IEC 62271-209 EXV

Edition 2.1 2022-09
EXTENDED VERSION

INTERNATIONAL STANDARD

colour inside

This extended version of IEC 62271-209:2019+AMD1:2022 includes the content of the references made to IEC 62271-1:2017+AMD1:2021 CSV and IEC 62271-203:2011

High-voltage switchgear and controlgear – Part 209: Cable connections for gas-insulated metal-enclosed switchgear for rated voltages above 52 kV – Fluid-filled and extruded insulation cables – Fluid-filled and dry-type cable-terminations

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IEC 62271-1
Edition 2.0 2017-07

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.

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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.

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

ICS 29.130.10; 29.130.99

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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Part 209: Cable connections for gas-insulated metal-enclosed switchgear for rated voltages above 52 kV – Fluid-filled and extruded insulation cables – Fluid-filled and dry-type cable terminations

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This extended version (EXV) of the official IEC Standard provides the user with a comprehensive content of the Standard.

IEC 62271-209:2019+AMD1:2022 EXV includes the content of the references made to IEC 62271-1:2017+AMD1:2021 CSV and IEC 62271-203:2011.

Particular subclauses of IEC 62271-1:2017+AMD1:2021 CSV and IEC 62271-203:2011 are displayed in the content on a blue background.

This consolidated version of the official IEC Standard and its amendment has been prepared for user convenience.

IEC 62271-209 edition 2.1 contains the second edition (2019-02) [documents 17C/696/FDIS and 17C/701/RVD] and its amendment 1 (2022-03) [documents 17C/833/FDIS and 17C/841/RVD].

International Standard IEC 62271-209 has been prepared by subcommittee 17C: Assemblies, of IEC technical committee 17: High-voltage switchgear and controlgear.

This second edition constitutes a technical revision.

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

a) New numbering in accordance with ISO/IEC directives, Part 2 (2016) and to IEC 62271-1:2017;
b) Clause 3: addition of a definition for plug-in cable termination, filling pressure and minimum function pressure for insulation;
c) Clause 7: An additional dielectric type test for plug-in cable termination was added; also a pressure type test as well as a leak rate test on the insulator of a cable termination was implemented;
d) Clause 12: New clause about safety practices;
e) Clause 13: New clause about influence of the product on the environment;
f) New informative Annex A: Mechanical forces applied on the flange of the cable connection enclosure.

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

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

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

The committee has decided that the contents of the base publication and its amendment will remain unchanged until the stability date indicated on the IEC web site under webstore.iec.ch in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

INTRODUCTION TO Amendment 1

This amendment includes the following modifications:

a) In accordance with the decision taken at IEC Plenary Meeting October 2019 in Shanghai (17C/Shanghai/Sec07) Subclause 6.103, Figure 1 and Figure 2 have been modified;

b) The CDV was modified in accordance with the above-mentioned documents and based on the decision taken at the virtual IEC Plenary Meeting in October 2021 (17C/823/RM).

NOTE CIGRE has published TB 784 “Standard design of a common, dry type plug-in interface for GIS and power cables up to 145 kV describing the basis for further standardisation of such a common interface. The matter will be dealt with during the next revision of IEC 62271-209.

HIGH-VOLTAGE SWITCHGEAR AND CONTROLGEAR –

Part 209: Cable connections for gas-insulated metal-enclosed switchgear for rated voltages above 52 kV – Fluid-filled and extruded insulation cables – Fluid-filled and dry-type cable terminations

1 Scope

This part of IEC 62271 covers the connection assembly of fluid-filled and extruded cables to gas-insulated metal enclosed switchgear (GIS), in single- or three-phase arrangements where the cable terminations are fluid-filled or dry-type and there is a separating insulating barrier between the cable insulation and the gas insulation of the switchgear.

The purpose of this document is to establish electrical and mechanical interchangeability between cable terminations and the gas-insulated metal-enclosed switchgear and to determine the limits of supply. It complements and amends, if applicable, the relevant IEC standards. For the purpose of this document the term "switchgear" is used for "gas-insulated metal enclosed switchgear".

It does not cover directly immersed cable terminations, as described in CIGRE brochure 89 [4][1].

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, *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*

[1] Numbers in square brackets refer to the Bibliography.

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 60068-2-1:2007, *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 60068-2-17:1994, *Basic environmental testing procedures – Part 2-17:Tests – Test Q: Sealing*

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 60141 (all parts), *Tests on oil-filled and gas-pressure cables and their accessories*

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

IEC 60376, *Specification of technical grade sulphur hexafluoride (SF_6) and complementary gases to be used in its mixtures for use in electrical equipment*

IEC 60480, *Guidelines for the checking and treatment of sulphur hexafluoride (SF_6) taken from electrical equipment and specification for its re-use*

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 60840, *Power cables with extruded insulation and their accessories for rated voltages above 30 kV (U_m = 36 kV) up to 150 kV (U_m = 170 kV) – Test methods and requirements*

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 62067, *Power cables with extruded insulation and their accessories for rated voltages above 150 kV (U_m = 170 kV) up to 500 kV (U_m = 550 kV) – Test methods and requirements*

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 62271-4, *High-voltage switchgear and controlgear – Part 4: Handling procedures for sulphur hexafluoride (SF_6) and its mixtures*

IEC 62271-203:2011, *High-voltage switchgear and controlgear – Part 203:Gas-insulated metal-enclosed switchgear for rated voltages above 52 kV*

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*

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 SF_6 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 SF_6 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 × m^3 x 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 $cm^3 \times s^{-1}$.

3.6.7.2
permissible leakage rate
$F_{p(liq)}$
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.]

3.8 Index of definitions

A – B

3.1

cable termination
equipment fitted to the end of a cable to ensure electrical connection with other parts of the system and to maintain the insulation up to the point of connection

3.1.1
fluid-filled cable termination
cable termination which comprises a separating insulating barrier between the cable insulation and the gas insulation of switchgear, including a fluid

3.1.2
dry-type cable termination
cable termination which comprises an elastomeric electrical stress control component in direct contact with a separating insulating barrier (insulator) between the cable insulation and the gas insulation of the switchgear, not requiring any fluid

3.2
main circuit end terminal
part of the main circuit of a gas-insulated metal enclosed switchgear forming part of the connection interface

3.3
cable connection enclosure
part of the gas-insulated metal-enclosed switchgear which houses the cable termination and the main circuit end terminal

3.4
cable connection assembly
combination of a cable termination, a cable connection enclosure and a main circuit end terminal, which mechanically and electrically connects the cable to the gas-insulated metal enclosed switchgear

3.5
plug-in cable termination
cable termination where cable/stress cone assembly can be engaged into the insulator assembly that is already installed into switchgear enclosure

3.6
design pressure
pressure used to determine the design of the enclosure and the components of the cable termination subjected to that pressure

Note 1 to entry: It is at least equal to the maximum pressure in the enclosure at the highest temperature that the gas used for insulation can reach under specified maximum service conditions.

