use (e. g. they shall be tested as normally installed in the gas-insulated or metal-enclosed switchgear and controlgear) with all associated components, the arrangement of which may influence the performance, such as connections, supports, provisions for venting, resistors etc.

Disconnector and earthing switches that are different in construction or mounting arrangements as compared to the given examples in Clause 7 shall be tested in conditions that are representative of the actual installation.

NOTE Associated components are likely to influence the performance. Mechanical forces due to the short-circuit current, venting of arc-products, the possibility of disruptive discharges, etc., could characterise this influence. It is recognized that, in some cases, such influences can be quite negligible.

The same setting of the position-signalling device for closed and open positions shall be used for the dielectric test and the short-time withstand current and peak withstand current tests.

The type tests for disconnector and earthing switch are listed in Table 11. For the type tests, the tolerances on test quantities are given in Annex C.

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

Table 11 – List of type tests

Type test, dependent upon application, rating or design	Condition	Related device		Subclauses
		Disconnector	Earthing switch	
Dielectric tests	a	x	x	7.2
Measurement of the resistance of the main circuit	a	x		7.3
Continuous current tests	a	x		7.4
Short-time withstand current and peak withstand current test	a	x	x	7.5
Mechanical endurance test	a	x	x	7.102.3
Verification of the protection	Assigned IP- and/or IK-code	x	x	7.6
Tightness tests	Controlled, sealed or closed pressure systems	x	x	7.7
EMC tests	$U_{rd} \geq 210$ kV for 7.9.1.1 Presence of electronic components on auxiliary and control circuit	x	x	7.8

Type test, dependent upon application, rating or design	Condition	Related device		Subclauses
		Disconnector	Earthing switch	
Additional tests on auxiliary and control circuits	Presence of auxiliary and control circuits	x	x	7.9
X- ray radiation test for vacuum interrupters	Presence of vacuum interrupters	x	x	7.10
Capacitive current making test	Making of discharging current / energy	x	x	7.101
Contact zone test	Divided support	x	x	7.102.2
Operation during application of rated static mechanical terminal loads	Assigned mechanical terminal load	x	x	7.102.4
Extended mechanical endurance tests	Class M1 or M2	x	x	7.102.5
Testing on mechanical interlocking devices	Presence of interlock blocking the operating shaft or power kinematic chain	x	x	7.102.6
Operation under severe ice conditions	10 mm and above	x	x	7.103
Low- and high-temperature tests	If maximum ambient temperature > +40 °C or minimum ambient temperature < -5 °C	x	x	7.104
Tests to verify the proper functioning of the position-indicating device	Presence of position indicating device	x	x	7.105
^a Mandatory without condition for the related device.				

7.1.2 Information for identification of test objects

Subclause 7.1.2 of IEC TS 62271-5:2024 is applicable with the following addition:

At the beginning of the type tests, the mechanical operating characteristics and their tolerances for the disconnector or earthing switch during opening and/or closing shall be given by the manufacturer.

7.1.3 Information to be included in type test reports

Refer to 7.1.3 of IEC TS 62271-5:2024 with the following additions (where applicable):

When for testing purposes, the insulators are not provided by the manufacturer of the disconnector or earthing switch, the most important features of insulators used during type tests shall be included in the relevant test reports for comparison with those described in the manufacturer's documentation:

- rated cantilever strength;
- rated torsional strength of support insulators (and operating insulators, where applicable);
- height and number of elements;
- creepage length and shed-profile;
- deflection under load.

In the case of dielectric tests, information shall be included regarding the smallest gap at which the indicating or signalling device can signal the position OPEN. For air-insulated devices, the minimum size of the gap and the height above ground used for the test shall be stated (see 7.2.4). Also the distance of the lowest part of insulation to ground shall be given.

7.2 Dielectric tests

7.2.1 General

Subclause 7.2.1 of IEC TS 62271-5:2024 is applicable.

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 with the following addition.

Dielectric tests on disconnectors or earthing switches when in the OPEN position shall be carried out with the minimum isolating distance for the disconnector or gap for the earthing switch at which the indicating or signalling device can signal the position OPEN or the minimum isolating distance compatible with the locking arrangements specified in 6.104.1, whichever is the smallest. This requirement does not apply to independent operated indoor disconnectors and earthing switches.

Where the design requires an adjustment of the position indicator or the position-signalling device, this shall be performed according to the instruction manual. No deviation of these devices is acceptable for dielectric tests.

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 additions:

Disconnectors of $U_{rd} \geq 105$ kV having an isolating distance in parallel to the base of the disconnector and having integrated earthing switches, shall also be tested in open position, in dry conditions only, with the direct voltage or power frequency peak test voltage given in Table 12 in the most disadvantageous dielectric position of the earthing switch. If the minimum temporary clearance is larger than the clearances to ground given in IEC 60071-11:2022, Table C.2, no test is required.

NOTE The first column of Table C.2 is to be compared with the relative switching level to ground of Table 1 or Table 2 and if does not exactly match the same value, choose the closest higher value.

Table 12 – Test voltages

Rated voltage U_{rd} kV	Test voltage direct voltage or peak AC kV
105	105
158	158
210	210
263	263
336	336
420	420
525	525
630	630
840	840

For testing of earthing switches, the test voltage shall be applied with the earthing switch in the most disadvantageous open position and with the other terminal and the frame earthed.

7.2.7 Test of disconnectors and earthing switches

Subclause 7.2.7 of IEC TS 62271-5:2024 is applicable with the following deviation:

For disconnector and earthing switch having their high-voltage electrical insulation exposed to ambient air (as in air insulated switchgear), the polarity reversal test, and the superimposed voltage test are not required.

When the disconnector is exposed to indoor service condition, only dry test is required, if not specified.

In case of impulse voltage tests across the isolating distance (or open switching device) the laboratory can in agreement with manufacturer include the value of the complementary voltage to the total voltage only on one terminal, instead of impulse on one side and complementary voltage on the other side.

NOTE Typically this approach can be done for the two-terminal configuration with 10 % of U_{rd} as bias voltage.

7.2.8 Artificial pollution tests for outdoor insulators

Subclause 7.2.8 of IEC TS 62271-5:2024 is applicable with the following addition.

NOTE The performance of parallel insulation can be affected under pollution and rain (additional pollution tests could be necessary).

7.2.9 Partial discharge tests

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

NOTE 1 The measurement of partial discharge test is a suitable means of detecting certain defects in the equipment under test and is a useful complement to the dielectric tests for GIS components, The AIS disconnector and earthing switch are not subjected to partial discharge test. Experience shows that partial discharges can lead in particular arrangements GIS to a degradation in the dielectric strength of the equipment, especially of solid insulation.

NOTE 2 Other methods, for example UHF or acoustic methods, for measuring or detecting the partial discharge other than the one considered in IEC 60270, can be employed by agreement.

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.

7.3 Resistance measurement

Subclause 7.3 of IEC TS 62271-5:2024 is applicable.

7.4 Continuous current tests

Subclause 7.4 of IEC TS 62271-5:2024 is applicable.

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.

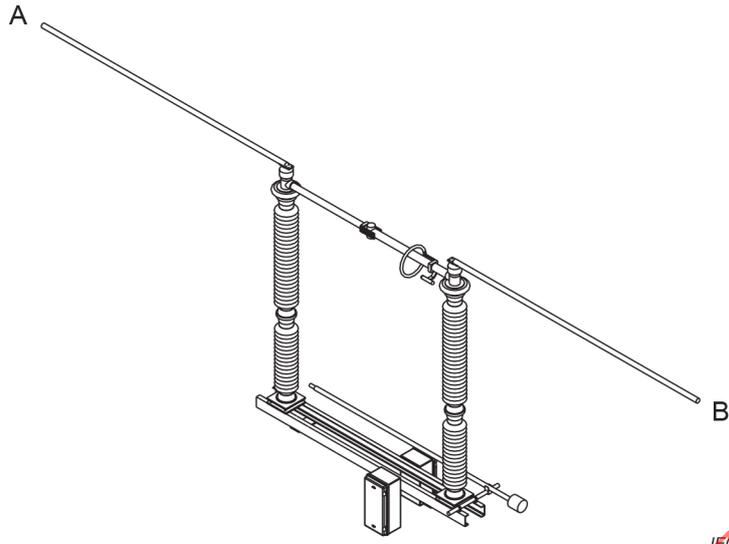
7.5.2 Arrangement of the disconnectors and earthing switches and of the test circuit

Subclause 7.5.2 of IEC TS 62271-5:2024 is applicable.

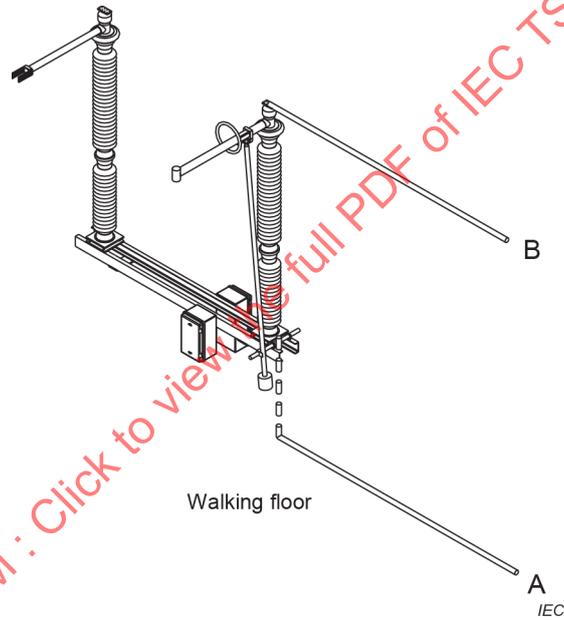
7.5.2.1 General test conditions

Figures 2 a) to g) provide a typical layout for different types of disconnectors and earthing switches.

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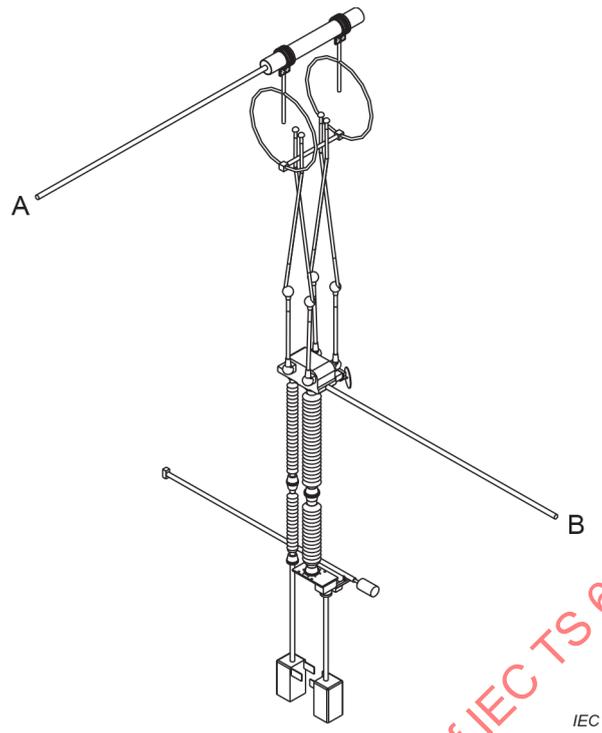


