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**High-voltage switchgear and controlgear –
Part 204: Rigid gas-insulated transmission lines for rated voltage above 52 kV**





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**High-voltage switchgear and controlgear –
Part 204: Rigid gas-insulated transmission lines for rated voltage above 52 kV**

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HIGH-VOLTAGE SWITCHGEAR AND CONTROLGEAR –

Part 1: Common specifications for alternating current switchgear and controlgear

INTERPRETATION SHEET 1

This interpretation sheet has been prepared by IEC technical committee 17: High-voltage switchgear and controlgear.

The text of this interpretation sheet is based on the following documents:

DISH	Report on voting
17/1090/DISH	17/1095/RVDISH

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

Interpretation of 4.2.2 of IEC 62271-1:2017 regarding the altitude correction factor

Subclause 4.2.2 of IEC 62271-1:2017 contains two references for calculation of the required insulation withstand level at altitudes higher than 1 000 m, IEC 60071-2:1996 and IEC TR 62271-306. The two references are in conflict, as the altitude correction factor according to IEC 60071-2:1996 starts at sea level and that of IEC TR 62271-306 starts at an altitude of 1 000 m. This results in different altitude correction factors.

As already stated in 5.3 of IEC 62271-1:2017, the rated insulation levels refer to normal service conditions. Altitudes up to 1 000 m above sea level are covered and need no altitude correction.

For altitudes higher than 1 000 m the equation provided in 4.5.1.1 b) of IEC TR 62271-306:2012 and in H.3.4 of IEC 60071-2:2018 shall be used, i.e.

$$k_{\text{alt}} = e^{m \left(\frac{H-1\,000}{8\,150} \right)}$$

where

k_{alt} is the altitude correction factor;

H is the altitude in m above sea level;

m is an exponent.

Conservative values for the exponent m are provided in Table 4 of IEC TR 62271-306:2012. For further details about the exponent m , see H.4 of IEC 60071-2:2018.

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

HIGH-VOLTAGE SWITCHGEAR AND CONTROLGEAR –

**Part 204: Rigid gas-insulated transmission lines
for rated voltage above 52 kV**

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Particular subclauses of IEC 62271-1:2017+AMD1:2021 CSV and IEC 62271-203:2022 are displayed in the content on a blue background.

IEC 62271-204 has been prepared by subcommittee 17C: Assemblies, of IEC technical committee 17: High-voltage switchgear and controlgear. It is an International Standard.

This second edition cancels and replaces the first edition published in 2011. This edition constitutes a technical revision.

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

- a) update to be in line with IEC 62271-1:2017 and alignment of the voltage ratings and the test voltages.
- b) addition of new information for welds on pressurized parts and gas tightness.

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

Draft	Report on voting
17C/840/FDIS	17C/846/RVD

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

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

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

This document is to be read in conjunction with IEC 62271-1:2017 and IEC 62271-203:2022, to which it refers and which are applicable unless otherwise specified. In order to simplify the indication of corresponding requirements, the same numbering of clauses and subclauses is used as in IEC 62271-1:2017 and IEC 62271-203:2022. Amendments to these clauses and subclauses are given under the same numbering, whilst additional subclauses are numbered from 101.

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

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

- reconfirmed,
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HIGH-VOLTAGE SWITCHGEAR AND CONTROLGEAR –

Part 204: Rigid gas-insulated transmission lines for rated voltage above 52 kV

1 Scope

This part of IEC 62271 applies to rigid HV gas-insulated transmission lines (GIL) in which the insulation is obtained, at least partly, by an insulating gas or gas mixture other than air at atmospheric pressure, for alternating current of rated voltages above 52 kV, and for service frequencies up to and including 60 Hz.

This document is applicable where the provisions of IEC 62271-203 do not cover the application of GIL (see Note 3).

At each end of the HV gas-insulated transmission line, a specific element is used for the connection between the HV gas-insulated transmission line and other equipment like bushings, power transformers or reactors, cable boxes, metal-enclosed surge arresters, voltage transformers or GIS, covered by their own specification.

Unless otherwise specified, the HV gas-insulated transmission line is designed to be used under normal service conditions.

NOTE 1 In this document, the term "HV gas-insulated transmission line" is abbreviated to "GIL".

NOTE 2 In this document, the word "gas" means gas or gas mixture, as defined by the manufacturer.

NOTE 3 Examples of GIL applications:

- where all or part of the HV gas-insulated transmission line is directly buried;
- where the HV gas-insulated transmission line is located, wholly or partly, in an area accessible to public;
- where the HV gas-insulated transmission line is long (typically longer than 500 m) and the typical gas compartment length exceeds the common practice of GIS technology.

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 60038:2009, *IEC standard voltages*

IEC 60050-131:2002, *International Electrotechnical Vocabulary (IEV) – Part 131: Circuit theory*

IEC 60050-151:2001, *International Electrotechnical Vocabulary (IEV) – Part 151: Electrical and magnetic devices*

IEC 60050-192:2015, *International Electrotechnical Vocabulary (IEV) – Part 192: Dependability*

IEC 60050-351, *International Electrotechnical Vocabulary (IEV) – Part 351: Control technology*

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

IEC 60050-551, *International Electrotechnical Vocabulary (IEV) – Part 551: Power electronics*

IEC 60050-581:2008, *International Electrotechnical Vocabulary (IEV) – Part 581: Electromechanical components for electronic equipment*

IEC 60050-601, *International Electrotechnical Vocabulary (IEV) – Chapter 601: Generation, transmission and distribution of electricity – General*

IEC 60050-605, *International Electrotechnical Vocabulary (IEV) – Chapter 605: Generation, transmission and distribution of electricity – Substations*

IEC 60050-614:2016, *International Electrotechnical Vocabulary (IEV) – Part 614: Generation, transmission and distribution of electricity – Operation*

IEC 60050-811, *International Electrotechnical Vocabulary (IEV) – Part 811: Electric traction*

IEC 60050-826:2004, *International Electrotechnical Vocabulary (IEV) – Part 826: Electrical installations*

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

IEC 60068-1:2013, *Environmental testing – Part 1: General and guidance*

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

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

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

IEC 60071-1:2006, *Insulation co-ordination – Part 1: Definitions, principles and rules*
IEC 60071-1:2006/AMD1:2010

IEC 60071-2:1996, *Insulation co-ordination – Part 2: Application guide*

IEC 60085:2007, *Electrical insulation – Thermal evaluation and designation*

IEC 60229:2007, *Electric cables – Tests on extruded oversheaths with a special protective function*

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

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

IEC 60287-3-1:2017, *Electric cables – Calculation of the current rating – Part 3-1: Operating conditions – Site reference conditions*

IEC 60296, *Fluids for electrotechnical applications – Unused mineral insulating oils for transformers and switchgear*

IEC 60376, *Specification of technical grade sulfur hexafluoride (SF₆) and complementary gases to be used in its mixtures for use in electrical equipment*

IEC 60480, *Specifications for the re-use of sulfur hexafluoride (SF₆) and its mixtures in electrical equipment*

IEC 60507, *Artificial pollution tests on high-voltage ceramic and glass insulators to be used on a.c. systems*

IEC 60512-2-2, *Connectors for electronic equipment – Tests and measurements – Part 2-2: Electrical continuity and contact resistance tests – Test 2b: Contact resistance – Specified test current method*

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

IEC 60529:1989/AMD1:1999

IEC 60529:1989/AMD2:2013

IEC TS 60815-1:2008, *Selection and dimensioning of high-voltage insulators intended for use in polluted conditions – Part 1: Definitions, information and general principles*

IEC TS 60815-2:2008, *Selection and dimensioning of high-voltage insulators intended for use in polluted conditions – Part 2: Ceramic and glass insulators for a.c. systems*

IEC TS 60815-3:2008, *Selection and dimensioning of high-voltage insulators intended for use in polluted conditions – Part 3: Polymer insulators for a.c. systems*

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

IEC 61000-4-11, *Electromagnetic compatibility (EMC) – Part 4-11: Testing and measurement techniques – Voltage dips, short interruptions and voltage variations immunity tests*

IEC 61000-4-17:2009, *Electromagnetic compatibility (EMC) – Part 4-17: Testing and measurement techniques – Ripple on d.c. input power port immunity test*

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

IEC 61000-4-29, *Electromagnetic compatibility (EMC) – Part 4-29: Testing and measurement techniques – Voltage dips, short interruptions and voltage variations on d.c. input power port immunity tests*