3.7
fluid
liquid or gas for insulation purposes

3.8
cable system
cable with installed accessories

3.9
filling pressure p_{re} for insulation
filling density ρ_{re} for insulation
pressure (in Pa), for insulation, referred to the standard atmospheric air conditions of 20 °C and 101,3 kPa, which may be expressed in relative or absolute terms (or density), to which the assembly is filled before being put into service

3.10
minimum functional pressure p_{me} for insulation
minimum functional density ρ_{me} for insulation
pressure (in Pa), for insulation, referred to the standard atmospheric air conditions of 20 °C and 101,3 kPa, which may be expressed in relative or absolute terms (or density), at which and above which the characteristics of the switchgear-cable connection are maintained and at which replenishment becomes necessary

4 Normal and special service conditions

4.1 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 2.1.

If the actual service conditions differ from these normal service conditions, high-voltage switchgear and controlgear and associated operating devices and auxiliary equipment shall be designed to comply with any special service conditions required by the user, or appropriate arrangements shall be made (refer to 2.2).

NOTE 1 Appropriate action should also be 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 (indoor) and IEC 60721-3-4 (outdoor).

At any altitude the dielectric characteristics of the internal insulation are identical with those measured at sea-level. For this internal insulation, therefore, no specific requirements concerning the altitude are applicable.

Some items of a GIS such as pressure relief devices and pressure and density monitoring devices may be affected by altitude. The manufacturer shall take appropriate measures if necessary.

4.2 Normal service conditions

4.2.1 Indoor switchgear and controlgear

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 preferred values of minimum ambient air temperature are –5 °C, –15 °C and –25 °C.

b) The influence of solar radiation may be neglected.

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. The manufacturer will assume that, in the absence of specific requirements from the user, there are none.

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.

   For these conditions, condensation may occasionally occur.

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

   NOTE 2 To withstand the effects of high humidity and condensation, such as breakdown of insulation or corrosion of metallic parts, switchgear designed for such conditions should be used.

NOTE 3 Condensation may be prevented by special design of the building or housing, by suitable ventilation and heating of the station or by the use of dehumidifying equipment.

f) Vibrations due to causes external to the switchgear and controlgear or earth tremors are insignificant relative to the normal operating duties of the equipment. The manufacturer will assume that, in absence of specific requirements from the user, there are none.

NOTE 4 The interpretation of the term “insignificant” is the responsibility of the user or specifier of the equipment. Either the user is not concerned with seismic events, or his analysis shows that the risk is “insignificant”.

4.2.2 Outdoor switchgear and controlgear

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 preferred values of minimum ambient air temperature are –10 °C, –25 °C, –30 °C and –40 °C.

Rapid temperature changes should be taken into account.

b) Solar radiation up to a level of 1 000 W/m^2 (on a clear day at noon) should be considered.

NOTE 1 Under certain levels of solar radiation, appropriate measures, for example roofing, forced ventilation, test simulating solar gain, etc., may be necessary, or derating may be used, in order not to exceed the specified temperature rises and design pressure limits.

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

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 pollution level II (medium) according to Table 1 of IEC 60815.

e) The ice coating shall be considered in the range from 1 mm up to, but not exceeding, 20 mm.

f) The wind speed does not exceed 34 m/s (corresponding to 700 Pa on cylindrical surfaces).

NOTE 3 Characteristics of wind are described in IEC 60721-2-2.

g) Consideration should be given to condensation or precipitations that may occur.

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

h) Vibrations due to causes external to the switchgear and controlgear or earth tremors are insignificant relative to the normal operating duties of the equipment. The manufacturer will assume that, in the absence of specific requirements from the user, there are none.

NOTE 5 The interpretation of the term “insignificant” is the responsibility of the user or specifier of the equipment. Either the user is not concerned with seismic events, or his analysis shows that the risk is “insignificant”.

4.3 Special service conditions

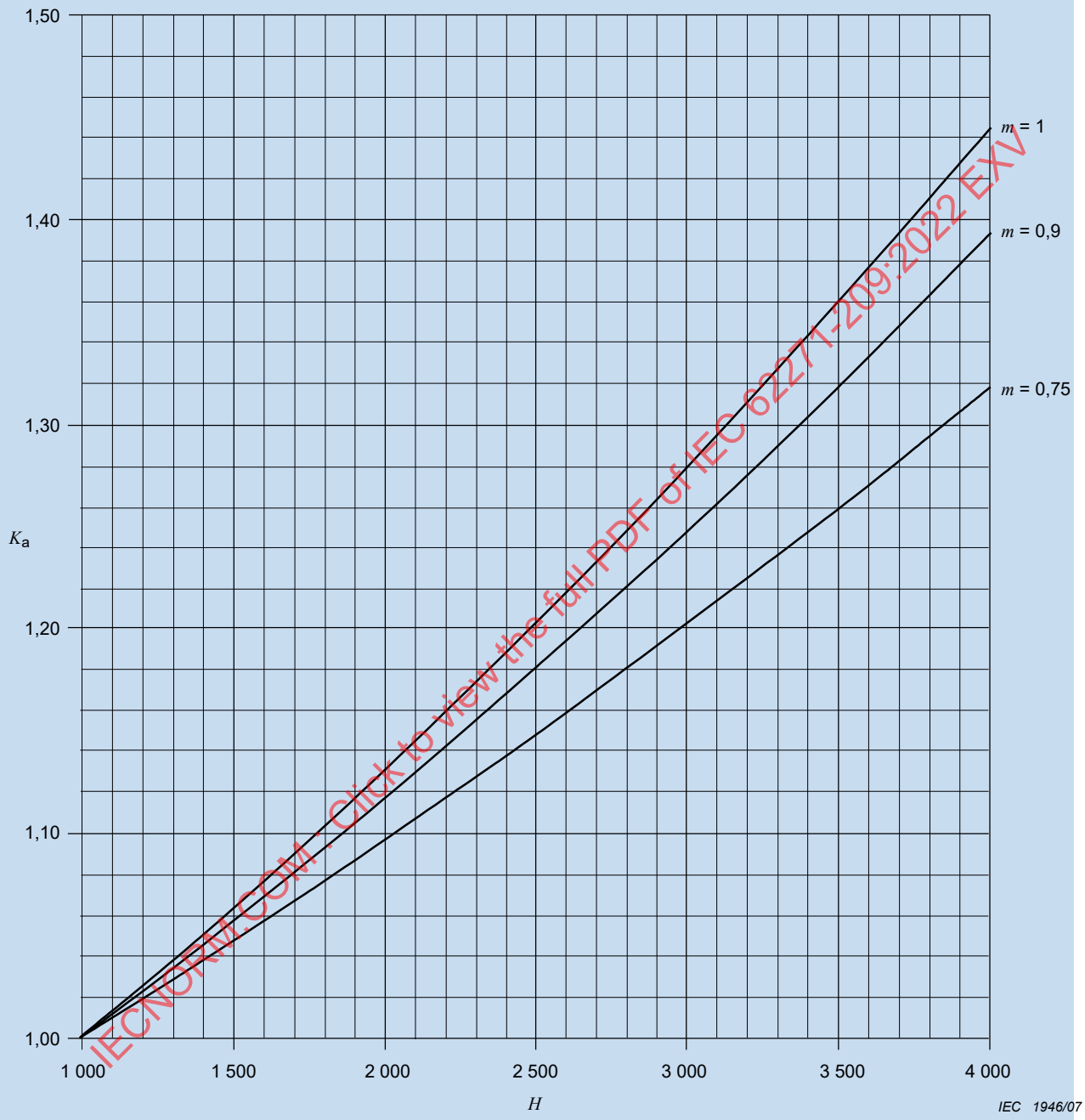
When high-voltage switchgear and controlgear is used under conditions different from the normal service conditions given in 4.2, the user's requirements should refer to standardized steps as follows.