a) Test arrangement of the centre-break disconnector

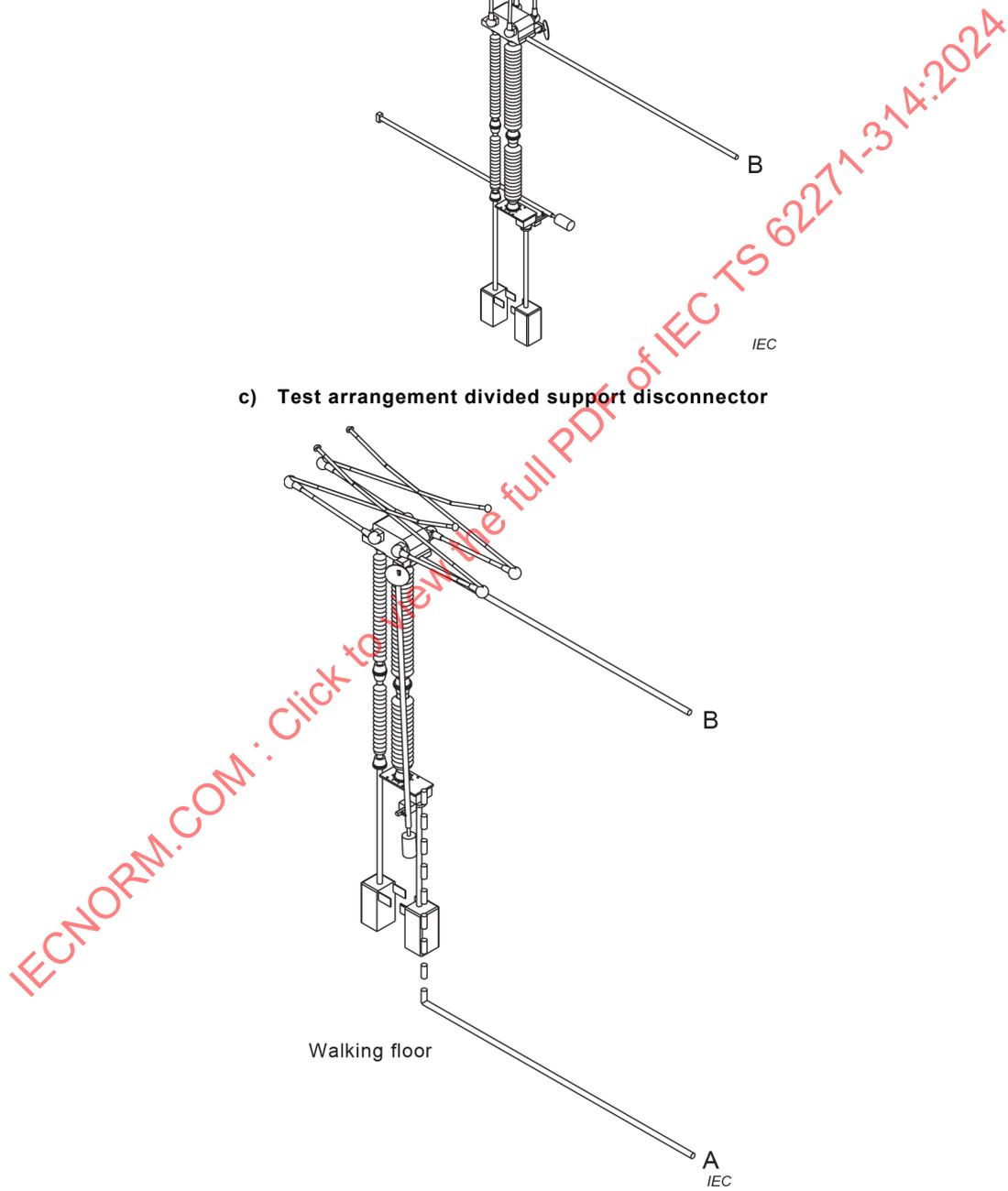


b) Test arrangement of earthing switch fitted on centre break

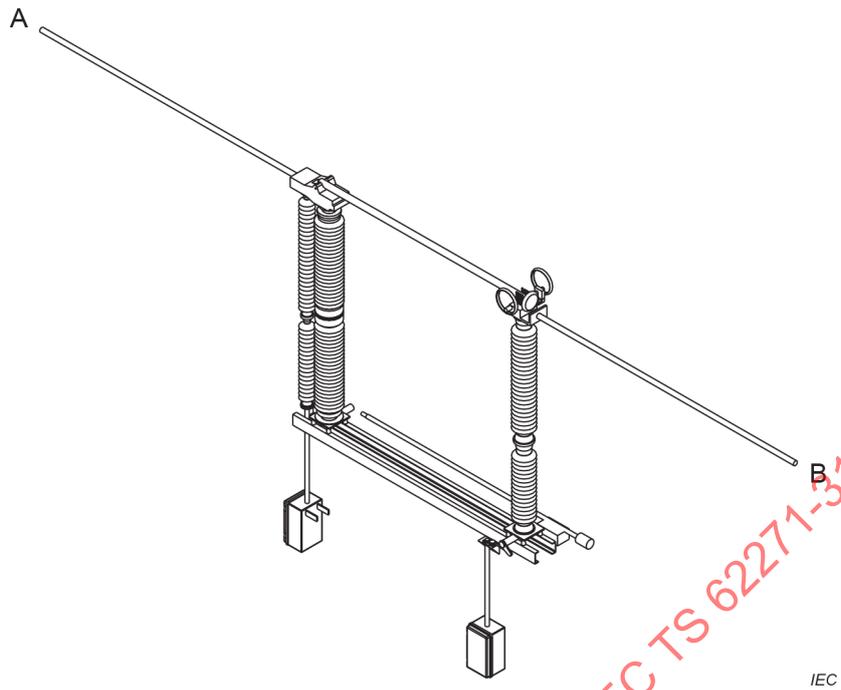
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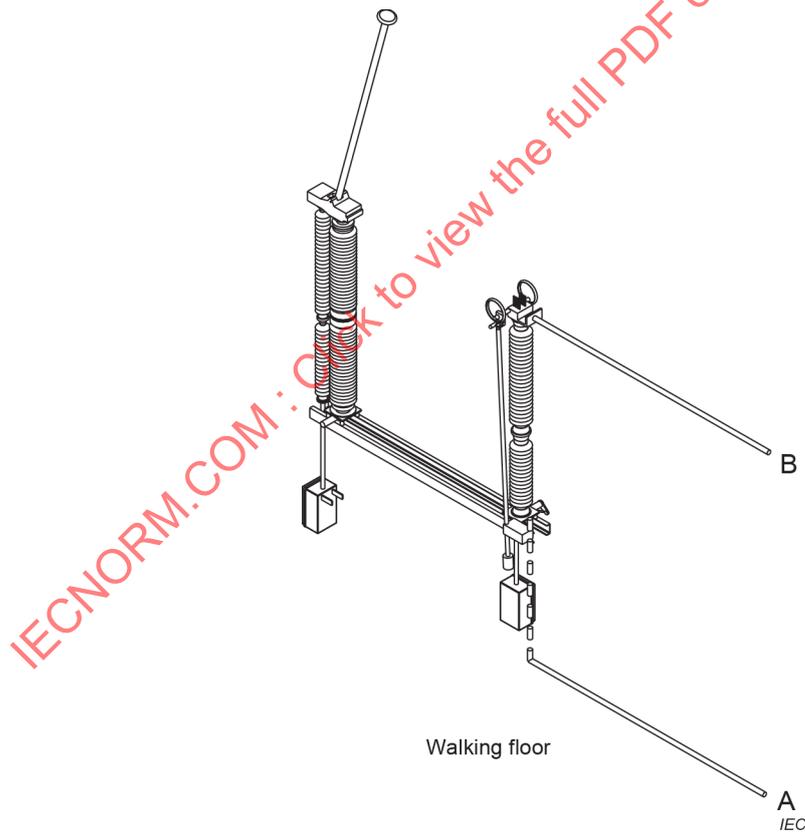
c) Test arrangement divided support disconnector



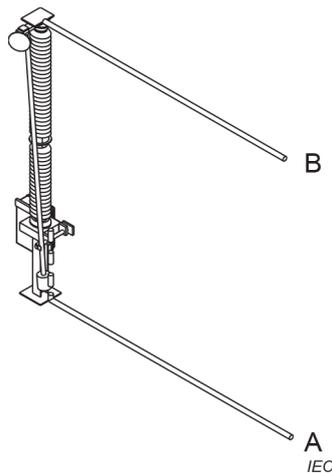
d) Test arrangement of earthing switch fitted on divided support disconnector



e) Test arrangement of vertical-break disconnector



f) Test arrangement of earthing switch fitted on vertical disconnector



g) Test arrangement of earthing switch (stand-alone)

Key

A-B shows the connection of test circuit feeding conductors to terminals of test object

Figure 2 – Examples of test arrangement from a) to g) of different type of disconnectors (horizontal and vertical) with and without earthing switch combined

The disconnectors or earthing switches under test shall be installed with their own operating mechanism as far as necessary to make the test representative.

Disconnectors having accessories to accommodate an arcing current switching capability, and earthing switches having current switching capability, shall be tested with these devices mounted.

Tests shall be carried out employing the least favourable position of the operating mechanism and the main contacts. Consideration should be given to 6.104.3 and, where applicable, to 7.105.

Where the design requires an adjustment of the position indicator or the position-signalling device, this shall be performed according to the instruction manual. No deviation of these devices is acceptable for short-circuit tests.

If the design allows tolerances, these shall be declared by the manufacturer prior to the test. The short-time withstand current and peak withstand current tests shall be performed with the signalling device set at the maximum or minimum specified tolerance giving the least favourable status of the main contacts indicated by the signalling device. This requirement does not apply to independently operated indoor disconnectors and earthing switches.

NOTE The least favourable status of the main contacts is the first position at which during closing operation the "CLOSED" signal appears.

Open type disconnectors and earthing switches shall be new, or in good condition, and mounted on a rigid supporting structure in any convenient mounting position. The test can be made by using a single pole DC circuit or by a single-phase AC circuit. The conductors connecting the disconnector to the test circuit shall leave each disconnector terminal in substantially a straight line parallel to the disconnector blade (horizontal disconnector) or orthogonal (vertical disconnector type and earthing switch). The unsupported distance of the conductor connected to the terminal of test object shall be at least the open-gap distance of the disconnector or earthing switch.

In order to minimize the effect of returning conductor to the disconnector, the returning conductor should be arranged for instance at a distance of at least two times open gap from the live part.

Where flexible conductors are used in the test setup, the terminals of the disconnectors or earthing switches under test shall be loaded with their longitudinal rated static mechanical terminal loads applied in the directions indicated by the manufacturer. For indoor applications with flexible conductors there is no need to apply terminal loads for the disconnector and the earthing switch.

The test arrangement shall also be representative of the least favourable conditions of electromagnetic forces tending to open the disconnector or earthing switch. The tests on an earthing switch integrated to a disconnector shall be made with the same test connections at the side of disconnector and for the returning conductor parallel to the feeding conductor.

Earthing switches not forming an integral part of a disconnector shall be tested in an arrangement that fulfils the same requirements as for disconnectors.

For divided support disconnectors and earthing switches, the vertical position of the contact in the contact zone shall be chosen to represent the most unfavourable condition with respect to the mounting of the fixed contact to flexible conductors or a rigid conductor. In case of doubt of the most unfavourable condition, the tests shall be performed in the highest and the lowest position of the contact within the rated contact zone.

Test results obtained on a disconnector or earthing switch placed in a certain position (e.g. horizontal or vertical) are valid only for the position of the disconnector or earthing switch during this test.

For tests the short-circuit path shall reproduce the manufacturer's stated installation conditions. In particular, consideration shall be given to the position and fixing method of the conductors used to connect the individual poles and the earth shall be considered.