IEC 61000-6-2, *Electromagnetic compatibility (EMC) – Part 6-2: Generic standards – Immunity for industrial environments*

IEC 61000-6-5, *Electromagnetic compatibility (EMC) – Part 6-5: Generic standards – Immunity for equipment used in power station and substation environment*

IEC 61180, *High-voltage test techniques for low-voltage equipment – Definitions, test and procedure requirements, test equipment*

IEC 61810-7:2006, *Electromechanical elementary relays – Part 7: Test and measurement procedures*

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

IEC 62271-4:2013, *High-voltage switchgear and controlgear – Part 4: Handling procedures for sulphur hexafluoride (SF₆) and its mixtures*

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

CISPR TR 18-2, *Radio interference characteristics of overhead power lines and high-voltage equipment – Part 2: Methods of measurement and procedure for determining limits*

ISO 9606 (all parts), *Qualification test of welders – Fusion welding*

ISO 9712, *Non-destructive testing – Qualification and certification of NDT personnel*

ISO 14732, *Welding personnel – Qualification testing of welding operators and weld setters for mechanized and automatic welding of metallic materials*

ISO 15609 (all parts), *Specification and qualification of welding procedures for metallic materials – Welding procedure specification*

ISO 15614 (all parts), *Specification and qualification of welding procedures for metallic materials – Welding procedure test*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60050-131, IEC 60050-151, IEC 60050-192, IEC 60050-351, IEC 60050-441, IEC 60050-551, IEC 60050-581, IEC 60050-601, IEC 60050-605, IEC 60050-614, IEC 60050-811 and IEC 60050-826, some of which are recalled hereunder, and the following apply.

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

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

NOTE Terms and definitions are classified in accordance with IEC 60050-441. References from other parts than IEC 60050-441 are classified so as to be aligned with the classification used in IEC 60050-441.

3.1 General terms and definitions

3.1.1

switchgear and controlgear

general term covering switching devices and their combination with associated control, measuring, protective and regulating equipment, also assemblies of such devices and equipment with associated interconnections, accessories, enclosures and supporting structures

[SOURCE: IEC 60050-441:2000, 441-11-01]

3.1.2**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.

[SOURCE: IEC 60050-614:2016, 614-03-02]

3.1.3**degree of protection**

extent of protection provided by an enclosure against access to hazardous parts, against ingress of solid foreign objects and/or ingress of water and against mechanical impact

[SOURCE: IEC 60529:1989, 3.3, modified – leave out “verified by standardized test methods” and add “against mechanical impact” after “water and”.]

3.1.4**IP code**

coding system to indicate the degrees of protection provided by an enclosure against access to hazardous parts, ingress of solid foreign objects, ingress of water and to give additional information in connection with such protection

[SOURCE: IEC 60529:1989, 3.4]

3.1.5**protection provided by an enclosure against access to hazardous parts**

protection of persons against

- contact with hazardous low-voltage live parts;
- contact with hazardous mechanical parts;
- approach to hazardous high-voltage live parts below adequate clearance inside an enclosure

Note 1 to entry: This protection may be provided:

- by means of the enclosure itself;
- by means of barriers as part of the enclosure or distances inside the enclosure.

[SOURCE: IEC 60529:1989, 3.6]

3.1.6**IK code**

coding system to indicate the degree of protection provided by an enclosure against harmful external mechanical impacts

[SOURCE: IEC 62262:2002, 3.3]

3.1.7**maintenance**

combination of all technical and management actions intended to retain an item in, or restore it to, a state in which it can perform as required

Note 1 to entry: Management is assumed to include supervision activities.

[SOURCE: IEC 60050-192:2015, 192-06-01]

3.1.8**visual inspection**

visual investigation of the principal features of the switchgear and controlgear

Note 1 to entry: This inspection is generally directed toward pressures and/or levels of fluids, tightness, position of relays, pollution of insulating parts, but actions such as lubricating, cleaning, washing, etc. which can be carried out with the switchgear and controlgear in service are also included.

Note 2 to entry: Observations resulting from inspection can lead to the decision to carry out overhaul.

Note 3 to entry: This inspection can be used for determining the state of tested objects on e.g. cracks in solid insulators.

3.1.9**diagnostic test**

comparative test of the characteristic parameters of switchgear and controlgear to verify that it performs its functions, by measuring one or more of these parameters

Note 1 to entry: The result from a diagnostic test can lead to the decision to carry out overhaul.

3.1.10**overhaul**

work performed with the objective of repairing or replacing parts which are found to be out of tolerance by inspection, diagnostic test, examination or as required by manufacturer's maintenance manual, in order to restore the component and/or the switchgear and controlgear to an acceptable condition (within tolerance)

3.1.11**failure**

loss of ability to perform as required

Note 1 to entry: A failure of an item is an event that results in a fault of that item: see fault (IEC 60050-192:2015, 192-04-01).

Note 2 to entry: Qualifiers, such as catastrophic, critical, major, minor, marginal and insignificant, can be used to categorize failures according to the severity of consequences, the choice and definitions of severity criteria depending upon the field of application.

Note 3 to entry: Qualifiers, such as misuse, mishandling and weakness, may be used to categorize failures according to the cause of failure.

[SOURCE: IEC 60050-192:2015, 192-03-01]

3.1.12**major failure** (of switchgear and controlgear)

failure of switchgear and controlgear which causes the cessation of one or more of its fundamental functions

Note 1 to entry: A major failure may result in an immediate change in the system operating conditions, for example, the backup protective equipment will be required to remove the fault or will result in mandatory removal from service within 30 min for unscheduled maintenance.

3.1.13**minor failure** (of switchgear and controlgear)

any failure of a constructional element or a subassembly which does not cause a major failure of the switchgear and controlgear

3.1.14**defect**

imperfection in the state of an item (or inherent weakness) which can result in one or more failures of the item itself, or of another item under the specific service or environmental or maintenance conditions, for a stated period of time

3.1.15**ambient air temperature**

temperature, determined under prescribed conditions, of the air surrounding the complete switching device or fuse

Note 1 to entry: For switching devices or fuses installed inside an enclosure, it is the temperature of the air outside the enclosure.

[SOURCE: IEC 60050-441:2000, 441-11-13]

3.1.16**monitoring**

observation of the operation of a system or part of a system to verify correct functioning by detecting incorrect functioning, this being done by measuring one or more variables of the system and comparing the measured values with the specified values

Note 1 to entry: Some definitions are given for this term in IEC 60050 (all parts). They are related to different cases of application.

3.1.17**supervision**

activity, performed either manually or automatically, intended to observe the state of an item

Note 1 to entry Automatic supervision may be performed internally or externally to the item.

3.1.18**site pollution severity class****SPS**

classification of pollution severity at a site, from very light to very heavy, as a function of the SPS (site pollution severity)

Note 1 to entry: Adapted from: IEC TS 60815-1:2008, 3.1.15, modified – the term (site pollution severity) is added.

3.1.19**internal insulation**

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

[SOURCE: IEC 60050-614:2016, 614-03-03, modified – addition of "parts of".]

3.1.20**non-sustained disruptive discharge****NSDD**

disruptive discharge associated with current interruption that does not result in the resumption of power frequency current or, in the case of capacitive current interruption, does not result in current in the main load circuit

3.2 Assemblies of switchgear and controlgear**3.2.1****test object**

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

3.3 Parts of assemblies**3.3.1****transport unit**

part of switchgear and controlgear intended for transportation without being dismantled

3.3.2

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

3.4.1

(mechanical) switch

mechanical switching device capable of making, carrying and breaking currents under normal circuit conditions which may include specified operating overload conditions and also carrying for a specified time currents under specified abnormal circuit conditions such as those of short-circuit

Note 1 to entry: A switch may be capable of making but not breaking short-circuit currents.

[SOURCE: IEC 60050-441:2000, 441-14-10]

3.4.2

disconnector

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

Note 1 to entry: A disconnector 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 disconnector occurs. It is also capable of carrying currents under normal circuit conditions and carrying currents for a specified time under abnormal conditions such as those of short-circuit.

[SOURCE: IEC 60050-441:2000, 441-14-05]

3.5 Parts of switchgear and controlgear

3.5.1

enclosure

housing affording the type and degree of protection suitable for the intended application

Note 1 to entry: Enclosures provide protection of persons or livestock against access to hazardous parts. Barriers, shapes of openings or any other means (whether attached to the enclosure or formed by the enclosed equipment) suitable to prevent or limit the penetration of the specified test probes, are considered as a part of the enclosure, when they are secured in position either by means of interlocks, keys, or by hardware requiring a tool to be removed.