4.3.1 Altitude

For installations at an altitude higher than 1 000 m, the insulation withstand level of external insulation at the service location shall be determined by multiplying the rated insulation levels by a factor K_a in accordance with Figure 1.

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.

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.



The altitude correction factor can be calculated from 4.2.2 of IEC 60071-2 with the following equation, which is modified to reflect that no correction is required up to 1 000 m:

$$K_a = e^{m\,(H-1\,000)/8150}$$

where

H is the altitude, in metres;

m is taken as a fixed value in each case for simplification as follows:

m = 1 for power-frequency, lightning impulse and phase-to-phase switching impulse voltages;

m = 0,9 for longitudinal switching impulse voltage;

m = 0,75 for phase-to-earth switching impulse voltage.

Figure 1 – Altitude correction factor

4.3.2 Pollution

For installation in polluted ambient air, pollution level III (heavy) or IV (very heavy) of IEC 60815 should be specified for outdoor installation.

For indoor installation, reference can be made to IEC 60932.

4.3.3 Temperature and humidity

For installation in a place where the ambient temperature can be outside the normal service condition range stated in 2.1, the preferred ranges of minimum and maximum temperature to be specified should be

a) –50 °C and +40 °C for very cold climates;

b) –5 °C and +55 °C for very hot climates.

In certain regions with frequent occurrence of warm humid winds, sudden changes of temperature may occur resulting in condensation even indoors.

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

4.3.4 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 abnormal conditions exists, requirements for the particular application should be specified by the user.

For installations where earthquakes are likely to occur, the severity level in accordance with IEC 62271-300 or IEC 62271-2 should be specified by the user.

4.3.5 Wind speed

In some regions, for example in North America, a value for the wind speed is 40 m/s.

4.3.6 Other parameters

When special environmental conditions prevail at the location where switchgear and controlgear is to be put in service, they should be specified by the user by reference to IEC 60721.

In the cases where higher than (>) is used in the table the values shall be specified by the user as described in IEC 62271-1.

Table 1 – Reference table of service conditions relevant to GIS

Item	Normal		Special	
	Indoor	Outdoor	Indoor	Outdoor
Ambient air temperature:				
Minimum (°C)	–5 or –25	–25 or –40	–25	–50
Maximum (°C)	+40	+40	+50	+50
Solar radiation (W/m^2)	Not applicable	1 000	Not applicable	>1 000
Altitude (m)	1 000	1 000	>1 000	>1 000

Site pollution severity [a]	Not applicable	c	c, d or e	d or e
Ice coating (mm)	Not applicable	1, 10 or 20	Not applicable	>20
Wind (m/s)	Not applicable	34	Not applicable	>34
Humidity (%)	95	100	98	100
Condensation or precipitation	Occasional	Yes	Yes	Yes
Vibration class	Not applicable	Not applicable	IEC 62271-207 IEC/TR 62271-300	IEC 62271-207 IEC/TR 62271-300
NOTE The user's specification may use any combination of normal or special service conditions above.				
[a] Site pollution severity c, d or e according to IEC/TS 60815-1:2008, 8.3.				

5 Ratings

5.1 General

When dimensioning the cable connection assembly, the following rated values shall apply:

a) rated voltage of the equipment of the cable connection (U_{rm});
b) rated insulation level (U_p, U_d and U_s where applicable);
c) rated frequency (f_r)
d) rated continuous current (I_r);
e) rated short-time withstand current (I_k);
f) rated peak withstand current (I_p);
g) rated duration of short circuit (t_k).

5.2 Rated voltage of the equipment of the cable connection (U_{rm})

The rated voltage for the equipment of the cable connection (U_{rm}) is equal to the lower of the values U_m for the cable system and U_r for the gas-insulated metal-enclosed switchgear and shall be selected from the following standard values:

72,5 kV – 100 kV – 123 kV – 145 kV – 170 kV – 245 kV – 300 kV – 362 kV – 420 kV – 550 kV

NOTE 1 Values above U_r = 550 kV are not considered.

NOTE 2 U_m = 100 kV is not defined in IEC 60840.

5.3 Rated insulation level (U_d, U_p, U_s)

The rated insulation level for the cable connection assembly shall be selected from the values given in IEC 60038 as well as IEC 62271-203.

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)

The connection interface of the main circuit shown in Figures 2 and 3 for fluid-filled cable terminations and Figures 4 and 5 for dry-type cable terminations is applicable at rated continuous currents up to 3 150 A.

The connection interface shall be designed so that at a current equal to the cable rated current corresponding to a maximum temperature of 90 °C, no heat transfer from the switchgear main circuit end terminal to the cable termination will occur.

NOTE As the maximum conductor temperature for cables is limited by the maximum operating temperature for the insulation, there are certain cable dielectrics which cannot withstand the maximum temperature specified for gas-insulated metal-enclosed switchgear if there is heat transfer across the connection interface to the cable terminations.

For cases when the above design requirement of 90 °C at rated continuous current of the cable system cannot be allowed because of cable design limitations, the manufacturer of the switchgear should provide the necessary data on temperature rise of the main circuit end terminal and of the insulating gas as a function of current.

5.6 Rated short-time withstand current (I_k)

Short-time currents of short circuit shall refer to the levels provided by the cable system, not exceeding the values defined for the switchgear in line with IEC 62271-1.

5.7 Rated peak withstand current (I_p)

Peak withstand currents of short circuit shall refer to the levels provided by the cable system, not exceeding the values defined for the switchgear in line with IEC 62271-1.

5.8 Rated duration of short circuit (t_k)

The duration of short circuit shall refer to the levels provided by the cable system, not exceeding the values given in IEC 62271-1.

6 Design and construction

6.1 Gas and vacuum tightness

6.1.1 General

The following specifications apply to all switchgear and controlgear that use vacuum or gas, other than ambient air, as an insulating, switching, combined insulating and switching, or operating medium.