Disconnectors and earthing switches to be connected in the substation to flexible or rigid conductors, according to their documentation, shall be tested using flexible conductors with their rated static mechanical terminal load (except for indoor application), (e.g. longitudinal direction F_{a1} or F_{a2} in Figure 10 and F_{a1} and F_{a2} in Figure 11). Disconnectors and earthing switches, according to their documentation, to be connected only to rigid conductors shall be tested with rigid conductors in a test arrangement with the same dimensions and without intentional static mechanical terminal load except the one given by the weight of rigid conductors. The dimensions and material of the conductors used shall be stated in the test report.

After applying 50 % of the longitudinal rated static terminal load, the disconnector or earthing switch may be adjusted, before the 100 % load is applied.

All details referring to the test arrangement are mandatory, the details of the disconnector and earthing switch shown are given as an example.

Unless the tested disconnector or earthing switch is solidly fixed to the foundation, the spring constant of the support structure has to be taken into consideration (IEC 60865-1).

The test report shall provide clear details of the mounting arrangements used for the tests or record that the disconnector was solidly fixed to the foundations.

The test arrangement should avoid introduction of forces not representative of service conditions by the connections to the supply, and static terminal loads larger than the rated static mechanical terminal loads of the test object.

7.5.3 Test current and duration

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

7.5.4 Conditions of disconnectors and earthing switches after test

Subclause 7.5.4 of IEC TS 62271-5:2024 is applicable with the following addition:

The short-circuit tests carried by a disconnector or earthing switch in the closed position shall not cause:

- mechanical damage to any part of the disconnector or earthing switch;
- separation of the contacts.

After the test, a no-load operation shall be made with the rated value of power supply for independent power-operated devices, with minimum value of power supply for dependent power-operated devices, and for manually (dependent or independent) operated devices with a force no higher than the values given for manually operated devices in 6.105. The disconnector or earthing switch shall open at the first attempt.

After the first no-load opening operation of the disconnector and earthing switch, the device must operate another 5 times within the manufacturer's defined operating parameters.

After the no-load operation, for earthing switches, sound earth connection and sound insulation shall be verified by the following:

- visual inspection shall be made (if possible). Significant contact erosion or significant contact welding should not be observed. Light welding of contacts is permitted;
- when significant contact erosion is suspected or if visual inspection is not possible without dismantling the contacts, sound earth connection shall be verified by checking the electrical continuity according to 7.3.3 of IEC TS 62271-5:2024;
- in case of doubt of insulating properties or if visual inspection is not possible without dismantling, 7.2.11 is applicable to verify the dielectric conditions across the isolating gap and to earth.

After the no-load operation(s), for disconnectors:

- to verify the current carrying capacity main circuit resistance measurement shall be made as close as possible to the contacts. The increase of resistance after the test shall not exceed 20 % of the value measured before the test;
- when the contact resistance exceeds this value a test under rated continuous current (7.4) shall demonstrate that the temperature rise in the contacts does not exceed the limits given in Table 9 of IEC TS 62271-5:2024, by monitoring the temperature at the points as close as possible to the contacts;
- visual inspection shall be made (if possible). In case of doubt of insulating properties or if visual inspection is not possible without dismantling, 7.2.11 is applicable to verify the dielectric conditions across the isolating gap and to earth.

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.

7.9 Additional tests on auxiliary and control circuits

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

7.10 X-ray radiation test for vacuum interrupters

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

7.101 Capacitive current making test – Cable discharging test

7.101.1 General

This test shall be performed only on earthing switches with a rated cable discharging current making capability and a rated voltage of 105 kV or above.

7.101.2 Classification of earthing switches with cable discharging current making capability

The discharging capability of an earthing switch is classified according to the requirements of a direct discharge of a HVDC cable, with stored residual discharge energy or by using a limiting discharging device (e.g. a resistor) to operate up to full system voltage. Table 8 and Table 9 in addition with description of test duties 1 and 2 are classifying the device to energy classes to cover a range of discharge applications, for which an earthing switch can be appropriate.

Test duty 1:

Direct discharge of HVDC cables without current limiting device. The test duty 1 describes the discharging process of a cable with residual voltage due to earthing with an earthing switch. To specify testing requirements the discharging case can be described by a damped current oscillation (for example see Figure 4) with a specified amount of energy, a peak current and a total oscillation time.

Test duty 2:

Earthing switch equipped with a current limiting device to discharge HVDC cables (e.g, using a current limiting resistor) specified mainly the discharge process of a HVDC cable at full system voltage when using a current limiting discharge device (resistor) in combination with an earthing switch.

7.101.3 Discharging making tests

7.101.3.1 Arrangement of the earthing switch for tests

The earthing switch under test shall be completely mounted on its own support or on an equivalent support. Its operating device shall be used in the manner prescribed and, if it is power operated either electrically or pneumatically, it shall be operated at the minimum supply voltage or minimum functional pressure for operation, respectively.

Before commencing making tests, five no-load operations shall be made to establish the mechanical operating characteristics of the earthing switch such as speed of travel, closing time and opening time.

For gas-insulated earthing switches, tests shall be performed at the minimum functional pressure for switching.

Earthing switches having an independent manual operation shall not be used and are not classified for discharging tests due to safety concerns.

To demonstrate the making performance of an earthing switch single-pole tests shall be performed.

7.101.3.2 Earthing of the test circuit

The test circuit shall be earthed through the terminal of the earthing switch (normally connected to earth). Test circuit according to Figure 3, see 7.101.3.4.7 or Figure 6 see 7.101.3.5.7.

7.101.3.3 Test procedure

The following test procedure consists of two circuits that forecast two different pre-arcing settings of test object. If not otherwise specified between manufacturer and customer, test duty 1 and test duty 2 shall be executed, otherwise only one of these test duties shall be chosen. The classified energy amount shall be discharged during the period of pre-arcing. In sum 20 operations, 10 making operations (close operations of the earthing switch) of each test duty, shall be done to verify a cable discharge capability of the test object. The specified Joule-integral E_j shall be fulfilled by the average value of all ten operations of each test duty.

If due to influence of arcing the specified Joule-Integral is not reached in the sum of all performed tests, then additional tests shall be performed.

The time between operations shall be sufficient to cool down the earthing switch as specified by the manufacturer instructions. All tests shall be performed without reconditioning of the earthing switch.

7.101.3.4 Test duty 1 (without current limiting resistor)

7.101.3.4.1 General

Ten operations shall be made. Each discharging operation (that means each joule integral of corresponding class shall be achieved) shall be finished before the test object maintains its contact position. This means before galvanic contact touch.

The tests should be performed in a test circuit according to Figure 3. The test circuit produces a damped oscillation by discharging a pre-charged capacitance. Care should be taken by considering the influence of the arc while choosing test circuit parameters. The arc resistance may influence the RLC current oscillation, by reducing the expected energy amount. This effect shall be compensated.

NOTE Test Duty 1 specify conditions of pre-arcing to prove that the device is able to dissipate during the arcing time all the energy without excessive wear that compromise the mechanical functionality of earthing switch. This proves the discharging capability of the test object in most onerous conditions.

7.101.3.4.2 Alternative test method for test-duty 1

In case of test laboratory limitations requiring higher test voltages or high cable capacitances the following alternative test method can be applied in agreement with the manufacturer/customer. The required Joule-integral I^2dt and peak current according to Table 8 is achieved by applying an equivalent direct voltage or an alternating voltage (AC), resulting to specified current and specified duration. Depending on the applied test voltage the test object moving contact arm can be fixed at the location where pre-arcing occurs or operated into the closing position. Both methods shall ensure discharging the capacitive energy within the pre-arcing period. Fixing the moveable contact may result in more onerous test condition. The tests should be performed in a test circuit according to Figure 5.

7.101.3.4.3 Test frequency test duty 1

The test frequency of test duty 1 simulating an RLC oscillation should be within reasonable values of 30 to 400 Hz (see Annex D). According to alternative test method for test duty 1, a test frequency of 50 to 60 Hz, if applying an AC current, shall be chosen.

7.101.3.4.4 Test current test duty 1

The test current shall be within the specified peak current with tolerance as defined in Table 8 ($\pm 5\%$). The test should be performed with original discharging current. Executing the discharge test according to alternative test method, the test current shall be a symmetrical AC current specified by peak current and Joule integral according to Table 8.

7.101.3.4.5 Test voltage test duty 1

The test voltage should be the rated voltage of the test object or an appropriate test voltage to fulfil the specified test parameters of Table 8. Test parameters are depending on the energy class of the earthing switch. In any case the test voltage shall not be below 10 kV and not exceeding the rated voltage of the test object.

Test voltage tolerance shall be $\pm 5\%$. During the performed switching tests the test voltage shall be measured across the earthing switch terminals.

7.101.3.4.6 Tests at reduced voltage test duty 1

Due to limitations of the test laboratory discharging tests may be performed at reduced test voltage, by using means, which ensures that the pre-arcing period at reduced test voltage is not shorter than at the rated voltage or a specified residual discharging voltage by the client (if below rated voltage).

Depending on the technology of the switch different means for cable discharging current tests at reduced voltage may be applicable:

- when possible, the pre-arcing may be initiated by a fuse wire. A thin and rigid wire shall be fastened across the expected arcing path between the contacts of the test object;
- for switches breaking under gas, the making tests may be performed under air or with gas at reduced pressure. The test voltage shall be reduced by the same ratio as the difference of the flashover distance of air or the insulating gas at rated minimum pressure. The mechanical characteristics shall be in the limits of the manufacturer tolerances.

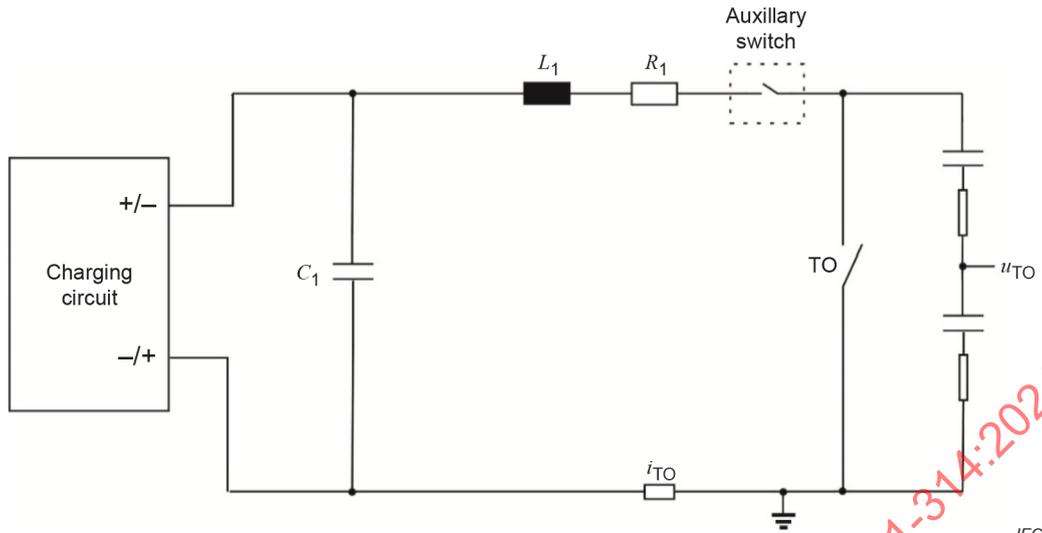
Prior to the cable discharging tests at reduced voltage, the average pre-arcing time at specified voltage (rated voltage or a specified residual voltage by the client, depending on when the HVDC cable should be discharged) and its standard deviation have to be known. These values can be calculated from 10 operations performed at specified voltage, taken from other type tests with the same type of earthing switch, or if not available, from extra tests, performed at reduced current in a range of 1 A to 10 A, not to cause essential contact erosion.