[SOURCE: IEC 60050-826:2004, 826-12-20, modified – the Note 1 to entry has been added]

3.5.2

hazardous part

part that is hazardous to approach or touch

[SOURCE: IEC 60529:1989, 3.5]

3.5.3

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]

3.5.4**auxiliary circuit** (of a switching device)

all the conductive parts of a switching device which are intended to be included in a circuit other than the main circuit, the earthing circuit and the control circuits of the device

Note 1 to entry: Some auxiliary circuits fulfil supplementary functions such as signalling, interlocking, etc., and, as such, they may be part of the control circuit of another switching device.

[SOURCE: IEC 60050-441:2000, 441-15-04, modified – "earthing circuit" has been added]

3.5.5**control circuit** (of a switching device)

all the conductive parts (other than the main circuit) of a switching device which are included in a circuit used for the closing operation or opening operation, or both, of the device

[SOURCE: IEC 60050-441:2000, 441-15-03]

3.5.6**auxiliary switch** (of a mechanical switching device)

switch containing one or more control and/or auxiliary contacts mechanically operated by a switching device

[SOURCE: IEC 60050-441:2000, 441-15-11]

3.5.7**control switch** (for control and auxiliary circuits)

mechanical switching device which serves the purpose of controlling the operation of switchgear or controlgear, including signalling, electrical interlocking, etc.

Note 1 to entry: A control switch consists of one or more contact elements with a common actuating system.

[SOURCE: IEC 60050-441:2000, 441-14-46]

3.5.8**auxiliary contact**

contact included in an auxiliary circuit and operated by the switching device

[SOURCE: IEC 60050-441:2000, 441-15-10, modified – delete "mechanically"]

3.5.9**control contact**

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

[SOURCE: IEC 60050-441:2000, 441-15-09, modified – delete "mechanical" and "mechanically"]

3.5.10**connection** (bolted or the equivalent)

two or more conductors designed to ensure permanent circuit continuity when forced together by means of screws, bolts or the equivalent

3.5.11**position indicating device**

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

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

3.5.12**monitoring device**

device intended to observe automatically the status of an item

3.5.13**pilot switch**

non-manual control switch actuated in response to specified condition of an actuating quantity

Note 1 to entry: The actuating quantity may be pressure, temperature, velocity, liquid level, elapsed time, etc.

[SOURCE: IEC 60050-441:2000, 441-14-48]

3.5.14**partition** (of an assembly)

part of an assembly separating one compartment from other compartments

[SOURCE: IEC 60050-441:2000, 441-13-06]

3.5.15**actuator**

part of the actuating system to which an external actuating force is applied

Note 1 to entry: The actuator may take the form of a handle, knob, push-button, roller, plunger, etc.

[SOURCE: IEC 60050-441:2000, 441-15-22]

3.5.16**splice**

connecting device with barrel(s) accommodating electrical conductor(s) with or without additional provision to accommodate and secure the insulation

[SOURCE: IEC 60050-581:2008, 581-24-19, modified – addition of "electrical".]

3.5.17**terminal**

point of interconnection of an electric circuit element, an electric circuit or a network with other electric circuit elements, electric circuits or networks

Note 1 to entry: For an electric circuit element, the terminals are the points at which or between which the related integral quantities are defined. At each terminal, there is only one electric current from outside into the element.

Note 2 to entry: The term "terminal" has a related meaning in IEC 60050-151.

[SOURCE: IEC 60050-131:2002, 131-11-11]

3.5.18**terminal block**

assembly of terminals in a housing or body of insulating material to facilitate interconnection between multiple conductors

[SOURCE: IEC 60050-581:2008, 581-26-26]

3.5.19**contactor****mechanical contactor**

mechanical switching device having only one position of rest, operated otherwise than by hand, capable of making, carrying and breaking currents under normal circuit conditions including operating overload conditions

Note 1 to entry: Contactors may be designated according to the method by which the force for closing the main contacts is provided.

[SOURCE: IEC 60050-441:2000, 441-14-33]

3.5.20

starter

combination of all the switching means necessary to start and stop a motor in combination with suitable overload protection

Note 1 to entry: Starters may be designated according to the method by which the force for closing the main contacts is provided.

[SOURCE: IEC 60050-441:2000, 441-14-38]

3.5.21

vacuum interrupter

component being part of a switching device in which electrical contacts operate in a highly evacuated, hermetically sealed environment

3.5.22

operation counter

device indicating the number of operating cycles a mechanical switching device has accomplished

3.5.23

coil

set of series-connected turns, usually coaxial

[SOURCE: IEC 60050-151:2001, 151-13-15]

3.5.24

auxiliary and control circuits

entity of

- control and auxiliary circuits, mounted on or adjacent to the switchgear or controlgear, including circuits in central control cubicles;
- equipment for monitoring, diagnostics, etc. that is part of the auxiliary circuits of the switchgear or controlgear;
- circuits connected to the secondary terminals of instrument transformers, that are part of the switchgear or controlgear

3.5.25

subassembly (of auxiliary and control circuits)

part of auxiliary and control circuits, with regard to function or position, having its own interface and normally placed in a separate enclosure

3.5.26

interchangeable subassembly (of an auxiliary and control circuits)

subassembly which is intended to be placed in various positions within an auxiliary and control circuits, or intended to be replaced by other similar subassemblies

Note 1 to entry: An interchangeable subassembly has an accessible interface.

3.5.27

interlocking device

device which makes the operation of a switching device dependent upon the position or operation of one or more other pieces of equipment

[SOURCE: IEC 60050-441:2000, 441-16-49]

3.6 Operational characteristics of switchgear and controlgear

3.6.1

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]

3.6.2

stored energy operation (of a mechanical switching device)

operation by means of energy stored in the drive 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, modified – addition of "drive".]

3.6.3

independent unlatched operation

stored energy operation where energy is stored and released in one continuous operation such that the speed and force of the operation are independent of the rate of applied energy

Note 1 to entry: The energy stored for the operation may originate from the operator (manual) or a power source.

3.6.4

positively driven operation

operation which, in accordance with specified requirements, is designed to ensure that auxiliary contacts of a mechanical switching device are in the respective positions corresponding to the open or closed position of the main contacts

Note 1 to entry: A positively driven operating device is made by the association of a moving part, linked mechanically to the main contact of the primary circuit, without the use of springs, and a sensing element. In the case of mechanical auxiliary contacts, this sensing element can be simply the fixed contact, directly connected to the secondary terminal. In the case where the function is achieved electronically, the sensing element can be a static transducer (optical, magnetic, etc.) associated with a static switch, or associated with an electronic or electro-optic transmitting element.

[SOURCE: IEC 60050-441:2000, 441-16-12, modified – the Note 1 to entry has been added]

3.6.5 Terms and definitions relative to pressure (or density)

3.6.5.1

filling pressure p_{re} for insulation and/or switching

filling density ρ_{re} for insulation and/or switching

pressure (in 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

3.6.5.2**filling pressure p_{rm} for operation****filling density ρ_{rm} for operation**

pressure (in Pa), for operation, 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 energy storage device is filled before being put into service or automatically replenished

3.6.5.3**alarm pressure p_{ae} for insulation and/or switching****alarm density ρ_{ae} for insulation and/or switching**

pressure (in 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 a monitoring signal may be provided

3.6.5.4**alarm pressure p_{am} for operation****alarm density ρ_{am} for operation**

pressure (in Pa), for operation, 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 a monitoring signal from the energy storage device may be provided

3.6.5.5**minimum functional pressure p_{me} for insulation and/or switching****minimum functional density ρ_{me} for insulation and/or switching**

pressure (in 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

3.6.5.6**minimum functional pressure p_{mm} for operation****minimum functional density ρ_{mm} for operation**

pressure (in Pa), for operation, 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 of the energy storage device becomes necessary

Note 1 to entry: This pressure is often designated as interlocking or lockout pressure.

3.6.6 Terms and definitions relating to gas and vacuum tightness**3.6.6.1****controlled pressure system for gas**

volume which is automatically replenished from an external compressed gas supply or internal gas source

Note 1 to entry: Examples of controlled pressure systems are air-blast circuit-breakers or pneumatic drive mechanisms.