For vacuum tightness no leakage rate F needs to be specified, instead the level of vacuum and the expected operating duration shall be given.

NOTE 1 IEC TR 62271-306 [4] and Cigre Brochure 430 [28] give some information, examples and guidance for tightness.

The absolute leakage rate F shall not exceed the specified value of the permissible leakage rate F_p at standardized ambient temperature of 20 °C.

An increased leakage rate at extreme temperatures is permissible, provided that this rate resets to a value not higher than the permissible value F_p at standardized ambient temperature of 20 °C. The increased temporary leakage rate shall not exceed the values given in 7.8.1.

NOTE 2 The average leakage rate observed during service life can be higher than the specified leakage rate due to the temporary increased leakage rate at temperatures above or below the standardized ambient temperature.

6.1.2 Controlled pressure systems for gas

The tightness of controlled pressure systems for gas is specified by the number of replenishments per day (N) or by the pressure drop per day (Δp). SF_6 gas and SF_6 mixtures are not applicable for controlled pressure systems.

NOTE Most controlled pressure systems use air as the gas; however, other gases can be used.

6.1.3 Closed pressure systems for gas

The tightness of closed pressure systems for gas is specified by the relative leakage rate F_{rel} of each compartment. The maximum values under the standardized ambient temperature of 20 °C are:

– for SF_6 and SF_6 mixtures, 0,5 % per year;
– for other gases, 1 % per year.

NOTE 1 Some local or governmental regulations can require a lower SF_6 leakage rate, e.g. 0,1 % per year.

The tightness characteristic of a closed pressure system and the time between replenishments under normal service conditions shall be stated by the manufacturer. This time shall be at least 10 years for maintenance planning purposes. Means shall be provided to enable gas systems to be replenished while the equipment is in service.

NOTE 2 The term “in service” implies “under live conditions”.

NOTE 3 Manufacturer’s instructions and the user’s operating practices provide guidance for replenishing gas.

6.1.4 Sealed pressure systems

The tightness of sealed pressure systems is specified by their expected operating duration. The expected operating duration shall be specified by the manufacturer and shall be at least 20 years. Other preferred values are 30 years and 40 years.

The tightness of gas insulated switchgear and controlgear shall be designed in a way to ensure that the minimum functional pressure (density) shall not be attained before the expected end of life. The manufacturer shall specify a permissible leakage rate.

NOTE 1 For some designs verification of an expected operating duration greater than 20 years can be impractical for a type or routine test.

NOTE 2 Sealed SF_6 switchgear and controlgear is considered to have insignificant SF_6 losses (less than 0,1 % per year) during their expected operating duration.

For conditions up to the maximum occurring gas operating pressure, the cable termination shall prevent insulating gas from the switchgear diffusing into the interior of the cable termination and into the cable. The cable termination shall prevent insulating fluid from the cable termination entering the switchgear. The insulator (part 4 in Figures 2 and 4) shall be capable of withstanding the vacuum conditions when the cable connection enclosure is evacuated, as part of the gas filling process.

In the case of a gas insulated cable or a gas insulated termination, the gas compartment of the cable or of the gas insulated termination shall be treated independently from the switchgear with respect to tightness.

6.101 Limits of supply

6.101.1 General

The limits of supply of gas-insulated metal-enclosed switchgear and the cable termination shall be in accordance with Figure 2 for fluid-filled cable terminations and Figure 4 for dry-type cable terminations.

6.101.2 Over-voltage protection and earthing

It is necessary to have either a direct low resistance connection or an insulated section bridged by non-linear resistors between part 6 and part 13 of Figure 2 for fluid-filled cable terminations and Figure 4 for dry-type cable terminations. To enable suitable connections to be made to the switchgear, for the purposes of this direct connection or installation of any sheath voltage limiting device, the switchgear manufacturer shall provide four connection

points per phase (evenly spaced around each phase) each comprising an M12 threaded hole of minimum 21 mm length (for all voltage levels). The position of these 4 connection points is different from the mechanical connection points used for fixing the cable termination insulator. The number of connection points used shall be determined by the cable system designer.

Where applicable, the number and characteristics of the non-linear resistors shall be determined by the cable system designer, and they shall be supplied by the cable termination manufacturer, taking into consideration the requirements of the user and the switchgear manufacturer. Reference is made to CIGRE TB 44, 1993 [5], as well as to IEEE 1300-2011, Clause 11 [3].

In addition, the installation design of the area around the cable termination shall take into account the space required to install any non-linear resistors, including adequate clearances to earth.

For three phases in one enclosure arrangements special clarification between the GIS manufacturer, the cable termination manufacturer and the cable system designer may be necessary because of limited space between the three phases.

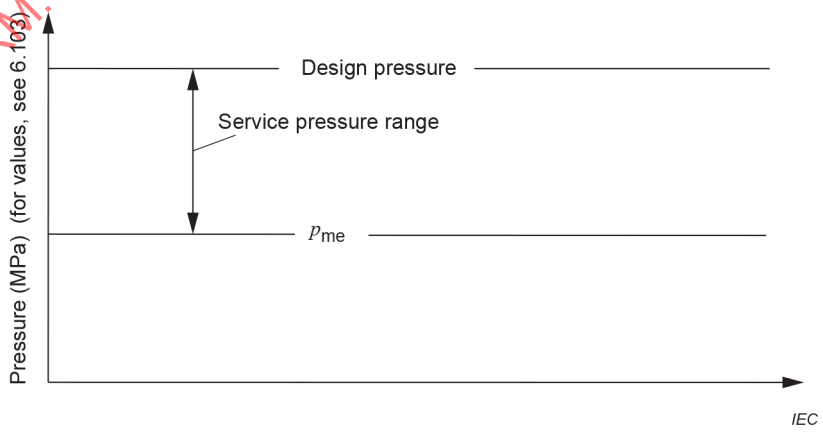
The overvoltage protection elements, i.e. connections between part 6 and part 13 of Figure 2 for fluid-filled cable terminations and Figure 4 for dry-type cable terminations as described above, are not meant to serve as the cable system grounding connection.

Earthing of enclosures shall be in accordance with the relevant subclause of IEC 62271-203:2011.

6.102 Filling pressure of insulating gas in the cable connection enclosure

If SF_6 is used as the insulating gas, the minimum functional pressure for insulation p_{me} used to determine the design of the cable termination insulation shall not exceed p_{me} = 0,35 MPa (absolute) at 20 °C for maximum rated voltages up to 300 kV. For maximum rated voltages exceeding 300 kV the minimum functional pressure for insulation p_{me} used to determine the design of the cable termination insulation shall not exceed p_{me} = 0,4 MPa (absolute) at 20°C (see Figure 1).