During cable discharging tests at reduced voltage, the pre-arcing times shall not be less than the above calculated average pre-arcing time plus two times its standard deviation.

7.101.3.4.7 Test circuits test duty 1

The test circuit parameters as shown in Figure 3 are defined by typical cable ratings to simulate an appropriate oscillation of a current discharge of a RLC circuit. Typical cable characteristics can be found in Table DD.1 and DD.3 to choose reasonable test elements related to test values of Table 8. A test circuit layout for alternative test method of test duty 1 is shown in Figure 5.

The circuit shown in Figure 3 represents the arrangements to adopt to obtain oscillating RLC discharge as per test duty 1 requirements.



Key

- C_1 : Cable capacitance
- L_1 : Inductance of cable and additional elements
- R_1 : Resistance of cable
- TO: Test Object – Earthing switch
- i_{TO} : Test current (shunt with adequate bandwidth)
- u_{TO} : Test Voltage (voltage divider, measurement across test object)

Figure 3 – Typical test circuit of oscillating RLC discharge

An example of Oscillating Discharge related to Test Duty 1 is shown in Figure 4.

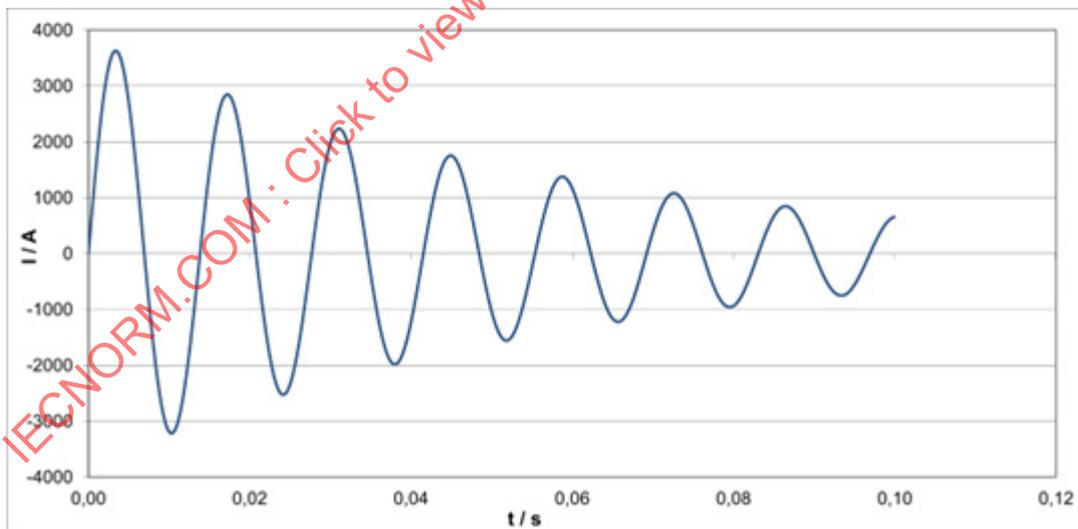
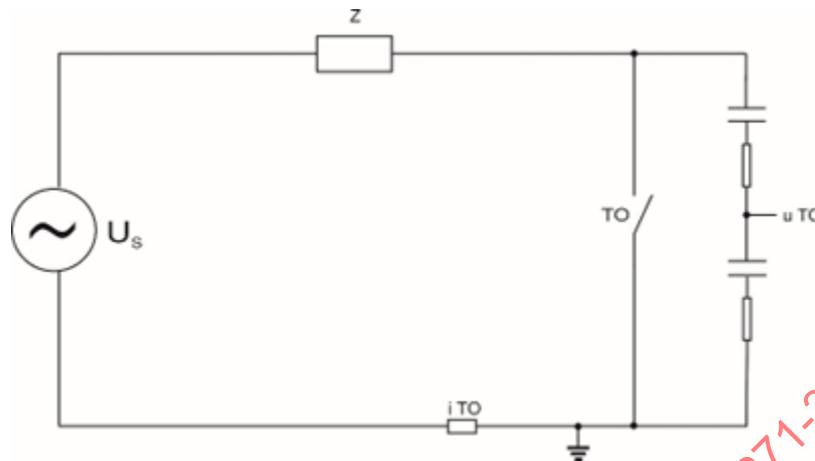


Figure 4 – Example of damped oscillating discharge of 525 kV XLPE cable of 300 km length, cross-section 2 000 mm² and with a residual voltage of $U_{res} = 100$ kV

Figure 5 provides a representation of a test circuit for test duty 1 using an alternative method with AC 50/60 Hz circuit:



Key

- U_s : Voltage source (AC)
- Z : Impedance for current adjustments
- TO: Test object
- i_{TO} : Measurement of test current (shunt or appropriate measuring device)
- u_{TO} : Voltage measurement across test object

Figure 5 – Alternative test circuit of test duty 1

7.101.3.5 Test duty 2 (with current limiting resistor)

7.101.3.5.1 General

Ten operations shall be made. If possible, the discharging tests according test duty 2 and Table 9 should be performed with rated direct voltage of the test object. Depending on the closing time of the test object and the duration of the discharge of the damped oscillation (aperiodic), the discharging operation might not be finished before contact touch of the earthing switch. This means a part of the discharged energy is dissipated after pre-arcing, while already reaching galvanic contact position of the earthing switch contacts.

Therefore, before performing discharging tests according test duty 2, the closing time of the test object and average pre-arcing time at rated direct voltage have to be known or determined.

The tests should be performed in a test circuit according to Figure 6 simulating an aperiodic damped test circuit (RLC circuit) by discharging a pre-charged capacitance using an appropriate discharge resistor.

7.101.3.5.2 Alternative test method for test duty 2

In case of test laboratory limitations requiring higher test voltages or high cable capacitances the following alternative test method can be applied in agreement with the manufacturer/customer. The required Joule- integral $\int I^2 dt$ and peak current according to Table 9 is achieved by applying an equivalent direct voltage or an alternating voltage (AC) resulting to specified current and specified duration. Depending on the applied test voltage the test object moving contact arm can be fixed at the location where pre-arcing occurs or operated into the closing position. Both methods shall ensure discharging the capacitive energy within the pre-arcing period. Fixing the moveable contact may result in more onerous test conditions.

7.101.3.5.3 Test frequency test duty 2

The discharge is described by a damped oscillation (aperiodic). According to alternative test method for test duty 2 a test frequency of 50 to 60 Hz if applying an AC current shall be chosen.

7.101.3.5.4 Test current test duty 2

The test current shall be within the specified current with tolerance as defined in Table 9 ($\pm 5\%$). The test should be performed with a damped discharging current, with an initial peak current decaying during specified duration. Executing the discharge test according to alternative test method, the test current shall be a symmetrical AC current specified by test current (RMS-value) and Joule-Integral of Table 9.

7.101.3.5.5 Test voltage test duty 2

When executing the discharge tests in an aperiodic RLC circuit, the tests should be executed at rated direct voltage of the test object.

While executing the discharge tests according to test duty 2 alternative test method, the test voltage shall not below 20 kV (tolerance $\pm 5\%$) and high enough to ensure arcing during the whole pre-arcing duration. A distinguishing of pre-arcing before contact touch shall be omitted. Initiation of pre-arcing by a fuse wire is accepted as described in 7.101.3.5.6.

Test voltage shall be measured during the test across the earthing switch terminals.

7.101.3.5.6 Tests at reduced voltage at test duty 2

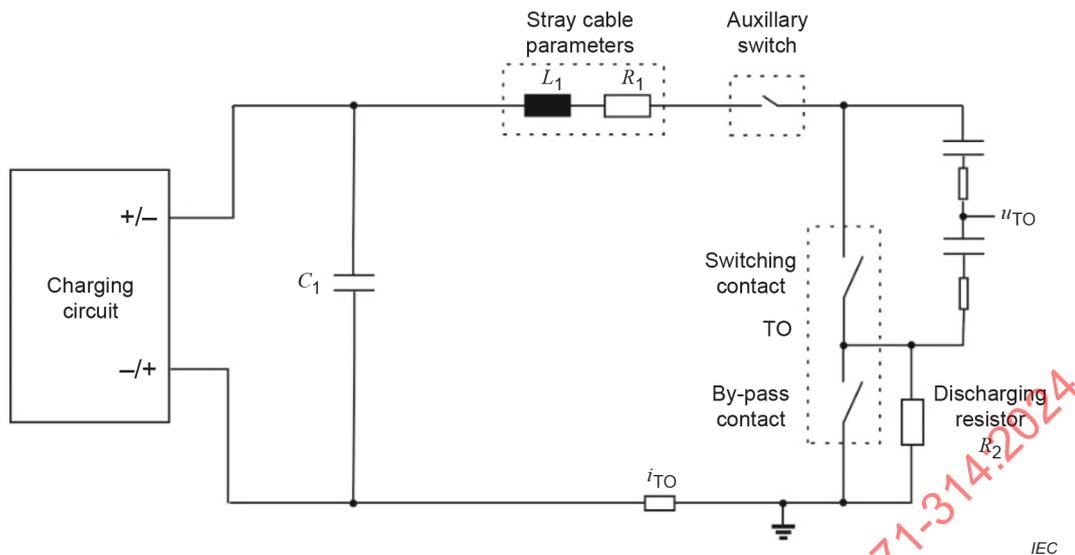
See information concerning tests at reduced voltage in 7.101.3.4.5.

7.101.3.5.7 Test circuits test duty 2

The test circuit as shown in Figure 6 should be defined by typical cable ratings and suitable discharge resistor to produce an appropriate damped RLC current discharge oscillation (aperiodic). Typical cable characteristics can be found in in Table D.1 and Table D.3 to choose reasonable test elements related to test values of Table 9.

Alternative test circuit of test duty 2 can be adopted from test duty 1 as shown in Figure 5.

A representation of a test circuit for test duty 2 using aperiodic RLC oscillation is given in Figure 6.

**Key**

C_1 : Cable capacitance

L_1 : Inductance of cable and additional elements (negligible for test circuit)

R_1 : Resistance of cable (negligible for test circuit)

R_2 : Discharging Resistor

TO: Test Object – Earthing Switch

i_{TO} : Test current (shunt with adequate bandwidth)

u_{TO} : Test voltage across test object (voltage divider)

Figure 6 – Typical test circuit with damped RLC discharging oscillation (aperiodic)

An example of a discharging impulse related to test duty 2 is given in Figure 7.

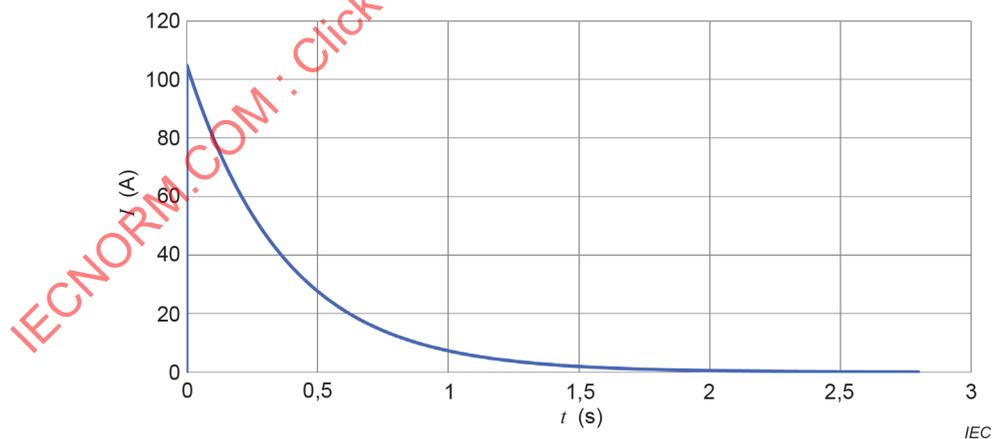


Figure 7 – Example of discharging impulse (damped discharging oscillation, aperiodic) of 525 kV XLPE cable of 300 km length at system voltage by using a discharge resistor of 5 k Ω

7.101.4 Behaviour of the earthing switch during tests

The earthing switch shall perform successfully without undue mechanical or electrical distress.