Note 2 to entry: A volume may consist of several permanently connected gas-filled compartments.

3.6.6.2**closed pressure system for gas**

volume which is replenished when needed by manual connection to an external gas source

Note 1 to entry: Example of closed pressure systems are SF₆ single-pressure circuit-breakers.

3.6.6.3**sealed pressure system**

volume for which no further liquid, gas or vacuum processing is required during its expected operating duration

Note 1 to entry: Examples of sealed pressure systems are vacuum interrupters or some SF₆ circuit-breakers.

Note 2 to entry: Sealed pressure systems are completely assembled and tested in the factory.

Note 3 to entry: Expected operating duration starts when the device is sealed.

3.6.6.4**absolute leakage rate** F

amount of gas escaped by time unit

Note 1 to entry: The absolute leakage rate is usually expressed in Pa × m³ × s⁻¹.

3.6.6.5**permissible leakage rate** F_p

maximum permissible absolute leakage rate of gas specified for a part, a component or a sub-assembly, or by using the tightness coordination chart, for an arrangement of parts, components or subassemblies connected together in one pressure system

3.6.6.6**relative leakage rate** F_{rel}

absolute leakage rate related to the total amount of gas in the system at filling pressure (or density)

Note 1 to entry: The relative leakage rate is expressed in percentage per year or per day.

3.6.6.7**time between replenishments** t_r

time elapsed between two replenishments performed manually when the pressure (density) reaches the alarm level, to compensate the leakage rate F

Note 1 to entry: This value is applicable to closed pressure systems.

3.6.6.8**number of replenishments per day** N

number of replenishments to compensate the leakage rate F

Note 1 to entry: This value is applicable to controlled pressure systems.

3.6.6.9**pressure drop** Δp

drop of pressure in a given time caused by the leakage rate F , without replenishment

3.6.6.10**tightness coordination chart**

survey document supplied by the manufacturer, used when testing parts, components or sub-assemblies, to demonstrate the relationship between the tightness of a complete system and that of the parts, components and/or sub-assemblies

3.6.6.11**sniffing**

action of slowly moving a leak meter sensing probe around an assembly to locate a gas leak

3.6.6.12**cumulative leakage measurement**

measurement which takes into account all the leaks from a given assembly to determine the leakage rate

3.6.7 Terms and definitions relating to liquid tightness**3.6.7.1****absolute leakage rate**

F_{liq}

amount of liquid escaped by time unit

Note 1 to entry: The absolute leakage rate is usually expressed in $\text{cm}^3 \times \text{s}^{-1}$.

3.6.7.2**permissible leakage rate**

$F_{\text{p(liq)}}$

maximum permissible leakage rate specified by the manufacturer for a liquid pressure system

3.6.7.3**number of replenishments per day**

N_{liq}

number of replenishments to compensate the leakage rate F_{liq}

3.6.7.4**pressure drop**

Δp_{liq}

drop in pressure in a given time caused by the leakage rate F_{liq} without replenishment

3.7 Characteristic quantities**3.7.1****isolating distance** (of a pole of a mechanical switching device)

clearance between open contacts meeting the withstand voltage requirements specified for disconnectors

[SOURCE: IEC 60050-441:2000, 441-17-35, modified – "safety" replaced by "withstand voltage".]

3.7.2**rated value**

value of a quantity used for specification purposes, established for a specified set of operating conditions of a component, device, equipment or system

[SOURCE: IEC 60050-151:2001, 151-16-08]

3.7.3**highest voltage for equipment**

U_{m}

greatest value of phase-to-phase voltage (RMS value) for which the equipment is designed in respect of its insulation as well as other characteristics which relate to this voltage in the relevant equipment standards

Note 1 to entry: Under normal service conditions specified by the relevant apparatus committee this voltage can be applied continuously to the equipment.

[SOURCE: IEC 60050-614: 2016, 614-03-01, modified – The note to entry was added]

3.7.4

supply voltage (of auxiliary and control circuits)

RMS value or, if applicable, the DC value, of the voltage existing at a given instant at a point of supply, measured over a given time interval

Note 1 to entry: If a supply voltage is specified for instance in the supply contract, then it is called “declared supply voltage”.

Note 2 to entry: The supply voltage of auxiliary and control circuits is measured at the circuit terminals of the apparatus itself during its operation, including, if necessary, the auxiliary resistors or accessories supplied or required by the manufacturer to be installed in series with it, but not including the conductors for the connection to the electricity supply.

[SOURCE: IEC 60050-614: 2016, 614-01-03, modified – add Note 2 to entry.]

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3.101**area accessible to public**

area accessible without restriction to any person

Note 1 to entry: A GIL installed above the ground and outside a substation is considered to be "installed in an area accessible to public".

3.102**gas-insulated transmission lines****GIL**

metal-enclosed lines in which the insulation is obtained, at least partly, by an insulating gas other than air at atmospheric pressure, with the external enclosure intended to be earthed

3.103**GIL enclosure**

part of GIL retaining the insulating gas under the required conditions protecting the equipment against external influences and providing a high degree of protection to personnel

3.104**compartment**

part of GIL totally gastight enclosed except for openings necessary for interconnection and control

3.105**partition**

gas tight support insulator of gas-insulated metal-enclosed switchgear separating two adjacent compartments

3.106**main circuit**

all the conductive parts of GIL included in a circuit which is intended to transmit electrical energy

[SOURCE: IEC 60050-441:1984, 441-13-02, modified – Replacement of "an assembly" by "GIL".]

3.107**ambient air temperature**

temperature, determined under required conditions, of the air surrounding the external GIL enclosure in case of installation in open air, open trenches or tunnels

[SOURCE: IEC 60050-441:1984, 441-11-13, modified – Replacement of “complete switching device or fuse” by “external GIL enclosure in case of installation in open air, open trenches or tunnels”.]

3.108**design temperature of the enclosure**

maximum temperature which can be reached on a GIL enclosure under service conditions

3.109**design pressure of the enclosure**

relative pressure used to determine the design of the enclosure

Note 1 to entry: It is at least equal to the maximum relative pressure in the enclosure at the design temperature of the enclosure.

3.110**design pressure of the partitions**

relative pressure across the partition

Note 1 to entry: It is at least equal to the maximum differential pressure across the partition during maintenance activities.

3.111**disconnecting unit**

unit to electrically isolate one side from another of the main circuit, mainly for site testing or maintenance

3.112**disruptive discharge**

phenomenon associated with the failure of insulation under electric stress, in which the discharge completely bridges the insulation, reducing the voltage between the electrodes to zero or almost zero

Note 1 to entry: The term applies to discharges in solid, liquid and gaseous dielectrics and to combinations of these.

Note 2 to entry: A disruptive discharge in a solid dielectric produces permanent loss of dielectric strength (non-self-restoring insulation); in a liquid or gaseous dielectric, the loss can be only temporary (self-restoring insulation).

Note 3 to entry: The term “sparkover” is used when a disruptive discharge occurs in a gaseous or liquid dielectric. The term “flashover” is used when a disruptive discharge occurs over the surface of a solid dielectric in a gaseous or liquid medium. The term “puncture” is used when a disruptive discharge occurs through a solid dielectric.

3.113**GIL section**

part of GIL which is defined by operational or other requirements such as maximum length for dielectric testing or installation sequence

Note 1 to entry: A GIL can consist on the assembly of several GIL sections.

Note 2 to entry: It can consist of one or more compartments.

Note 3 to entry: Sections can be segregated by disconnecting units.

4 Normal and special service conditions

4.1 Normal service conditions

4.1.1 General

Unless otherwise specified, high-voltage switchgear and controlgear, including the operating devices and the auxiliary equipment which form an integral part of them, are intended to be used in accordance with their rated characteristics and the normal service conditions listed in 4.1.

Operation under normal service conditions is considered to be covered by the type tests according to this document and relevant product standard.

The normal service conditions which apply to a GIL depending on the installation conditions are given in 4.101, 4.102 and 4.103. When more than one of these installation conditions apply, the relevant subclause shall apply to each section of the GIL.