The filling pressure p_{re} of insulating gas is assigned by the switchgear manufacturer but shall in no case be lower than p_{me}. The service pressure is in no case higher than the design pressure as per 6.103.



p_{me} minimal functional pressure for insulation depending on rated voltage

Figure 1 – Operating pressure of the gas insulation in the cable connection enclosure

If a gas other than SF_6 or a gas mixture is used, the minimum functional pressure shall be chosen to provide the same dielectric performance as in case of SF_6. The minimum functional pressure shall be below the maximum service pressure and design pressure of the enclosure as per 6.103.

6.103 Pressure withstand requirements

The design pressure for the outside of the cable termination is determined by the particular GIS design around the GIS/cable interface. Typical maximum gas pressures in service are up to 1,1 MPa (absolute) for SF_6 and up to 1,5 MPa (absolute) for other gases and gas mixtures.

The particular pressure withstand requirements coming from the specific gas and GIS design shall be thoroughly coordinated between GIS and cable termination manufacturer as well as the user.

NOTE Due to the lower service current of a HV-cable connection than the rated current of a GIS, the related temperature and pressure rise within the cable compartment can be lower. The design pressure of the GIS could be higher than the design pressure of the cable termination.

6.104 Mechanical forces on cable terminations

The manufacturer of the cable termination in a three-phase connection shall take into account the total dynamic forces generated during short circuit conditions. These forces consist of those generated within the cable termination and those coming from the main circuit of the switchgear. The maximum additional force applied from the switchgear to the connection interface (Figures 2 or 4) transversely and then being transferred from the main circuit end terminal shall not exceed 5 kN for a three phase arrangement. For single-phase connections, the maximum additional force applied from the switchgear to the connection interface (Figures 2 or 4) transversely and then being transferred from the main circuit end terminal shall not exceed 2 kN. It is the responsibility of the manufacturer of the switchgear to ensure that the specified forces are not exceeded or to agree with the cable termination manufacturer that the cable termination shall withstand the higher forces.

For both single-phase and three-phase connections, additional forces and movements from the switchgear can be experienced due to temperature variations and vibrations in service. These forces can act on both switchgear and cable termination and depend largely on the switchgear layout, termination installation, cable design and the methods of mechanical support. The design of any support structure shall take into account these forces and movements. It is particularly important that the support for the switchgear shall not be affixed to the insulator collar and/or clamping flange, parts 9 and 11 of Figures 2 or 4. Further information regarding mechanical forces on the flanges of the cable connection enclosure are given in Annex A.

For seismic requirements, the switchgear manufacturer carries out a seismic calculation in order to identify the location of mechanical reinforcements; reference is made to IEC 62271-207 [2].

6.105 Switchgear connection interface and cable termination connection interface

The normal current-carrying contact surfaces of the switchgear and cable termination connection interface (refer to parts 2 and 3 of Figures 2 and 4) shall be silver coated or copper coated or non-coated solid copper.

7 Type tests

7.1 General

7.1.1 Basics

The type tests are for the purpose of proving the ratings and characteristics of switchgear and controlgear, their operating devices and their auxiliary equipment. Each individual type test or type test sequence shall be made on test objects as defined in 3.2.1, in the condition as required for service (filled with the specified types and quantities of liquid or gas), with their operating devices and auxiliary equipment, all of which in principle shall be in, or restored to, a new and clean condition at the beginning of each type test or type test sequence.

Reconditioning during individual type tests or test sequence may be allowed, according to the relevant IEC product standard. The manufacturer shall provide a statement to the testing laboratory of those parts that may be renewed during the tests.

Tolerances on test quantities are listed in Table E.1.

Information regarding the extension of validity of type tests is given in Annex J (informative).

7.1.2 Information for identification of test objects

The manufacturer shall submit to the testing laboratory, drawings and other data containing sufficient information to unambiguously identify by type the essential details and parts of the switchgear and controlgear presented for test. A summary list of the drawings and data schedules shall be supplied by the manufacturer and shall be uniquely referenced and shall contain a statement that the manufacturer guarantees that the drawings or data sheets listed are the correct version and represent the switchgear and controlgear to be tested.

The testing laboratory shall check that drawings and data sheets adequately represent the essential details and parts of the test object but is not responsible for the accuracy of the detailed information.

Particular drawings or data required to be submitted by the manufacturer to the test laboratory for identification of essential parts of test object are specified in Annex A (normative).

7.1.3 Information to be included in type-test reports

The results of all type-tests shall be recorded in type-test reports containing sufficient data to prove compliance with the ratings and the test clauses of the relevant standards and sufficient information shall be included so that the essential parts of the test object can be identified. In particular, the following information shall be included:

– the manufacturer;
– the type designation and the serial number of the test object;
– the rated characteristics of the test object as specified in the relevant IEC standard;
– the general description of the test object, including number of poles;
– the manufacturer, type, serial numbers and ratings of essential parts, where applicable (for example, drive mechanisms, interrupters, shunt impedances);
– the general details of the supporting structure of the switching device or enclosed switchgear of which the switching device forms an integral part;
– the details of the operating-mechanism and devices employed during tests, where applicable;
– photographs to illustrate the condition of the test object before and after test;
– sufficient outline drawings and data schedules to represent the test object;

- the reference numbers of all drawings including revision number submitted to identify the essential parts of the test object;
- a statement that the test object complies with the drawings submitted;
- details of the testing arrangements (including diagram of test circuit);
- statements of the behaviour of the test object during tests, its condition after tests and any parts renewed or reconditioned during the tests;
- in case of breaking operations with some specific technologies, NSDDs may occur during the recovery voltage period. Their number is of no significance to interpreting the performance of the device under test. They shall be reported in the test report only in order to differentiate them from restrikes;
- records of the test quantities during each test or test duty, as specified in the relevant IEC standard;
- the location, laboratory name where the tests were conducted and date of test.

If SF_6 is used, technical grade SF_6 in accordance with IEC 60376 or used SF_6 in accordance with IEC 60480 shall be used.

7.2 Electrical type tests of cable terminations

7.2.1 General

The electric type tests of the cable termination shall be carried out according to the electrical type tests defined in IEC 60141 (all parts) or IEC 60840 or IEC 62067 as relevant for the cable design. Where applicable the insulator shall be tested to 7.2.4.

The cable termination shall be installed in an enclosure as per 7.2.2, filled with insulating gas at the pressure not exceeding p_{me}+0,02 MPa with filling pressure specified in 6.102.

The design of the main circuit end terminal (part 1 in Figures 2 or 4 respectively) used in the test as connection to part 3 of the cable connection assembly shall comply with Figures 2 and 4 respectively of this document.

7.2.2 Electrical type test of cable terminations in a single-phase enclosure

The cable termination is surrounded by a metal cylinder connected to earth, the maximum internal diameter is equal to d_5 for the four standard sizes of cable connection enclosure (d_5 in Figure 3 for fluid-filled cable terminations and Figure 5 for dry-type cable terminations). The minimum length of the metal cylinder shall be in accordance with the dimension l_5 given in Figures 3 and 5.