Outward emission of flame or metallic particles from the earthing switch during operation is permitted, if this does not impair its insulation level. Flame or metallic particles shall not be projected beyond the boundaries specified by the manufacturer in the operating instructions.

7.101.5 Condition of earthing switch after tests

The mechanical operating characteristics shall be within the tolerances given by the manufacturer. Five no-load operations shall be done after the discharging tests to verify mechanical characteristics. The insulation of the earthing switch shall be essentially in the same condition as before the test.

It is recognized that mechanical wear and erosion due to arcing, as well as deposits on the insulators caused by the decomposition of the arc extinguishing medium, will impair the switching capability of the earthing switch.

However isolating properties of the earthing switch shall not be impaired. The quality of the material used for arc extinguishing, if any, may be impaired and its amount reduced below the normal level.

The isolating properties of the test object in the open position shall not be reduced below what corresponds to normal wear and ageing, by deterioration of insulating parts.

No-load operation and visual inspection of the test object after tests are usually sufficient for verification of the isolating properties. In case of doubt, an appropriate test as mentioned below can be performed.

If the isolating properties are doubted, a voltage test as condition check according to 7.2.11 of IEC TS 62271-5:2024 shall be performed to verify the insulating properties. The minimum functional pressure of the gas for insulation shall be used, if applicable.

7.101.6 Test reports

In addition to the requirements given in 7.1.2 and 7.1.3 of IEC TS 62271-5:2024 the type test report shall contain the following information:

- a) The oscillograms or similar records of the tests performed;
- b) test circuit;
- c) test currents;
- d) test voltages;
- e) arcing times;
- f) number of making operations;
- g) condition of the contacts after test.

General information concerning the supporting structure of the test object should be included. The operating time of the earthing switch and the type of operating devices employed during the tests shall be recorded.

7.102 Operating and mechanical endurance tests

7.102.1 General test conditions

The test shall be made at the ambient air temperature of the test location. During the test, the ambient temperatures shall be recorded and maximum and minimum values included in the test report.

The supply voltage shall be measured at the terminals of the operating devices with full current flowing. Auxiliary equipment forming part of the operating device shall be included.

7.102.2 Contact zone test

This test shall be made in order to prove satisfactory operation of divided support disconnectors or divided support earthing switches, in the various positions of the fixed contact within the limits of the rated contact zone defined according to 5.101 and Figures 8 and/or 9. With the device in the open position, the fixed contact shall be placed in the following positions:

- at a height of h on the vertical axis of the assembly;
- at a height of $h - z_r$ on the same axis;
- at a height equal to h and displaced from the vertical axis horizontally by $+y_r / 2$;
- at a height equal to h and displaced from the vertical axis horizontally by $-y_r / 2$;
- positions a) to d) at a distance equal to $+x_r / 2$;
- positions a) to d) at a distance equal to $-x_r / 2$,

where:

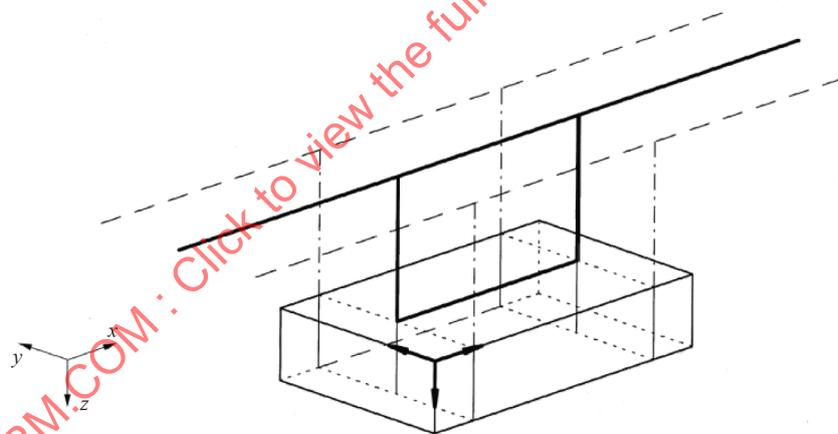
h is the highest position (stated by the manufacturer) of the fixed contact above the mounting plane;

x_r is the total amplitude of movement of the fixed contact in the x -direction;

y_r is the total amplitude of movement of the fixed contact in the y -direction;

the subscript, r , indicates the rated value assigned to the disconnector or earthing switch by the manufacturer.

In each position, the device shall close and open correctly.

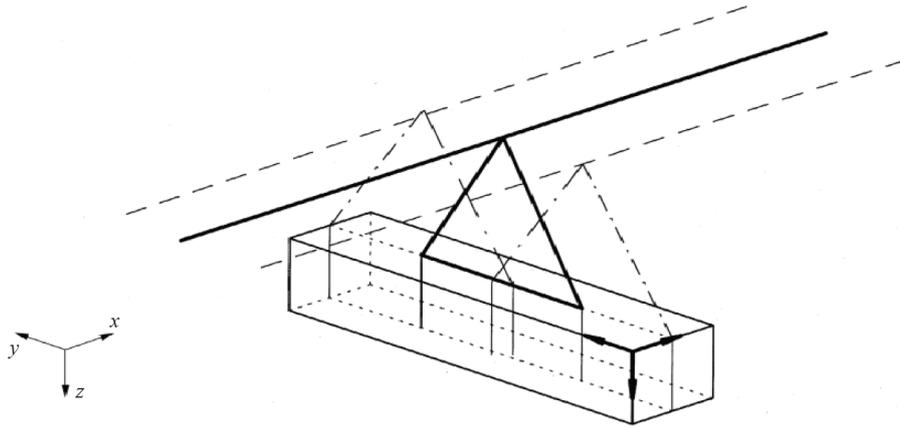


IEC

Key

- x Longitudinal to support (influence of temperature)
- y Perpendicular to support (influence of wind)
- z Vertical deflection (temperature and ice)

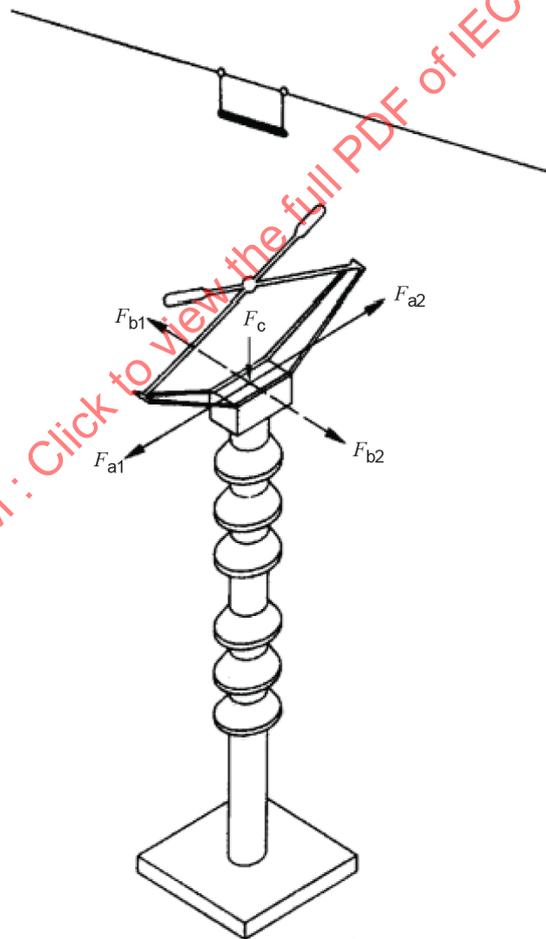
Figure 8 – Fixed contact parallel to support



Key

- x Longitudinal to support (influence of temperature)
- y Perpendicular to support (influence of wind)
- z Vertical deflection (temperature and ice)

Figure 9 – Fixed contact perpendicular to support



IEC

NOTE Above the pantograph, the fixed contact is shown

Figure 10 – Example of the application of rated static mechanical terminal loads to a (divided support) pantograph disconnector (or earthing switch)

7.102.3 Mechanical endurance test

7.102.3.1 Test procedure

The tests defined in 7.102.3.1 and in 7.102.3.2 shall be performed on disconnectors and earthing switches of class M0.

The mechanical endurance test shall consist of 1 000 operating cycles. For disconnectors or earthing switches having a rated terminal load, 50 % of the rated static terminal load shall be applied during the test in direction F_{a1} or F_{a2} (Figure 10 and Figure 11), without voltage on, or current through, the main circuit. For disconnectors having two or three insulators and a normally horizontal isolating gap, the 50 % rated static terminal load shall be applied at both sides of the disconnector, but in opposite directions. For disconnectors and earthing switches with one insulator (operating insulators not being taken into consideration), the terminal load shall be applied to only one side of the disconnector or earthing switch. After applying 50 % of the rated static terminal load, the disconnector or earthing switch may be adjusted before performing the tests.

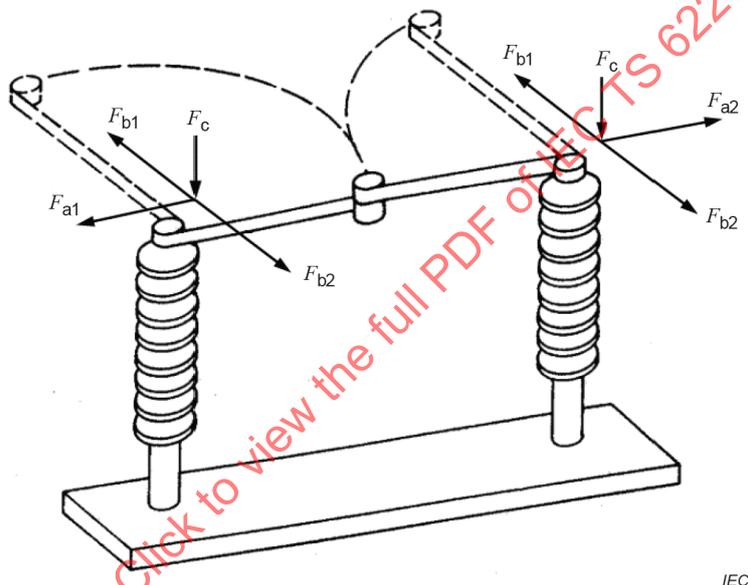


Figure 11 – Example of the application of rated static mechanical terminal loads to a two-column disconnector

The closed and open positions shall be attained during each operating cycle.

During the test, the operation of the control and auxiliary contacts and position-signalling devices (if any) shall meet the requirements expressed in 6.104 and 6.4 of IEC TS 62271-5:2024. The test is considered failed if any of the control and auxiliary contacts and position-signalling devices do not operate at one of the close-open operating cycles.

The test shall be made on disconnectors and earthing switches equipped with their own operating mechanisms. During the test, lubrication in accordance with the manufacturer's instructions is permitted, but no mechanical adjustment or other maintenance is allowed.