4.1.2 Indoor switchgear and controlgear

The normal service conditions for indoor switchgear and controlgear are:

- a) the ambient air temperature does not exceed 40 °C and its average value, measured over a period of 24 h does not exceed 35 °C. The ambient air temperature does not drop below –5 °C;
- b) there is no influence from solar radiation;
- c) the altitude does not exceed 1 000 m;
- d) the ambient air is not significantly polluted by dust, smoke, corrosive and/or flammable gases, vapours or salt and would be considered as having site pollution severity class (SPS) “very light” according to IEC TS 60815-1:2008;
- e) the conditions of humidity are as follows:

- the average value of the relative humidity, measured over a period of 24 h, does not exceed 95 %;
- the average value of the water vapour pressure, over a period of 24 h, does not exceed 2,2 kPa;
- the average value of the relative humidity, over a period of one month, does not exceed 90 %;
- the average value of the water vapour pressure, over a period of one month, does not exceed 1,8 kPa.

NOTE 1 Condensation can be expected where sudden temperature changes occur in periods of high humidity.

NOTE 2 High humidity can also be due to ground level rainwater or for underground applications, from incoming cable raceways connected to switchgear.

- f) vibrations due to causes external to the switchgear and controlgear or earth tremors do not exceed the impact of vibrations caused by operation of the switchgear itself.

4.1.3 Outdoor switchgear and controlgear

The normal service conditions for outdoor switchgear and controlgear are:

- a) the ambient air temperature does not exceed 40 °C and its average value, measured over a period of 24 h does not exceed 35 °C;

the ambient air temperature does not drop below –25 °C;

NOTE 1 Rapid temperature changes can occur, for example a hot sunny day followed by a sudden rain.

- b) solar radiation does not exceed a level of 1 000 W/m²;

NOTE 2 Details of global solar radiation are given in IEC 60721-2-4 [6].

- c) the altitude does not exceed 1 000 m;
- d) the ambient air may be polluted by dust, smoke, corrosive gas, vapours or salt, the pollution does not exceed site pollution severity class (SPS) “medium” as defined by IEC TS 60815-1:2008;
- e) ice coating does not exceed 20 mm;
- f) the wind speed does not exceed 34 m/s;

NOTE 3 Characteristics of wind are defined in IEC 60721-2-2 [8].

- g) the average humidity values given in 4.1.2 e) may be exceeded. Condensation or precipitation may occur;

NOTE 4 Characteristics of precipitation are defined in IEC 60721-2-2 [8].

NOTE 5 The conditions of humidity are always the effect of a combination of relative humidity with other environmental parameters, primarily temperature and rapid change of temperature.

- h) vibrations due to causes external to the switchgear and controlgear or earth tremors do not exceed the impact of vibrations caused by operation of the switchgear itself.

4.2 Special service conditions

4.2.1 General

When high-voltage switchgear and controlgear is expected to be used under conditions different from the normal service conditions given in 4.1, the user's requirements should refer to standardized steps in 4.2.2 up to 4.2.7 if not provided by product standards.

NOTE 1 Appropriate actions are also taken to ensure proper operation under such conditions of other components, such as relays.

NOTE 2 Detailed information concerning classification of environmental conditions is given in IEC 60721-3-3 [9] (indoor) and IEC 60721-3-4 [10] (outdoor).

4.2.2 Altitude

For installations at an altitude higher than 1 000 m, the required insulation withstand level of external insulation at the service location shall be determined according to Clause 4 of IEC 60071-2:1996. The rated insulation level of the switchgear and controlgear should be equal to or higher than this value, reference is made to IEC TR 62271-306 [4].

NOTE 1 For internal insulation, the dielectric characteristics are identical at any altitude and no special precautions need to be taken. For external and internal insulation, refer to IEC 60071-2:1996.

NOTE 2 For low-voltage auxiliary and control equipment, no special precautions need to be taken if the altitude is lower than 2 000 m. For higher altitudes, refer to IEC 60664-1 [11].

4.2.3 Exposure to pollution

For outdoor application ambient air that may be polluted by dust, smoke, corrosive gas, vapours or salt at a level that exceeds severity class (SPS) “medium” as defined by IEC TS 60815-1:2008 should be classified as “heavy” or “very heavy” as defined by IEC TS 60815-1:2008.

For indoor application, ambient air that may be polluted by dust, smoke, corrosive gas, vapours or salt at a level that exceeds severity class (SPS) “very light” as defined by IEC TS 60815-1:2008 should be classified as “light”, “medium”, “heavy” or “very heavy” as defined by IEC TS 60815-1:2008.

NOTE More information about exposure to pollution can be found in Annex K (informative).

For indoor application up to and including 52 kV, IEC TS 62271-304 [12] can be specified, in particular if there are concerns regarding pollution of the switchgear insulation.

4.2.4 Temperature and humidity

For installation at a location where the ambient temperature can be different from the normal service condition ranges stated in 4.1, the ranges of minimum and maximum temperature to be specified should be:

- a) -50 °C to 40 °C for extremely cold climates;
- b) -40 °C to 40 °C for very cold climates;
- c) -30 °C to 40 °C for cold climates;
- d) -25 °C to 40 °C for cold climates (indoor conditions);
- e) -15 °C to 40 °C for moderate climates (indoor conditions);
- f) -5 °C to 55 °C for very hot climates.

In tropical indoor conditions, the average value of relative humidity measured during a period of 24 h can be up to 98 %.

NOTE In certain regions with frequent occurrence of warm humid winds, sudden changes of temperature and/or atmospheric pressure can occur.

4.2.5 Exposure to abnormal vibrations, shock or tilting

Standard switchgear and controlgear is designed for mounting on substantially level structures, free from excessive vibration, shock, or tilting. Where any of these standard conditions may not exist, the requirements for the particular application should be specified by the user.

For installations where earthquakes are likely to occur, the severity level according to a relevant publication or specification (e.g. IEC TR 62271-300 [13], IEC 62271-207 [14] and IEC TS 62271-210 [15]) should be specified by the user. In case of earthquake risk, the user should specify the operational requirements and admissible damage level.

Installations with other unusual forms of vibration shall be identified, such as installations in close proximity to mine blasting or mobile applications.

NOTE Other relevant publications for seismic evaluations are IEEE Standard 693 [16] and IEEE Standard C37.81 [17].

4.2.6 Wind speed

If the wind speed is expected to be in excess of the normal service wind speed of 34 m/s, the user should specify the requirements for a particular application.

4.2.7 Other parameters

When special environmental conditions prevail at the location where switchgear and controlgear is to be placed in service, they should be specified by the user by reference to IEC 60721-1 [18], IEC 60721-2 (all parts) [19] and IEC 60721-3 (all parts) [20].

4.101 Installation in open air

For determining the ratings of GIL for open air installation, the normal service conditions of IEC 62271-1:2017 shall apply. These are also valid for open trenches.

If the actual service conditions differ from the normal service conditions, the ratings shall be adapted accordingly.

4.102 Buried installation

General values for thermal resistivity and soil temperature are:

- 1,2 K · m/W, and 20 °C in summer;
- 0,85 K · m/W, and 10 °C in winter.

For guidance, values given in IEC 60287-3-1 can be considered.

For long distance transmission lines (several kilometres), site measurement of soil resistivity should also be considered.

NOTE 1 The use of controlled backfill with a given soil thermal resistivity can also be considered.

NOTE 2 A risk of thermal runaway exists if the soil surrounding the buried GIL becomes dry. In order not to dry out the soil, a maximum service temperature of the enclosure in the range of 50 °C to 60 °C is generally considered acceptable.

The depth of laying should be agreed between manufacturer and user. The determination of depth of laying shall take into account thermo mechanical stresses, safety requirements and local regulations.

4.103 Installation in tunnel, shaft or similar situation

Forced cooling is an adequate method to handle with the waste heat and can be used in case of tunnel, shaft or similar installations.

In the case of long vertical shafts and inclined tunnels or sections thereof, attention shall be paid to thermal and density gradients.

5 Ratings

5.1 General

The rating of a GIL consists of the following:

- a) rated voltage (U_r);
- b) rated insulation level (U_d , U_p , U_s);
- c) rated frequency (f_r);
- d) rated continuous current (I_r);
- e) rated short-time withstand current (I_k) (for main and earthing circuits);
- f) rated peak withstand current (I_p) (for main and earthing circuits);
- g) rated duration of short-circuit (t_k);
- h) rated supply voltage of auxiliary and control circuits (U_a);
- i) rated supply frequency of auxiliary and control circuits.

5.2 Rated voltage (U_r)

5.2.1 General

The rated voltage (U_r), as used in this document, is the phase-to-phase RMS voltage equal to the maximum system voltage for which the equipment is designed. It indicates the maximum value of the "highest system voltage" of networks for which the equipment may be used (see 3.7.3, highest voltage for equipment U_m). The rated voltages are given in 5.2.2 and 5.2.3 below.