7.2.3 Electrical type test of cable termination in a three-phase enclosure

The single-phase test arrangement using the single-phase cable connection enclosure from the switchgear covers the test requirements of the cable termination in a three-phase enclosure as it imposes a more severe dielectric stress to the test object. It is therefore the referenced type test arrangement.

7.2.4 Additional electrical type tests on the insulator to be installed by switchgear manufacturer (plug in cable termination)

In some applications the termination insulator is installed in the switchgear enclosure by the switchgear manufacturer and is consequently subject to routine and on site test procedures applicable to the switchgear. In order to cover this application the following test shall be carried out.

The insulator shall be installed as specified by the cable termination manufacturer in order to cover later routine test at the switchgear manufacturer's works and on site tests. Because the

cable will not be fitted to the termination, any special devices required shall be fitted on the cable side of the insulator. Such devices shall be provided by the cable termination supplier. The test shall be done at ambient temperature (20 ± 15) °C. Test voltages shall be applied as specified in Table 1.

Table 1 – Test voltages for additional electrical type tests according to 7.2.4

Rated voltage of the equipment of cable connection U_{rm} kV (RMS value) (NOTE 1)	**Power-frequency voltage tests** U_d kV (RMS value)		**Switching impulse withstand voltage** U_{ss} kV (peak value)	**Lightning impulse withstand voltage** U_{ps} kV (peak value)
	Phase-to-earth withstand voltage test (t = 1 min) IEC 62271-203:2011 Cl. 7.1.101 (NOTE 2)	Test voltage for PD measurement $U_{pd\text{-}test}$ (>1 min) IEC 62271-203:2011, 7.1.102 (NOTE 2)	Phase-to-earth IEC 62271-203:2011, 10.2.101.2.4 (NOTE 3)	Phase-to-earth IEC 62271-203:2011, 10.2.101.2.4 (NOTE 3)
(1)	(2)	(3)	(4)	(5)
72,5	140	1,2 U_r	-	260
100	185	1,2 U_r	-	360
123	230	1,2 U_r	-	440
145	275	1,2 U_r	-	520
170	325	1,2 U_r	-	600
245	460	1,2 U_r	-	840
300	460	1,2 U_r	680	840
362	520	1,2 U_r	760	940
420	650	1,2 U_r	840	1 140
550	710	1,2 U_r	940	1 240

NOTE 1 The rated voltage for equipment U_{rm} applies as per 5.2.

NOTE 2 The AC type test voltages cover the switchgear routine test, which the insulator can be subjected to.

NOTE 3 The impulse voltage type tests cover the switchgear on site test, which the insulator can be subjected to.

For further details and test procedure regarding dielectric tests on the insulator, reference is made in Table 1 to the applicable clauses of IEC 62271-203:2011.

7.1.101 Power-frequency voltage tests on the main circuit

The power-frequency voltage test of GIS shall be performed according to the requirements in 6.2.6.1 or 6.2.7.1 to earth, between phases (if applicable) and across the open switching devices. The voltage test across the open switching device may be carried out at one side of the switching device. The withstand voltages for routine tests shall be those specified in column (2) of Tables 2 and 3.

The tests shall be performed at the minimum functional pressure for insulation.

7.1.102 Partial discharge measurement

The measurement of partial discharges shall be performed to detect possible material and manufacturing defects.

Partial discharge tests shall be performed in accordance with 6.2.9.

The measurement of partial discharges shall be performed with dielectric tests after mechanical routine tests.

The test shall be carried out on all components of a switchgear and controlgear. It may be performed on the complete switchgear and controlgear, if applicable, or on transport units or on individual components. Tests on simple components containing no solid insulation may be excepted.

10.2.101.2.4 Test voltages

Considering that

– transport units have normally been subjected to routine test,
– the probability of disruptive discharges is higher for the complete installation than for individual functional units,
– disruptive discharges in correctly installed equipment shall be avoided,

the test voltage for dielectric tests on site shall be as shown in Table 7.

Table 7 – On site test voltages

Rated voltage for equipment U_r kV (r.m.s. value)	**On-site short-duration power-frequency withstand voltage** U_{ds} kV (r.m.s. value)	**On-site switching impulse withstand voltage** U_{ss} kV (peak value)	**On-site lightning impulse withstand voltage** U_{ps} kV (peak value)
(1)	**(2)** (see Note 1)	**(3)**	**(4)**
72,5	120	-	260
100	165	-	360
123	200	-	440
145	235	-	520
170	270	-	600
245	380	-	840
300	380	680	840
362	425	760	940
420	515	840	1 140
550	560	940	1 240
800	760	1 140	1 680

NOTE 1 Values of column (2) are only applicable for SF_6 insulation or when SF_6 is a major part of the gas mixture. For other insulation refer to Tables 1 and 2 of IEC 62271-1, applying a factor 0,8 on column (2).

NOTE 2 The on-site test voltages have been calculated as follows:

U_{ds} (on-site test value) = $U_p \times 0{,}45 \times 0{,}8$ (column (2))

U_{ss} (on-site test value) = $U_s \times 0{,}8$ (column (3))

U_{ps} (on-site test value) = $U_p \times 0{,}8$ (column (4))

All values have been rounded up to the next higher modus 5 kV.

NOTE 3 If other insulation levels than the preferred values of Tables 2 and 3 (e.g. the lower insulation levels of Tables 1 and 2 in IEC 62271-1) are specified, then the on-site test voltage should be calculated according to Note 2.

In certain circumstances, for technical or practical reasons, dielectric tests on site may be carried out with reduced voltage values. Details are given in C.3.

7.3 Pressure test on the insulator of a cable termination

The insulator shall be secured in exactly the same manner as in service. The test shall be carried out at ambient temperature (20 ± 15) °C. Hydraulic pressure shall be applied to the switchgear side of the insulator with the cable side open to atmosphere. The pressure shall be increased at a rate of not more than 0,4 MPa/min until it reaches three times the design pressure (e.g. design pressure of 0,85 MPa absolute leads to a test pressure of 3 x 0,75 MPa = 2,25 MPa relative), which shall be held for 1 min.

7.4 Leak rate type test on the insulator of a cable termination

The test shall be performed at ambient temperature (20 ± 15) °C on an insulator of a cable termination installed in a suitable chamber. The insulator shall be installed in a manner close to the service conditions. The test shall be carried out in accordance with IEC 60068-2-17:1994, Clause 8 (the test method Qm is the preferred method to determine the relative leakage rate).

The measured leak rate shall not exceed 10^{-7} Pa x m^3/s at minimal functional pressure for insulation p_{me} (see Figure 1).

NOTE The volume of the cable termination compartment is unknown during type test, therefore a leak rate flux instead of leak rate percentage is given.

8 Routine tests

8.1 General

Routine tests of a cable termination shall be carried out according to IEC 60141 (all parts) or IEC 60840 or IEC 62067 as applicable. In addition the tests in the following 8.2 and 8.3 shall be carried out.