On a disconnector or earthing switch having a power-operated mechanism:

- 900 close-open operating cycles shall be made at the rated supply voltage and/or rated pressure of compressed gas supply;
- 50 close-open operating cycles at the specified minimum supply voltage and/or minimum pressure of compressed gas supply;

- 50 close-open operating cycles at the specified maximum supply voltage and/or maximum pressure of compressed gas supply.

No specific time intervals between operating cycles or between closing and opening operations are required. These tests shall be made, however, at a rate such that the temperature rises of the energised electrical control components do not exceed the specified values. For the same purpose, external cooling may be applied during the test.

For manually operated disconnectors and earthing switches, the handle may, for convenience of testing, be replaced by an external power-operated device. In this case, it is not necessary to vary the power parameters.

7.102.3.2 Verification of successful operation

For the evaluation of the operating characteristics, before and after the mechanical endurance test programme, the following operations shall be performed without the static terminal load applied:

- five close-open operating cycles at the rated supply voltage and/or pressure (if any);
- five close-open operating cycles at the minimum supply voltage and/or pressure (if any);
- five close-open operating cycles at the maximum supply voltage and/or pressure (if any);
- five close-open manual operations if the switching device can be operated manually.

During these operating cycles, the operating characteristics, such as, if applicable, operating times, power consumption, maximum forces for manual operation, shall be recorded. Satisfactory operation of control and auxiliary contacts and position-indicating devices (if any) shall be verified. In order to limit the number of oscillograms in the report, only two showing extreme values can be included in the test report.

The variation between the average values of each parameter, measured before and after the mechanical endurance test, shall be within the tolerances specified by the manufacturer.

After the test, all parts, including contacts, shall be visually inspected to check their good condition and they shall not show undue wear; see also 7.4.6.2, point 6, of IEC TS 62271-5:2024. The main circuit resistance, i.e. on disconnectors, shall be measured before and after the mechanical endurance test, as close as possible to the contacts. The resistance shall not increase by more than 20 % from the value measured before the test. If this limit is exceeded, a test under rated continuous current (7.4) shall demonstrate that the temperature rise in the contacts does not exceed the limits given in Table 9 of IEC TS 62271-5:2024, by monitoring the temperature at the points as close as possible to the contacts.

For earthing switches where contacts are visible, the fully closed and open positions during operation after the mechanical endurance test shall be verified by visual inspection.

For earthing switches where contacts are not visible, the fully closed and open positions during operation after the mechanical endurance test shall be verified by using the travel records or other appropriate methods.

For gas-insulated disconnectors and earthing switches, a tightness test according to 7.7 shall be performed before and after the mechanical endurance test.

For resistor-fitted disconnectors in metal-enclosed gas-insulated switchgear, the maximum variation of the ohmic resistance of the complete resistor after the test shall not exceed 5 % from the value measured before the test.

7.102.4 Operation during the application of rated static mechanical terminal loads

Twenty operating cycles with the rated power supply shall be made with the rated mechanical static terminal loads applied at each terminal in the directions specified by the manufacturer. When more than one load configuration (according to Table 5) is specified by the manufacturer, the 20 operating cycles shall be repeated for each configuration. The three components of each terminal load may be applied by a conductor pulling in the resultant direction and with the resultant force of the three vectors.

NOTE Any possible combination of the resultant forces applied at the terminals corresponds to one load configuration.

Examples of terminal loads applied at different types of disconnectors are shown in Figure 10 and Figure 11.

One example of possible load configuration for a two columns disconnector (for installation with rigid conductors) is given here below:

- longitudinal (straight) load applied in direction F_{a1} at one terminal and F_{a2} at the opposite terminal;
- transversal (cross) load applied in direction F_{b1} or F_{b2} , at both terminals in the same direction;
- vertical load applied in direction F_c at both terminals (except for disconnectors specified to be connected to flexible conductors).

For only manually operated disconnectors and earthing switches the number of operating cycles is reduced to 10.

The loads (F_a , F_b , F_c) shall be applied on both terminals at the same time for two- and three-column disconnectors.

The disconnector or earthing switch may be adjusted before the test and after having been loaded with 50 % of the rated longitudinal or perpendicular mechanical terminal force.

During each operation, the disconnector or earthing switch shall close and open correctly.

For verification, before and after the complete sequence of operating cycles, 7.102.3.2 and the appropriate comparators as required in 7.102.3.1 for mechanical endurance tests, are applicable (i.e. without static mechanical terminal loads applied).

7.102.5 Extended mechanical endurance tests

The tests defined in this subclause shall be performed on disconnectors and earthing switches class M1 and M2.

In the case of disconnectors and earthing switches in GIS, the enclosure shall not be opened during the test.

Tests shall be carried out as follows:

- a) The extended mechanical endurance tests programme shall consist of a number of close-open operations carried out in accordance with 7.102.1 and 7.102.3.1.

According to the class assigned, one of the following number of operating cycles shall be performed:

- 2 000 (for class M1);
- 10 000 (for class M2).

After the first series of 1 000 operating cycles, some maintenance such as lubrication and mechanical adjustment is allowed and shall be performed in accordance with the manufacturer's instructions, and its reference included in the test report. Change of parts in the main circuit and in the kinematic chain is not permitted.

After each next series of 1 000 operating cycles, or at maintenance intervals (if of less than 1 000 operating cycles), the operating characteristics shall be recorded and evaluated (if power operated) at the rated pressure or voltage.

The programme of maintenance shall be defined by the manufacturer before the tests and recorded in the test report.

- b) Before and after the total test programme, verification of successful operation shall be performed as required in 7.102.3.2.
- c) In addition, after the total test programme, checks and tests shall be performed as follows:
 - contact zone test (7.102.2), if applicable;
 - verification of operation during application of rated static mechanical terminal loads (7.102.4), if applicable;
 - verification of satisfactory operation with the minimum duration of the operating signal specified in the manufacturer's documentation;
 - verification of operation of the mechanical strain-limiting devices, if any.

7.102.6 Testing of mechanical interlocking devices

Disconnectors and earthing switches which are not covered by switchgear and controlgear assembly standards (e.g. IEC 62271-200, IEC 62271-201 and IEC 62271-203) shall be tested as follows, if mechanical interlocking devices are provided blocking the operating shaft or power kinematic chain.

All interlocking devices shall be submitted to 5 attempts to perform close and/or open operation for any interlocked position of disconnector and/or earthing switch, in order to prove compliance with requirements in 6.12.

Before each attempt, the interlocking devices shall be set in the position intended to prevent the operation of the switching device and then one attempt shall be made to operate the interlocked switching device. Operating forces given in 6.12 shall be employed and no adjustment shall be made to the switching devices or interlocking devices.

The tests are considered satisfactory if the interlocked switching devices and the interlocking devices are in proper working order and if the forces required to operate the switching devices are practically the same before and after the tests.

The operating forces are considered the same if the average value measured after the test is within the maximum and minimum values measured before the test. At least three close/open operations should be performed before the test to fix the minimum and maximum values for acceptance of the close or open operation after the test.

7.103 Operation under severe ice conditions

7.103.1 General

The tests defined in this subclause shall be made only if the manufacturer claims the suitability of disconnectors and earthing switches for operation under severe ice conditions (i. e. 10 mm ice coating and above).

Disconnectors and earthing switches having accessories on live part like arcing horn, whips, resistors and others shall be tested with these devices mounted.

NOTE Formation of ice can produce difficulties in the operation of electric power systems. Under certain atmospheric conditions, a deposit of ice can build up to a thickness that sometimes makes the operation of outdoor switching equipment difficult.

7.103.2 Test arrangement

- a) All parts of the disconnect or earthing switch to be tested shall be assembled, together with their operating mechanism, in a room which can be cooled to a temperature according to the requirements given in 7.103.3. The energizing of heating elements of the control mechanism is permitted during the test. Supports, operating insulators and other operating members may be shortened to reduce the height of the assembly to suit the test facilities available, provided the angle of rotation of the parts affected and the bending of thrust linkages remain unchanged.

In choosing the refrigeration capacity required, the heat content of the water with which the apparatus under test is sprayed should be taken into account.

- b) A single-pole is tested if each pole has a separate operating mechanism, modifications of mounting structures, post insulators are allowed. In any cases, it is not allowed to change the original isolating distance for the disconnect or the gap for the earthing switch.
- c) The disconnect or earthing switch shall be tested for operation from the open position and the closed position separately.
- d) Prior to the test, any trace of oil or grease on parts that do not need to be lubricated in service shall be removed with an appropriate solvent. This is because thin films of oil or grease prevent ice from adhering and greatly change the results of tests.
- e) For measurement of ice thickness, a copper bar or tube 30 mm in diameter and 1 m in length shall be mounted in a horizontal position in a place where it will receive the same general rainfall as the apparatus under test.
- f) The arrangement shall allow the entire apparatus to be sprayed with artificial rain falling from above at various angles, from the vertical to 45°. The water used in the spray should be cooled to a temperature between 0 °C and 3 °C and shall reach the test object in the liquid state.

7.103.3 Test procedure

7.103.3.1 Checks before the formation of ice coating

Before testing, the disconnect/earthing switch shall be subjected to:

- 5 close-open operating cycles at the rated supply and/or pressure (if any);
- 5 close-open manual operations if the switching device can only be operated manually;
- the measurement of the resistance of the main circuit in accordance with 7.3.4.

During the operating cycles, operating characteristics such as, if applicable, operating times, power consumption, maximum forces for manual operations, shall be recorded. Satisfactory operation of control and auxiliary contacts, and position-indicating device (if any) shall be verified. It is not necessary to include all the oscillograms recorded in the type test report.

7.103.3.2 Formation of ice coating

Nature produces ice coatings which may be divided into two general categories:

- a) clear ice, generally resulting from rain falling through air somewhat below the freezing point of water;
- b) rime ice, characterized by a white appearance, formed for example from atmospheric moisture condensing on cold surfaces.

For type tests a coating of solid clear ice of the required thickness shall be produced according to the procedure described below.

- a) Lower the room temperature down to 2 °C and start the spray of pre-cooled water. Continue this spray for a minimum of 1 h while holding the room temperature between 0,5 °C and 3 °C;
- b) Lower the room temperature down to the range between –7 °C and –3 °C while continuing the water spray. The rate of temperature change is not critical and may be whatever is obtainable with available refrigeration apparatus;
- c) Hold the room temperature within –7 °C and –3 °C and continue to spray until the specified thickness of ice can be measured on the top surface of the test bar. The amount of water should be controlled to cause ice to build up at the rate of approximately 6 mm/h;

NOTE 1 If the specific thermal capacities per unit surface area of test bar and apparatus under test differ considerably, even identical spraying conditions can produce very different ice coatings. These differences in thickness can be minimized by short periods of spraying alternating with longer periods of cooling.

NOTE 2 As a guide, it has been observed that between 20 l and 80 l per hour per m² of area sprayed is required to cause ice to be deposited at a rate of approximately 6 mm/h.

- d) Discontinue the spray and maintain the room temperature within –7 °C and –3 °C for a period of at least 4₀⁺² h. This ensures that all parts of the disconnect/earthing switch and the ice coating have reached a constant temperature.

7.103.3.3 Checks after the formation of ice coating

After the formation of ice coating, the satisfactory operation of the disconnect/earthing switch shall be checked:

- if the disconnect or earthing switch is manually operated, the operation will be considered as satisfactorily completed if the apparatus has been operated to its final closed or open position applying normal operating forces (being permissible to remove the ice from the insertion point of the handle);
- if the disconnect or earthing switch is electrically, pneumatically or hydraulically operated, the operation will be considered as satisfactorily completed if the apparatus has been operated on the first attempt up to its final closed or open position by the operating device supplied at its rated voltage or pressure.