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

5.2.2 Range I for rated voltages of 245 kV and below

Series I: 3,6 kV – 7,2 kV – 12 kV – 17,5 kV – 24 kV – 36 kV – 40,5 kV – 52 kV – 72,5 kV – 100 kV – 123 kV – 145 kV – 170 kV – 245 kV.

Series II (Voltages based on the current practice in some countries, e.g. US):

4,76 kV – 8,25 kV – 15 kV (see Note 1) – 15,5 kV – 25,8 kV (see Note 2) – 27 kV – 38 kV – 48,3 kV – 72,5 kV – 123 kV – 145 kV – 170 kV – 245 kV.

NOTE 1 The 15 kV rating is used in US and some other countries. It has historically been associated with metal-clad and metal-enclosed switchgear used for applications that are primarily indoors and/or outdoors where the insulation level is less than that required for outdoor overhead applications. For applications other than metal-clad or metal-enclosed switchgear, the 15,5 kV rating is preferred.

NOTE 2 The 25,8 kV, still used in IEEE C37.04 [21] as a circuit breaker rating and in some other countries, has been replaced by the 27 kV rating in most relevant equipment standards. For new applications and designs, the 27 kV rating is preferred.

5.2.3 Range II for rated voltages above 245 kV

300 kV – 362 kV – 420 kV – 550 kV – 800 kV – 1 100 kV – 1 200 kV.

5.3 Rated insulation level (U_d , U_p , U_s)

The rated insulation level of switchgear and controlgear shall be selected from the values given in Table 1, Table 2, Table 3 and Table 4.

Withstand values given in Table 1, Table 2, Table 3 and Table 4 cover the application of switchgear and controlgear under normal service conditions defined in 4.1 including altitudes from sea level up to 1 000 m. However for testing purposes to verify a rating or capability, they shall be considered as insulation values at the standardized reference atmosphere temperature (20 °C), pressure (101,3 kPa) and humidity (11 g/m³) specified in IEC 60071-1:2006 and IEC 60071-1:2006/AMD1:2010. For special service conditions, refer to IEC TR 62271-306 [4].

NOTE According to IEC 60071-1:2006 and IEC 60071-1:2006/AMD1:2010 the insulation levels in Table 1 to Table 4 cover the temperature range of -40 °C up to 40 °C.

The rated withstand voltage values for lightning impulse voltage (U_p), switching impulse voltage (U_s) (when applicable), and rated short-duration power-frequency voltage (U_d) shall be selected without crossing the horizontal marked lines in Table 1, Table 2, Table 3, and Table 4.

The "common values" used in Table 1 and Table 2 apply to phase-to-earth, between phases and across the open switching device, if not otherwise specified in this document. The withstand voltage values "across the isolating distance" apply to the switching devices where the clearance between open contacts is designed to meet the dielectric requirements specified for disconnectors.

Rated insulation levels shall be chosen from IEC 62271-203 on the basis of insulation coordination study for the specific installation in order to consider parameters like overvoltages, voltage reflections, etc. Specific insulation coordination studies are recommended for each installation. For more information, see [1]¹.

Although internal arcing faults can largely be avoided by the choice of a suitable insulation level, measures to limit external overvoltages at each end of the installation (e.g. surge arresters) should be considered.

¹ Numbers in square brackets refer to the Bibliography.

Table 1 – Rated insulation levels for rated voltages of range I, series I

Rated voltage U_r kV (RMS value)	Rated short-duration power-frequency withstand voltage U_d kV (RMS value)		Rated lightning impulse withstand voltage U_p kV (peak value)	
	Common value	Across the isolating distance	Common value	Across the isolating distance
(1)	(2)	(3)	(4)	(5)
3,6	10	12	20	23
			40	46
7,2	20	23	40	46
			60	70
12	28	32	60	70
			75	85
17,5	38	45	75	85
			95	110
24	50	60	95	110
			125	145
36	70	80	145	165
			170	195
40,5 (NOTE)	80	90	185	215
52	95	110	250	290
72,5	140	160	325	375
100	150	175	380	440
	185	210	450	520
123	185	210	450	520
	230	265	550	630
145	230	265	550	630
	275	315	650	750
170	275	315	650	750
	325	375	750	860
245	360	415	850	950
	395	460	950	1 050
	460	530	1 050	1 200

NOTE The rated voltage of 40,5 kV is recognized in IEC 60038:2009 with a note that unification with the rated voltage of 36 kV is under consideration. Present values are adopted from IEC 60071-1:2006, Annex B.

**Table 2 – Rated insulation levels for rated voltages of range I, series II
(based on current practice in some countries, including US)**

Rated voltage U_r kV (RMS value)	Rated short-duration power-frequency withstand voltage U_d kV (RMS value)		Rated lightning impulse withstand voltage U_p kV (peak value)	
	Common value	Across the isolating distance	Common value	Across the isolating distance
(1)	(2)	(3)	(4)	(5)
4,76	19	21	60	66
8,25	36	40	95	105
15 (NOTE)	36	40	95	105
15,5	36	40	95	105
	50	55	110	121
25,8 (NOTE)	60	66	125	138
			150	165
27	60	66	125	138
	70	77	150	165
38	70	77	150	165
	80	88	170	187
	95	105	200	220
48,3	105	115	250	275
	120	132	250	275
72,5	160	--	350	385
	175	193	350	385
123	260	286	550	--
	280	308	550	605
145	310	--	650	--
	335	369	650	715
170	365	--	750	--
	385	424	750	825
245	425	--	900	--
	465	512	900	990

NOTE For 15 kV and 25,8 kV ratings, see NOTE 1 and NOTE 2 in 5.2.2.

Table 3 – Rated insulation levels for rated voltages of range II

Rated voltage U_r kV (RMS value)	Rated short-duration power-frequency withstand voltage U_d kV (RMS value)		Rated switching impulse withstand voltage U_s kV (peak value)			Rated lightning impulse withstand voltage U_p kV (peak value)	
	Phase-to-earth and between phases (NOTE 2)	Across open switching device and/or isolating distance (NOTE 2)	Phase-to-earth and across open switching device (NOTE 2)	Between phases (NOTES 2 and 3)	Across isolating distance (NOTES 1 and 2)	Phase-to-earth and between phases (NOTE 2)	Across open switching device and/or isolating distance (NOTES 1 and 2)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
300	395	435	750	1 125	700(+245)	950	950(+170)
			850	1 275		1 050	1 050(+170)
362	450	520	850	1 275	800(+295)	1 050	1 050(+205)
			950	1 425		1 175	1 175(+205)
420	520	610	950	1 425	900(+345)	1 300	1 300(+240)
			1 050	1 575		1 425	1 425(+240)
550	620	800	1 050	1 680	900(+450)	1 425	1 425(+315)
			1 175	1 760		1 550	1 550(+315)
800	830	1 150	1 425	2 420	1 175(+650)	2 100	2 100(+455)
			1 550	2 480			
1 100	1 100	1 100	1 550	2 635	1 550 + (900)	2 250	2 250 + (630)
		1 100 + (635)	1 800	2 880	1 675 + (900)	2 400	2 400 + (630)
1 200	1 200	1 200	1 800	2 970	1 675 + (980)	2 400	2 400 + (685)
		1 200 + (695)	1 950	3 120		2 550	2 550 + (685)

NOTE 1 In column (6), values in brackets are the peak values $U_r \times \sqrt{2}/\sqrt{3}$ of the power-frequency voltage applied to the opposite terminal (combined voltage).

In column (8), values in brackets are the peak values $0,7 U_r \times \sqrt{2}/\sqrt{3}$ of the power-frequency voltage applied to the opposite terminal (combined voltage).

NOTE 2 Values of column (2) are applicable:

- a) for type tests, phase-to-earth and phase-to-phase;
- b) for routine tests, phase-to-earth, phase-to-phase, and across the open switching device.

The values of columns (3),(4), (5), (6), (7) and (8) are applicable for type tests only.

NOTE 3 These values are derived using the multiplying factors given in Table 3 of IEC 60071-1:2006/AMD1:2010.