If the cable termination insulator is pre-installed during switchgear manufacturing, this insulator will be subject to routine tests and on site tests specified in IEC 62271-203 when these are carried out on the switchgear. For these tests the insulator shall be installed and special devices shall be fitted if required for the test, as specified by the cable termination manufacturer. Such devices shall be provided by the cable termination supplier.

8.2 Pressure test

Routine pressure tests of the insulator of a cable termination shall be carried out at 2 times design pressure (relative) for one minute. The insulator shall be secured in exactly the same manner as in service and the pressure shall be applied from the switchgear side. The insulator shall not show any signs of overstress or leakage.

8.3 Visual inspection

The visual inspection shall be made of all surfaces and shall not show any signs of significant defects. Critical machined dimensions shall be confirmed by measurements.

9 Standard dimensions

9.1 General

Standard dimensions are specified in order to ensure compatibility between switchgear and cable terminations conforming to this document.

9.2 Fluid-filled cable terminations

Standard dimensions for fluid-filled cable connection enclosures, main circuit end terminals and cable terminations applied to single-phase enclosures are shown in Figure 3. Four standard sizes cover the voltage range (U_r) from 72,5 kV to 550 kV.

9.3 Dry-type cable terminations

Standard dimensions for dry-type cable-connection enclosures, main circuit end terminals and cable terminations applied to single-phase enclosures are shown in Figure 5. Four standard sizes cover the voltage range (U_r) from 72,5 kV to 550 kV. Figure 4 shows the two types of dry-type cable termination. Type A incorporates an elastomeric electrical stress control component inside the insulating barrier. Type B incorporates the insulating barrier inside the elastomeric electrical stress control component.

For use of dry type cable terminations according to Figure 5 in enclosures for fluid-filled terminations according to Figure 3, suitable interface adaptor(s) shall be supplied by the cable termination manufacturer.

9.4 Three-phase cable connection enclosure

The minimum dimensions of the three-phase cable connection enclosure are defined by the minimum phase to phase distance arising out of d_{10} and the minimum phase to ground distance arising out of $d_5/2$ in accordance with Figures 3 and 5 respectively.

10 Information to be given with enquiries, tenders and orders

Refer to IEC 60840 or IEC 62067 or IEC 60141 (all parts), and IEC 62271-203. In addition, the user and the manufacturers shall consider the installation requirements of the equipment. Manufacturers shall state the specific requirements for civil, electrical and installation clearances applicable to the switchgear, cable termination and cable. Information shall be provided in particular and if required in relation to switchgear/cable termination installation sequence as well as positioning and temporary fixing of the relevant components.

At the time of ordering or manufacturing a switchgear, it is very often not known whether and how the foreseen cable systems will be tested at site. In order to improve this situation, the user of the switchgear has to identify in his inquiry each cable feeder and which testing method will be applied. It is assumed that generally an AC or DC test will be executed at site. The following main test methods are defined:

a) in case that one end of the cable is installed outdoors, the outdoor located accessible cable end may be used to apply the test voltage;
b) in case of a cable connection between two switchgears or between switchgear and transformer, the cable connection enclosure in the switchgear may be used to apply the test voltage.

It is the responsibility of the user to indicate in the enquiry for the switchgear which feeders of the switchgear shall be foreseen for cable testing and which test method is required.

11 Rules for transport, storage, erection, service and maintenance

11.1 General

It is essential that the transport, storage and installation of switchgear and controlgear, as well as their operation and maintenance in service, is performed in accordance with instructions given by the manufacturer.

Consequently, the manufacturer shall provide the appropriate version of the instruction manual for the transport, storage, installation, operation and maintenance of switchgear and controlgear. The instructions for the transport and storage should be given at a convenient time before delivery, and the instructions for the installation, operation and maintenance should be given by the time of delivery at the latest. It is preferable that the operation manual be a separate document from the installation and maintenance manual.

It is impossible, here, to cover in detail the complete rules for the installation, operation and maintenance of each one of the different types of apparatus manufactured, but the following information is given relative to the most important points to be considered for the instructions provided by the manufacturer.

11.2 Conditions during transport, storage and installation

A special agreement should be made between manufacturer and user if the service conditions of temperature and humidity defined in the order cannot be guaranteed during transport, storage and installation. Special precautions may be essential for the protection of insulation during transport, storage and installation, and prior to energizing, to prevent moisture absorption due, for instance, to rain, snow or condensation. Vibrations during transport should be considered. Appropriate instructions should be given by the manufacturer.

Special packaging should be proposed by the manufacturer for long term storage of parts for maintenance needs according to customer specifications.

11.3 Installation

11.3.1 General

For each type of switchgear and controlgear the instructions provided by the manufacturer shall include at least the items listed below.

11.3.2 Unpacking and lifting

Each complete equipment shall be provided with adequate lifting facilities and labelled (externally) to show the correct method of lifting. The equipment shall be labelled (externally) to indicate its maximum mass, in kg, when fully equipped. Special lifting devices shall be capable of lifting the mass of each transport unit and special precautions shall be detailed in the installation manual (for example lifting brackets/bolts that are not intended to be left outdoors shall be removed at site).

Required information for unpacking should be given.

11.3.3 Assembly

When the switchgear and controlgear is not fully assembled for transport, all transport units should be clearly marked. Drawings showing assembly of these parts should be provided with the switchgear and controlgear.

11.3.4 Mounting

Instructions for the mounting of switchgear and controlgear, operating device and auxiliary equipment should include sufficient details of locations and foundations to enable site preparation to be completed.

These instructions should also indicate:

– the total mass of the apparatus inclusive of extinguishing or insulating fluids;
– the mass of extinguishing or insulating fluids;
– the mass of each unit to be lifted separately.

11.3.5 Connections

Instructions should include information on:

– connection of conductors, comprising the necessary advice to prevent overheating and unnecessary strain on the switchgear and controlgear and to provide adequate clearance distances;

– connection of auxiliary circuits;

– connection of liquid or gas systems, if any, including size and arrangement of piping;

– connection for earthing;

– auxiliary contacts available to the user.

11.3.6 Information about gas and gas mixtures for controlled and closed pressure systems

For controlled and closed pressure systems filled with gas mixture, the percentage of the different gases and their associated tolerances shall be defined by the manufacturer taking into account handling and uncertainty of measurement. Appropriate gas filling procedures are defined in IEC 62271-4.

During commissioning or maintenance, the maximum allowable humidity content within gas-filled switchgear and controlgear filled with gas at the filling pressure (density) for insulation shall be checked by dew point measurement. Appropriate correction factors shall be used for measurements performed at temperatures other than 20 °C according to the manufacturer´s instruction manual.