Immediately after the closing operation, the electrical continuity across the contacts shall be checked.

When the disconnect/earthing switch is ice-free, it shall be subjected to the same checks of 7.103.3.1, with the room temperature restored to normal ambient temperature (above 10 °C). The apparatus shall be considered to have passed the test if its mechanical and electrical performance is not affected; this condition shall be considered as met if:

- the resistance measured before the formation of ice coating has not increased by more than 20 %;
- the variation between the average values of each parameter, measured before the formation of ice coating, is within the tolerances given by the manufacturer.

The complete ice coating procedure and subsequent checks shall be performed for each position (i.e. closed/open) on each disconnect and/or earthing switch. Ice coating shall be naturally removed between tests, for example by leaving the apparatus enough time at adequate room temperature.

7.104 Low- and high-temperature tests

7.104.1 General

If the temperature limits for the service conditions of the apparatus (defined by the manufacturer) are above +40 °C or below –5 °C, the following procedure shall be applied.

Single poles may be tested individually if each pole has a separate operating mechanism. In the case of poles apparatus having one common operating mechanism for the poles, the complete device shall be tested.

If the testing laboratory cannot accommodate complete standard, modifications of mounting structures, post insulators or spacing, wherever possible, are permitted to enable tests on poles. In adapted arrangement, changing the original isolating distance for the disconnector or the gap for the earthing switch is not allowed.

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

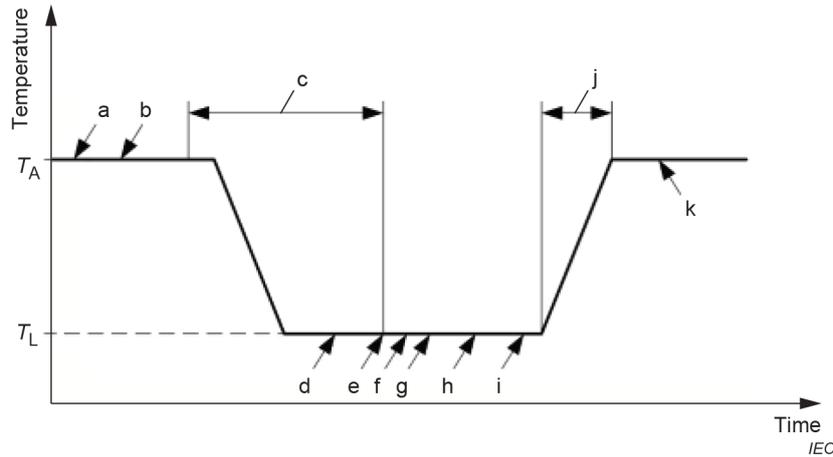
No maintenance, replacement of parts, lubrication or readjustment of the apparatus is permissible during the tests. For insulation pressure systems the tests shall be performed at rated filling pressure for insulation and/or switching. The characteristics recorded shall be within the tolerances specified by the manufacturer.

7.104.2 Measurement of ambient air temperature

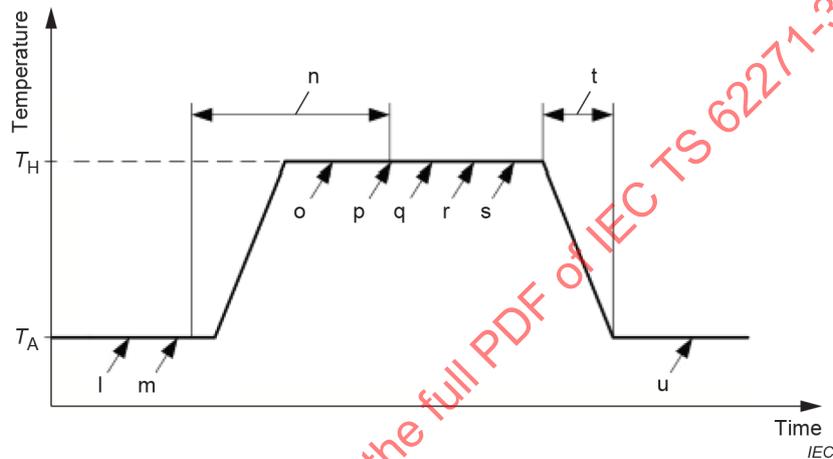
The maximum temperature deviation over the height of the apparatus shall not exceed 5 K, measured at a distance of 1 m from the apparatus.

7.104.3 Low-temperature test

The diagram of the test sequences and identification of the application points for the tests specified are given in Figure 12a).



a) Low temperature test



b) High temperature test

NOTE Letters a to u identify application points of tests specified in 7.104.3 and 7.104.4.

Figure 12 – Test sequences for low and high temperature tests

If the low-temperature test is performed immediately after the high-temperature test and using the same sample, the low-temperature test can proceed after completion of item (t) of the high-temperature test. In this case, items (a) and (b) are omitted.

- a) The test object shall be adjusted in accordance with the manufacturer's instructions;
- b) Characteristics and settings of the test object shall be recorded in accordance with 7.102.3.2 and at an ambient air temperature of $(20 \pm 5) \text{ }^\circ\text{C}$ (T_A). The tightness test for insulation pressure systems shall be performed according to 7.7;
- c) With the disconnector in close position and/or the earthing switch in open position, the air temperature shall be decreased to the appropriate, minimum ambient air temperature (T_L), according to the service conditions defined by the manufacturer and in accordance with Clause 4. A rate of change of $(10 \pm 5) \text{ K/h}$ is recommended. For $-40 \text{ }^\circ\text{C}$ or $-50 \text{ }^\circ\text{C}$ a lower rate of cooling is admitted. The disconnector shall be kept in close position and/or the earthing switch in open position for a minimum of 12 h after the ambient air temperature stabilises at T_L ;

- d) During the 12-h period with the disconnecter in the closed position and/or the earthing switch in the open position at temperature T_L , a tightness test shall be performed on insulation pressure systems. An increased leakage rate is acceptable, provided that it returns to the original value when the apparatus 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 10 of IEC TS 62271-5:2024. This tightness test shall be integral and performed by the accumulation method with appropriate apparatus for measurement of SF₆ concentration at the low temperature of the air in the testing room. For uniform diffusion of the SF₆ leaked inside the control volume, the use of a mixer or fan is highly recommended;
- e) After minimum 6 h at temperature T_L , the disconnecter that have reach the ambient temperature (± 2 °C in one h) shall be opened and closed and/or the earthing switch shall be closed and opened three times at rated values of supply voltage and operating pressure, if applicable. The operating characteristics shall be recorded;
- f) The low-temperature behaviour of the apparatus shall be verified, if applicable, by disconnecting the supply of all heating devices, including also the anti-condensation heating elements, for a duration t_x . At the end of the interval t_x , an operating order, at rated values of supply voltage and operating pressure, shall be given, if applicable. Then the disconnecter shall open and/or the earthing switch shall close. The operating characteristics shall be recorded;
- The value of t_x up to which the apparatus is still operable without auxiliary power to the heaters, is stated by the manufacturer (not less than 2 h). In the absence of such a statement, the value is equal to 2 h;
- g) The disconnecter shall be left in open position and/or the earthing switch shall be left in close position for minimum 2 h;
- h) During the 2-h period with the disconnecter in open position and/or the earthing switch in closed position at temperature T_L , a tightness test shall be performed according to 7.7 for insulation pressure systems using a cumulative leakage method as indicated in item (d);
- i) After 2 h at temperature T_L , the disconnecter shall be closed and/or the earthing switch shall be opened three times at rated values of supply voltage and operating pressure, if applicable. The operating characteristics shall be recorded;
- j) After completing the three closing and the three opening operations, the air temperature shall be increased to ambient air temperature T_A at a rate of change of approximately 10 K/h;
- k) After the apparatus has stabilised thermally at ambient air temperature T_A , a recheck shall be made of the apparatus settings, and the operating characteristics shall be recorded and verified according to 7.102.3.2. A tightness test shall be made as in item b) for comparison with the initial characteristics.

For combined function earthing switches including a disconnecter function, the operation of the disconnecter and the operation of the earthing switch as described in items (e) and (i) shall be spaced by 2 h or by $t_x + 2$ h in case of heating devices are switched off. For insulation pressure systems a tightness test shall be performed at least once when both disconnecter and earthing switch are in the open position.

After the complete low temperature test the pressure shall not be under the minimum functional pressure.

7.104.4 High-temperature test

The diagram of the test sequence and identification of the application points for the tests specified are given in Figure 12b).

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

- a) The test object shall be adjusted in accordance with the manufacturer's instructions;
- b) Characteristics and settings of the test object shall be recorded in accordance with 7.102.3.2 and at an ambient air temperature of $(20 \pm 5) ^\circ\text{C}$ (T_A). The tightness test for insulation pressure systems shall be performed according to 7.7;
- c) With the disconnecter in closed position and/or the earthing switch in open position, the air temperature shall be increased to the maximum ambient air temperature (T_H), declared by the manufacturer, at a rate of change of approximately 10 K/h. The disconnecter shall be kept in close position and/or the earthing switch in open position for 6 h after the ambient air temperature stabilises at T_H ;
- d) During the 6 h period with the disconnecter in close position and/or the earthing switch in open position at temperature T_H , a tightness test shall be performed for insulation pressure systems;
- e) After minimum 6 h at temperature T_H , the disconnecter, that have reach the ambient temperature ($\pm 2 ^\circ\text{C}$ in one h) shall be opened and/or the earthing switch shall be closed three times at rated values of supply voltage and operating pressure, if applicable. The operating characteristics shall be recorded;
- f) The disconnecter shall be left in open position and/or the earthing switch shall be left in the closed position for 2 h;
- g) During the 2-h period with the disconnecter in the open position and/or the earthing switch in the closed position at temperature T_H , a tightness test shall be performed for insulation pressure systems using a cumulative leakage method as indicated in item (d) of 7.104.3;
- h) After 2 h at temperature T_H , the disconnecter shall be closed and/or the earthing switch shall be opened three times at rated values of supply voltage and operating pressure, if applicable. The operating characteristics shall be recorded;
- i) After completing the three closing and the three opening operations, the air temperature shall be decreased to ambient air temperature T_A at a rate of change of approximately 10 K/h;
- j) After the apparatus has stabilised thermally at ambient air temperature T_A , a recheck shall be made of the apparatus settings, operating characteristics and tightness as in items (l) and (m) for comparison with the initial characteristics.

For combined function earthing switches including a disconnecter function, the operation of the disconnecter and the operation of the earthing switch as described in items (p) and (s) shall be spaced by 2 h. A tightness test shall be performed at least once when both disconnecter and earthing switch are in the open position.

After the complete high-temperature test the pressure shall not be under the minimum functional pressure.

7.105 Tests to verify the proper functioning of the position-indicating device

7.105.1 General

These tests apply, when a position indicator according to 6.104.3.2 is used.

The equipment shall pass all the tests defined in 7.105.2, in order to verify both the sufficient strength of the power kinematic chain and the reliability of the position-indicating kinematic chain.

One test object may be used for each operation mode.

7.105.2 Tests on the power kinematic chain and the position-indicating kinematic chain

The moving contact is locked in closed position for a disconnecter and in open position for an earthing switch.

A disconnecter or earthing switch operated by a common operating device, only the moving contact of the pole located farthest from the point of transmission of the energy from the power source along the power kinematic chain is locked.