Table 4 – Additional rated insulation levels for range II, based on current practice in some countries, including US

Rated voltage U_r kV (RMS value)	Rated short-duration power-frequency withstand voltage U_d kV (RMS value)		Rated switching impulse withstand voltage U_s kV (peak value)		Rated lightning impulse withstand voltage U_p kV (peak value)	
	Phase-to-earth and between phases	Across open switching device and/or isolating distance	Phase-to-earth switching device closed	Terminal to terminal, switching device open	Phase-to-earth and between phases	Across open switching device and/or isolating distance
	(NOTE)	(NOTE)	(NOTE)	(NOTE)	(NOTE)	(NOTE)
(1)	(2)	(3)	(4)	(5)	(6)	(7)
362	555	555	825	900	1 300	1 300
362	610	671	885	825+(295)	1 300	1 430
550	860	890	1 180	1 300	1 800	1 800
550	810	891	1 150	1 000+(450)	1 800	1 980
800	960	960	1 430	1 500	2 050	2 050
800	940	1 034	1 300	1 000+(650)	2 050	2 255

NOTE Values of column (2) are applicable:

a) for type tests, phase-to-earth and phase-to-phase;

b) for routine tests, phase-to-earth, phase-to-phase, and across the open switching device.

Values of columns (3), (4), (5), (6) and (7) are applicable for type tests only.

In Column (5), values in brackets are the peak values $U_r \sqrt{2}/\sqrt{3}$ of the power-frequency voltage applied to the opposite terminal (combined voltage).

5.4 Rated frequency (f_r)

The preferred values of the rated frequency are 16,7 Hz, 25 Hz, 50 Hz and 60 Hz.

5.5 Rated continuous current (I_r)

This rating defines the RMS value of the current the switchgear and controlgear can carry continuously for its service conditions (see Clause 4).

The values of rated continuous current should be selected from the R 10 series, specified in IEC 60059.

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

NOTE 2 The term rated continuous current associated with the continuous current test in 7.5 as used in this edition is equivalent to the term rated normal current used in the previous edition of this document.

The rated continuous current is defined for a single or a three-phase GIL installed above ground with an ambient air temperature at 40 °C. For other installation conditions, the maximum allowable continuous current can differ from the rated continuous current. See Annex A.

5.6 Rated short-time withstand current (I_k)

This rating defines the RMS value of the short-circuit current that the switchgear and controlgear can carry in the closed position during its rated duration (see 5.8) under its service conditions (see Clause 4).

The value of rated short-time withstand current should be selected from the R 10 series specified in IEC 60059.

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

5.7 Rated peak withstand current (I_p)

This rating defines the peak current associated with the first major loop of the rated short-time withstand current that the switchgear and controlgear can carry in the closed position under its service conditions (see Clause 4).

The rated peak withstand current is obtained by multiplying the RMS value of the rated short-time withstand current with a peak factor. This peak factor is a function of the DC time constant of the network and the rated frequency.

A DC time constant of 45 ms covers the majority of cases and corresponds to a rated peak withstand current equal to 2,5 times the rated short-time withstand current for a rated frequency of 50 Hz. For a rated frequency of 60 Hz, it is equal to 2,6 times the rated short-time withstand current.

Table 5 gives peak factors for different time constants and rated frequencies.

NOTE 1 IEC TR 62271-306 [4] gives the information for calculating peak factors according to rated frequency and time constant of the network.

NOTE 2 For non-simultaneous drive mechanisms of each pole the peak factor can be different, for details, see IEC TR 62271-306 [4].

Table 5 – Peak factors for rated peak withstand current

Rated frequency (f_r) Hz	DC time constant ms			
	45	60	75	120
16,7	2,1	2,3	2,4	2,5
25	2,3	2,4	2,5	2,6
50	2,5	2,6	2,7	2,7
60	2,6	2,7	2,7	2,7

5.8 Rated duration of short-circuit (t_k)

This rating defines the interval of time for which the switchgear and controlgear can carry, in the closed position, a current equal to its rated short-time withstand current.

The preferred value of rated duration of short-circuit is 1 s.

An alternative value lower or higher than 1 s may be chosen, e.g. 0,5 s, 2 s, 3 s.

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

5.9.1 General

Several auxiliary voltages can be used on a single piece of switchgear and controlgear.

5.9.2 Rated supply voltage (U_a)

The rated supply voltage should be selected from the standard values given in Table 6 and Table 7.

Table 6 – Direct current voltage

U_a V
24
48
60
110
125
220
250

Table 7 – Alternating current voltage

Line number	Three-phase, three-wire or four-wire systems V	Single-phase, three-wire systems V	Single-phase, two-wire systems V
(1)	(2)	(3)	(4)
1	–	120/240	120
2	120/208	–	120
3	(220/380)	–	(220)
4	230/400	–	230
5	(240/415)	–	(240)
6	277/480	–	277
7	347/600	–	347

The value 230/400 V indicated in line 4 of this table should be, in the future, the IEC standard voltage replacing the values 220/380 V and 240/415 V in lines 3 and 5 and its adoption is recommended in new systems. The voltage variations of existing systems at 220/380 V and 240/415 V should be brought within the range 230/400 V $\pm$ 23/40 V. The reduction of this range will be considered at a later stage of standardization.

NOTE The lower values in the column (2) of this table are voltages to neutral and the higher values are voltages between phases. The lower value in the column (3) is the voltage to neutral and the higher value is the voltage between lines.

5.10 Rated supply frequency of auxiliary and control circuits

When alternating current supply voltage is used, the preferred values of rated supply frequency are 50 Hz and 60 Hz.

5.11 Rated pressure of compressed gas supply for controlled pressure systems

Not applicable.

6 Design and construction

Any GIL equipment which requires routine preventive maintenance or diagnostic testing should be easily accessible.

GIL should be designed so that normal service, inspection and maintenance operations can be carried out safely, including the checking of phase sequence after erection and extension.

The equipment should be designed such that the mechanical stress caused by all relevant loads, for example thermal expansion, agreed permitted movement of foundations, external vibration, earthquakes, soil loading, wind and ice, do not impair the assigned performance of the equipment.

6.1 Requirements for liquids in GIL

Not applicable.

6.2 Requirements for gases in GIL

The manufacturer shall specify the type and the required quantity, and quality of the gas used in switchgear and controlgear.

The manufacturer shall provide the user with necessary instructions for renewing the gas and maintaining its required quantity and quality (refer to 11.5.2 and item a) of 11.5.3). This requirement does not apply to sealed pressure systems.

For sulphur hexafluoride (SF_6) filled switchgear and controlgear, SF_6 in accordance with IEC 60376 for new SF_6 and IEC 60480 for reused SF_6 shall be used. For switchgear and controlgear with SF_6 mixtures, reference is made to IEC 62271-4.

In order to prevent condensation, the maximum allowable humidity content within gas-filled switchgear and controlgear filled with gas at the filling density for insulation ρ_{re} shall be such that the dew point at filling pressure (density) for insulation is not higher than -5 °C for a measurement at 20 °C during service life, refer to 11.3.6.

In case a gas mixture is used, the manufacturer should provide information about the gas characteristics such as dielectric strength, mixing ratio, process of mixing and filling pressure.

NOTE See references [2], [3] and [4].

6.3 Earthing

Switchgear and controlgear shall be provided with a reliable earthing point for connection of an earthing conductor suitable for specified fault conditions. The connecting point shall be marked with the "protective earth" symbol, as indicated by symbol IEC 60417-5019:2006-08. Conductive parts of the switchgear and controlgear intended to be connected to the earthing system, may be designed to be part of the earthing circuit.

All conductive components and enclosures that may be touched during normal operating conditions and are intended to be earthed shall be designed to carry 30 A (DC) with a voltage drop of maximum 3 V to the earthing point provided at the switchgear and controlgear.

NOTE For guidance on the connection of the earthing point of the switchgear and controlgear to the main station earth, Clause 10 of IEC 61936-1:2010 and IEC 61936-1:2010/AMD1:2014 [22] applies.

6.3.101 Earthing of the main circuits

To ensure safety during maintenance work, all parts of the main circuits to which access is required or provided shall be capable of being earthed. In addition, it shall be possible, after the opening of the enclosure, to connect earth electrodes to the conductor for the duration of the work.

Earthing can be made by

- a) earthing switches with a making capacity equal to the rated peak withstand current, if there is still a possibility that the circuit connected is live;
- b) earthing switches without a short-circuit making capability or with a short-circuit making capability lower than the rated peak withstand current, if there is a certainty that the circuit connected is not live, or
- c) removable earthing devices, only by agreement between manufacturer and user.