The tests consist of three attempts performed on the switching device with its own complete operating device equipped with a strain limiting device (if any) and/or with a torque (force) controlling system (if any).

- For manual operation (for dependent and for independent), the normal operation handle shall be used to perform the attempts. During the tests, double the normal forces shall be employed, with a minimum of 200 N, but limited to a force of 750 N or to the operation of a strain-limiting device or torque (force) controlling system. This force shall be applied halfway along the length of the gripping part of the operating handle. Where the operating handle or the operating device incorporates a feature which limits the operating torque (force), the switching device shall be operated until the strain-limiting device operates, provided that the operating handle with strain-limiting device is not interchangeable with other handles;
- For power operation (for dependent and for independent), the maximum supply voltage or pressure for operation (if power operated or if release operated) as defined in 5.6 and 5.8 shall be applied respectively during the attempts. In the case of the presence of a strain-limiting device or torque (force) controlling system, the switching device shall be operated until the strain-limiting device or torque (force) controlling system operates.

No adjustment or replacement shall be made along the position indicating chain between the attempts. No break on the mechanical kinematic chain shall be produced during the test, except for strain limiting devices designed to break which will have to be replaced after they break. The test is considered passed if the position-indicating device indicates correctly the position of the moving contacts.

If the position-indicating device is marked directly on a mechanical part of the power kinematic chain no additional test is required.

The enclosure providing protection to the position-indicating kinematic chain shall be tested for its IP and IK (in accordance with 6.104.3.1). The blows shall be applied to the points of the enclosure that are likely to be the weakest in relation to the protection of the indicating kinematic chain.

8 Routine tests

8.1 General

Clause 8 of IEC TS 62271-5:2024 is applicable with the following additions:

Addition to the list of routine tests:

- a) mechanical operating tests in accordance with 8.101;
- b) verification of earthing function in accordance with 8.102.

Disconnectors and earthing switches used in neutral buses integrated in enclosed switchgear shall be tested as part of the switchgear assembly in accordance with IEC 62271-200, IEC 62271-201 or IEC 62271-203.

8.2 Dielectric test on the main circuit

Subclause 8.2 of IEC TS 62271-5:2024 is applicable with the following additions and/or deviations:

In case of disconnectors or earthing switches placed

- inside sealed pressure systems, the dielectric test may be performed at rated filling pressure for insulation;
- inside controlled or closed pressure systems, the dielectric test shall be performed at minimum functional pressure for insulation;
- for testing of earthing switches, the test voltage shall be applied with the earthing switch in the open position, between all the insulated terminals connected together and the bases earthed (e.g. A-to F earthed).

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 only to disconnectors.

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

Operating tests are made to ensure that the disconnectors or earthing switches show the specified operating behaviour within the specified supply voltage, if any, and supply pressure limits, if any, of their operating mechanisms.

During these tests, which are performed without voltage on, or current flowing through the main circuit, it shall be verified that:

- the disconnectors or earthing switches open and close correctly when their operating mechanisms are energized;
- the interlocks work properly in any interlocked position;
- the position-indicating and -signalling devices indicate correctly the open and closed positions.

The disconnector or earthing switch shall be subjected to the following tests:

- at specified minimum supply voltage and/or pressure (if any): five operating cycles;
- at specified maximum supply voltage and/or pressure (if any): five operating cycles;
- if a disconnector or earthing switch can be operated manually: five manual operating cycles.

During these operating cycles, the operating characteristics such as, if applicable, operating times, power consumption, maximum forces for manual operation, shall be verified. Satisfactory operation of control and auxiliary contacts, and position-indicating devices (if any) shall be verified. The values of each parameter shall be within the tolerances specified by the manufacturer.

During these tests no adjustment shall be made and the operation shall be faultless. The closed and open position shall be reached with the specified indication and signalling during each operating cycle.

After these tests, no parts of the disconnecter or earthing switch shall be damaged.

For disconnectors and earthing switches of $U_{rd} \geq 105$ kV, the mechanical operating routine tests may be performed on sub-assemblies.

Where mechanical routine tests are performed on separate components, they shall be repeated at site on a complete assembled disconnecter during the commissioning tests. The same total number of operations as specified in 7.102.3.2 shall be performed.

8.102 Verification of earthing function

The earthing function shall be verified according to the manufacturer's specification. However, test of electrical continuity shall be performed. Some examples of other routine tests that can be specified are as follows:

- contact resistance;
- contact pressure;
- visual inspection;
- dimension check;
- electrical continuity.

9 Guide to the selection of disconnectors and earthing switches (informative)

9.1 General

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

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

- continuous current load and overload conditions;
- existing fault conditions;
- static and dynamic terminal loads resulting from the substation design;
- use of rigid or flexible conductors to be connected to the disconnecter or earthing switch or to which the separated contact is mounted;
- environmental conditions (climat, pollution, etc.);
- altitude of the substation site;
- required operational performance (mechanical endurance);
- switching requirements (short-circuit making capacity of earthing switches).

When selecting a disconnecter or earthing switch, due allowance should be made for the likely future development of the system so that the disconnecter or earthing switch is suitable not merely for immediate requirements, but also for those of the future.

9.2 Selection of rated values

Subclause 9.2 of IEC TS 62271-5:2024 is applicable.

9.2.101 General

All rated characteristics and classes of a disconnector or earthing switch given in Clause 5 should be considered, as far as applicable, together with 9.2.102 to 9.2.107.

9.2.102 Selection of rated voltage and preferred rated insulation level

The rated voltage of the disconnector or earthing switch should be chosen so as to be at least equal to the highest voltage of the system at the point where the disconnector or earthing switch is to be installed.

The rated voltage of a disconnector or earthing switch should be selected from the rated values and their related insulation levels given in 5.2, 5.3 of IEC TS 62271-5:2024 and 5.3 of this document.

For disconnectors and earthing switches installed at high altitudes, refer to 4.2.2 of IEC TS 62271-5:2024.

9.2.103 Selection of rated continuous current

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

It should be noted that disconnectors have no standardized continuous overcurrent capability. When selecting a disconnector, therefore, the rated continuous current should be such as to make it suitable for any load current that may occur in service. Where intermittent overcurrents are expected to be frequent and severe, the manufacturer should be consulted.

9.2.104 Selection of rated contact zone

For proper function of a divided support disconnector or earthing switch, the user should ensure that the fixed contact stays within the limits given in 5.101 by considering the service conditions when specifying the substation design and the cantilever strength of the insulators.

When selecting the rated contact zone, the user should verify that the rated contact zone specified by the manufacturer is not exceeded in its specific application for the following additional constraints, if applicable:

- a longitudinal deflection resulting from wind acting on other connected components that are perpendicular to the bus work and from equipment movement;
- a perpendicular deflection resulting from forces from wind on other connected components that are perpendicular to the bus work and from equipment movement;
- a vertical deflection resulting from other vertical loads hung from the bus and from operating loads imposed by the operation of other equipment connected to the bus.

9.2.105 Selection of rated static mechanical terminal load

The rated static mechanical terminal load should be selected based on the requirements of 5.102 and the definition of 3.7.118. The most disadvantageous conditions should be considered by the user when specifying the rated static terminal loads.

To calculate the required static terminal loads as well as the required strength of insulators, the forces resulting from the conductors connected to the disconnector or earthing switch, including the forces of wind and ice (if applicable) and minimum specified ambient air temperature on these conductors should be considered.

9.2.106 Selection of rated short-time withstand current and of rated duration of short-circuit

Subclauses 5.5.2 and 5.5.4 of IEC TS 62271-5:2024 are applicable.

NOTE For short-time currents it can be considered that the thermal stress is constant when $I^2t = \text{constant}$.

9.2.107 Selection of rated peak withstand current

The selected disconnector or earthing switch should have a rated peak withstand current not less than the highest peak value of the fault current occurring in the actual system

Subclause 5.5.3 of IEC TS 62271-5:2024 should be considered.

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 with the following additions.

9.5.101 Local environmental conditions

For the normal and special service conditions for disconnectors and earthing switches, Clause 4 of IEC TS 62271-5:2024 applies.

For disconnectors and earthing switches, pollution conditions in certain areas both outdoors and indoors are unfavourable on account of smoke, chemical fumes, salt-laden spray, etc. Where such adverse conditions are known to exist, special consideration should be given to the design and materials used with the disconnector or earthing switch. In these conditions, care should be taken when considering the performance of parallel insulation. Pollution tests could be necessary to be performed on the disconnector or the earthing switch.

For insulators normally exposed to the atmosphere, refer to 6.15 of IEC TS 62271-5:2024. The performance of an insulator in polluted atmospheres also depends on the frequency with which artificial washing or other pollution control methods are carried out or natural cleaning occurs.

NOTE Insulator designs which have been proved by testing to fulfil the requirements of the user, can have a nominal creepage distance smaller than that given by the product of the rated voltage and the minimum specific creepage distance.

For open-terminal, indoor installations in coastal areas where salt deposit is a problem, it is recommended, for $U_{rd} \geq 105$ kV, to use equipment with outdoor insulation as this is more readily available than special indoor insulation. The use of GIS installations is also possible.

If a disconnector or earthing switch is to be located where the wind speed exceeds 34 m/s, this should be stated in the enquiry.

If a disconnector or earthing switch is to be located in a surrounding where an ice-coating with a thickness exceeding 1 mm is expected, this should be stated in the enquiry, taking 7.103 into consideration.

10 Information to be given with enquiries, tenders and orders

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 replaced by the following:

When enquiring for or ordering a disconnecter or an earthing switch, the following information, where applicable, should be supplied by the enquirer:

- a) particulars of system, i.e. nominal and highest voltages;
- b) service conditions, including minimum and maximum ambient air temperatures if different from the normal values (refer to Clause 9), altitude if over 1 000 m, ice and any special conditions likely to exist or arise, for example unusual exposure to steam or vapour, moisture, fumes, explosive gases, excessive dust or salt air (see 9.5.101);
- c) characteristics of the disconnecter or earthing switch. The following information should be given:
 - 1) indoor or outdoor installation;
 - 2) unidirectional or bidirectional;
 - 3) rated voltage (see 5.2);
 - 4) Preferred rated insulation level where a choice exists between different insulation levels corresponding to a given rated voltage or, if other than rated, desired insulation level (see 5.3);
 - 5) rated continuous current (I_{rd}) (for disconnectors only) (see 5.4);
 - 6) rated short-time withstand current (I_{kd}), (see 5.5.2);
 - 7) rated peak withstand current (I_{pd}) (see 5.5.3),
 - 8) rated duration of short-circuit (if different from 1 s), (see 5.5.4);
 - 9) rated static mechanical terminal loads, if applicable (see 5.102);
 - 10) use of rigid or flexible conductors to be connected to the disconnecter or earthing switch or to which the separated contact is mounted, if applicable (see 5.102);
 - 11) mounting conditions and HV connections, for example hanging arrangement of the fixed contact of the disconnecter and earthing switch; support structure to be supplied with the equipment or not, if applicable;
 - 12) requirements for insulators (if applicable) to be used with the disconnecter and earthing switch:
 - class of pollution taken from IEC TS 60815-1 [3];
 - profile of the sheds (if applicable); taken from IEC TS 60815 (all parts) [2];
 - see item 11);
 - 13) required contact zone (see 5.101); if applicable;
 - 14) operation under severe ice conditions (see 5.105), if applicable;
 - 15) rated mechanical endurance class, if different from M0 (see 5.103 and 5.104);
 - 16) degree of protection for the enclosure and partitions (if any of both);
 - 17) circuit diagrams;