Each part being capable of being disconnected shall be capable of being earthed.

Consideration should be given to the ability of the first operated earthing device to dissipate the maximum level of trapped charge on the isolated circuit.

Where the earthing switches form part of the plant connected to the transmission line, the user shall ensure that they comply with the above items a) to c).

The earthing circuit can be degraded after being subjected to the rated short-circuit current. After such event, earthing circuit can be replaced if applicable.

6.3.102 Earthing of the enclosure

The enclosures shall be capable of being connected to earth. All metal parts intended to be earthed, which do not belong to a main or an auxiliary circuit, shall be connected to earth. For the interconnection of enclosures, frames, etc., fastening (e.g. bolting or welding) is generally acceptable for providing electrical continuity. If the fastening is done by bolting, provisions shall be given in order that a proper electrical contact is provided. If not, the mechanical joint shall be by-passed by a proper electrical connection such as copper or aluminum leads of proper cross section.

The continuity of the earthing circuits shall be ensured taking into account the thermal and electrical stresses caused by the current they can carry.

It is envisaged that most GIL installation will be solidly bonded and earthed at both ends. The particular design has an influence on heat dissipation, step and touch voltages and the external magnetic field. These are discussed in Annex B.

The design of the earthing of the enclosure shall be compatible with the measures for corrosion protection when the GIL is buried.

6.4 Auxiliary and control equipment

6.4.1 General

Switchgear and controlgear include all auxiliary and control equipment and circuits, including but not limited to, electronic controls, supervision, monitoring and communication.

Auxiliary and control equipment and circuits shall operate normally when the voltage measured during operation at the supply terminals of the auxiliary and control equipment and circuits:

- is within 85 % to 110 % of rated supply voltage (U_a);

- in the case of DC, a ripple voltage is not greater than 5 % of U_a ;
- is free of the voltage dips and interruptions which exceed the limits declared by the manufacturer according to IEC 61000-4-29 (DC supply voltage) and IEC 61000-4-11 (AC supply voltage).

In case of supply interruptions (also during operations) that exceed the duration limits declared by the manufacturer for normal operation:

- there shall be no false operation, false alarms or false remote signalling resulting from the interruption or re-instatement of the supply;
- the manufacturer shall state the behaviour of the device when the supply voltage gets interrupted (for example impact on internal energy storage);
- the manufacturer shall state the behaviour of the device when the supply voltage returns;
- subsequent actions shall only be completed in response to a new valid operational command (where applicable).

The fulfilment of the above conditions can be demonstrated at any convenient dip duration that exceeds the declared limit.

NOTE 1 Possible actions can be:

- completing the pending action without manual intervention such that the equipment achieves a defined, safe operating state for example open, closed, charged, discharged;
- manual intervention such that the equipment achieves a defined, safe operating state for example open, closed, charged, discharged;
- completing the action after giving another command for the same switching operation that was interrupted.

This choice can also be dependent on the duration of the interruption.

Specific conditions are given in 6.9 for shunt closing releases, shunt opening releases and under-voltage releases.

For supply voltages lower than the minimum stated above, precautions shall be taken to prevent any damage to electronic equipment and/or unsafe operation.

Requirements for the interface with digital communication that ensure compliance with IEC 61850 (all parts) [23] are detailed in IEC 62271-3 [24].

NOTE 2 The logical nodes in IEC 62271-3:2015 (XCBB, XSWI) and their additional data objects described in Annex B of IEC 62271-3:2015 cover only some properties required by the electronic nameplates of some switchgear and controlgear of the IEC 62271 series of standards. The other properties required for the physical nameplate, tendering, quotation and ordering phases are not covered.

6.4.2 Protection against electric shock

6.4.2.1 Protection of auxiliary and control circuits from the main circuit

Auxiliary and control circuits that are installed on the frame of switchgear and controlgear shall be suitably protected against disruptive discharge from the main circuit. This is verified by dielectric type tests specified in 7.2, see 7.2.5 c).

6.4.2.2 Safety clearance during service

Auxiliary and control circuits to which access is required during service shall be accessible without the need to compromise clearances to hazardous parts.

6.4.3 Components installed in enclosures

6.4.3.1 Selection of components

All components used in the auxiliary and control circuits shall be designed or selected to be operational with their rated characteristics over the full range of service conditions inside auxiliary and control circuits enclosures. Suitable precautions (for example, heaters, ventilators, insulation, etc.) should be taken to ensure that those service conditions essential for proper operation of relays, contactors, low-voltage switches, meters, operation counters, push-buttons, etc. are maintained.

NOTE These internal conditions in control cabinet for auxiliary and control circuits can differ from the external service conditions specified in Clause 4.

The loss of “suitable precautions” shall not cause failure of the auxiliary and control circuits within the enclosure or untimely operation of the switchgear within the specified time. Selection of components should take into account the temperature obtained in the cabinet of the control and auxiliary circuit during a 2-hour period following the loss of the “suitable precautions” in order to ensure the proper operation of switchgear and controlgear until the end of this 2-hour period.

After this 2-hour period non-operation is acceptable. If the loss of the “suitable precautions” is longer than 2 h but does not exceed 24 h in total, the functionality of the switchgear and controlgear shall come back to its original characteristics when the service conditions are recovered.

Where heating is essential for correct functioning of the equipment, monitoring of the heating circuit shall be provided.

In the case of switchgear and controlgear designed for outdoor installation, suitable arrangements (ventilation and/or internal heating, etc.) may be required to prevent harmful condensation in auxiliary and control circuit enclosures.

6.4.3.2 Accessibility

Closing and opening actuators and emergency shut-down system actuators shall be located between 0,4 m and 2 m above the floor, ground or operating platform normally used by operating personnel.

Other actuators should be located at such a height that they can be easily operated, and indicating devices should be located at such a height as to be readily legible.

Where a component may need adjustment during its service life, access shall be provided with protection level of at least IP XXB, refer to IEC 60529:1989, IEC 60529:1989/AMD1:1999 and IEC 60529:1989/AMD2:2013.

6.4.3.3 Identification

Identification of components installed in enclosures shall be in agreement with the indication on the wiring diagrams and drawings. If a component is of the plug-in type, an identifying mark should be placed on the component and on the fixed part where the component plugs in.

6.4.3.4 Requirements for auxiliary and control circuit components

6.4.3.4.1 General

The auxiliary and control circuit components shall comply with applicable IEC standards if one exists. Annex D (informative) is provided as a quick reference to many of the component standards.

6.4.3.4.2 Cables and wiring

Where a facility for external wiring is provided, it shall be through an appropriate connecting device, e.g. terminal blocks or plug-in terminations.

Polarity reversal at the interfacing point shall not damage auxiliary and control circuits.

Terminal blocks should be fixed. Cables between two terminal blocks shall have no intermediate splices or soldered joints.

Cables and wiring shall be adequately supported and shall not rest against sharp edges.

The available wiring space for external connection shall permit spreading of the cores of multi-core cables and the proper termination of the conductors without undue stresses.

Conductors connected to components mounted on doors shall be so installed that no mechanical damage can occur to the conductors as a result of movement of these doors.

6.4.3.4.3 Terminals

If facilities are provided for connecting incoming and outgoing neutral, protective and PEN (protective earthed neutral) conductors, they shall be situated in the vicinity of the associated phase conductor terminal.

6.4.3.4.4 Auxiliary switches

Auxiliary switches shall be suitable for the number of operating cycles specified for the high-voltage switching device to which they are linked.

Auxiliary switches which are operated in conjunction with the main contacts shall be positively driven in both directions. An auxiliary switch may consist of a set of two one-way positively driven auxiliary contacts (one for each direction).

6.4.3.4.5 Auxiliary and control contacts

Auxiliary and control contacts shall be suitable for the number of operating cycles specified for the switching device. This requirement is verified by the mechanical endurance test of the high-voltage switching devices to which they are linked.

The operational characteristics of the auxiliary contacts that are made available to the user shall comply with one of the classes shown in Table 8.

Table 8 – Auxiliary contact classes

DC current				
Class	Rated continuous current	Rated short-time withstand current	Breaking capacity	
			$U_a \leq 48 \text{ V}$	$110 \text{ V} \leq U_a \leq 250 \text{ V}$
1	10 A	100 A/30 ms		440 W
2	2 A	100 A/30 ms		22 W
3	200 mA	1 A/30 ms	50 mA	