The maximum allowable humidity content for equipment filled or re-filled with new or used gas should be such that the dew point inside the switchgear compartment is not higher than

– −10 °C for equipment with adsorber material;

– −15 °C for equipment without adsorber material

during commissioning or after maintenance for a measurement at filling pressure (density) for insulation and at 20 °C.

NOTE 1 These dew point values during commissioning are expected to give a dew point value lower than -5 °C during service life, for a measurement at 20 °C.

NOTE 2 The measurement of the dew point is specified at a given temperature due to the possible exchange of water between gas and solid materials when the temperature changes, which could change the measured value.

NOTE 3 An example of measurement and determination of the dew point is given in IEEE C37.122.5 [35].

11.3.7 Final installation inspection

Instructions should be provided for inspection and tests which should be made after the switchgear and controlgear has been installed and all connections have been completed.

These instructions should include:

– a schedule of recommended site tests to establish correct operation;

– procedures for carrying out any adjustment that may be necessary to obtain correct operation;

– recommendations for any relevant measurements that should be made and recorded to help with future maintenance decisions;

– a procedure for qualitative gas tightness test at site (sniffing test) on all field assembled connections for closed pressure systems, reference is made to 8.5.3;

– instructions for final inspection and putting into service.

Guidance for electromagnetic compatibility site measurements is given in Annex H (informative).

11.3.8 Basic input data by the user

These data should include:

a) access limitations to the local site;

b) local working conditions and any restrictions that may apply (for example, safety equipment, normal working hours, union requirements for supervisor, manufacturer's and local installation crew, etc.);

c) availability and capacity of lifting and handling equipment;

d) availability, number and experience of local personnel;

e) specific pressure vessel rules and procedures that may apply during installation and commissioning tests;

f) interface requirements for high-voltage cables and transformers;

g) in the case of extensions to existing switchgear and controlgear:

1) provisions for the extension available within existing primary and secondary equipment;
2) in-service conditions or operating restrictions that apply;
3) safety regulations that locally apply.

11.3.9 Basic input data by the manufacturer

These data should include:

a) space necessary for installation and assembly;

b) size and weight of components and testing equipment;

c) site conditions regarding cleanliness and temperature for clean installation and preparation area;

d) number and experience of local personnel required for installation;

e) time and activity schedules for installation and commissioning;

f) electric power, lighting, water and other needs for installation and commissioning;

g) proposed training of installation and service personnel;

h) in case of extension to existing switchgear and controlgear:

1) out-of-service requirements of existing components related to the installation schedule;
2) safety precautions.

i) gas filling procedure (mixed gases) and dew point verification, if necessary.

11.4 Operating instructions

The operating instructions given by the manufacturer shall contain the following information:

– a general description of the equipment with particular attention to the technical description of its characteristics and operation so that the user has an adequate understanding of the main principles involved;

– a description of the safety features of the equipment and the operation of the interlocks and padlocking facilities;

– as relevant, a description of the action to be taken to manipulate the equipment for operation isolation, earthing, maintenance, and testing;

– as relevant, measures against corrosion should be given.

11.5 Maintenance

11.5.1 General

The effectiveness of maintenance depends mainly on the way instructions are prepared by the manufacturer and implemented by the user.

11.5.2 Information about fluids and gas to be included in maintenance manual

Where applicable, the following information shall be provided by the manufacturer:

j) type and required quantity and quality of liquid to be used in switchgear and controlgear;

k) type and required quantity and quality of gas to be used in switchgear and controlgear.

11.5.3 Recommendations for the manufacturer

The manufacturer should be responsible for ensuring the continued availability of spare parts required for maintenance for a period of not less than 10 years from the date of final manufacture of the switchgear and controlgear.

The manufacturer should inform the purchasers of a particular type of switchgear and controlgear about corrective actions required by systematic defects and failures detected in service.

The manufacturer's maintenance manual should include the following information listed below.

a) Extent and frequency of maintenance. For this purpose the following factors should be considered:

   1) switching operations (current and number);
   2) total number of operations;
   3) time in service (periodic intervals);
   4) environmental conditions;
   5) activity after a seismic event (if applicable);
   6) measurements and diagnostic tests, (if any).

b) Detailed description of the maintenance work:

   1) recommended place for the maintenance work (indoor, outdoor, in factory, on site, etc.);
   2) procedures for inspection, diagnostic tests, examination, overhaul;
   3) reference to drawings;
   4) reference to part numbers;
   5) use of special equipment or tools;
   6) precautions to be observed (for example cleanliness and possible effects of harmful arcing by-products);
   7) lubrication procedures.

c) Comprehensive drawings of the details of the switchgear and controlgear important for maintenance, with clear identification (part number and description) of assemblies, subassemblies and significant parts.

NOTE Expanded detail drawings which indicate the relative position of components in assemblies and subassemblies are a common illustration method.

d) Limits of values, which can be measured during operation or routine maintenance and tolerances which, when exceeded, make corrective action necessary, for example:

   1) pressures, density levels, gas mixtures tolerance;

2) resistance and/or capacitance (of the main circuit);
3) operating times;
4) resistance of the main circuits;
5) insulating liquid or gas characteristics;
6) quantities and quality of liquid or gas (see IEC 60480 and IEC 62271-4 for SF_6);
7) dew point inside gas-filled switchgear compartment according to 11.3.6;
8) permissible erosion of parts subject to wear;
9) torques;
10) important dimensions.

e) Specifications for auxiliary maintenance materials, including warning of known non-compatibility of materials:

1) grease;
2) oil;
3) fluid;
4) cleaning and degreasing agents.

f) List of special tools, lifting and access equipment.

g) Tests after the maintenance work.

h) List of the recommended spare parts (description, reference number, quantities) and advice for storage.

i) Estimate of active scheduled maintenance time, carried out in accordance with an established time schedule.

j) How to proceed with the equipment at the end of its operating life, taking into consideration environmental requirements.

11.5.4 Recommendations for the user

If the user wishes to perform maintenance, the maintenance manual of the manufacturer should be followed.

The user should record the following information:

– the serial number and the type of the switchgear and controlgear;
– the date when the switchgear and controlgear is put in service;
– the results of all measurements and tests including diagnostic tests carried out during the life of the switchgear and controlgear;
– dates and extent of the maintenance work carried out;
– the history of service, periodical records of the operation counters and other indications (for example short-circuit operations);
– references to any failure report.

In case of failure and defects, the user should make a failure report and should inform the manufacturer by stating the special circumstances and measures taken. Depending upon the nature of the failure, an analysis of the failure should be made in collaboration with the manufacturer.

11.5.5 Failure report

The purpose of the failure report is to standardize the recording of the switchgear and controlgear failures with the following objectives:

– to describe the failure using a common terminology;

– to provide data for the user statistics;
– to provide a meaningful feedback to the manufacturer.

The following gives guidance on how to make a failure report.

A failure report should include the points listed below.

a) Identification of the switchgear which failed:
   1) substation name;
   2) identification of the switchgear (manufacturer, type, serial number, ratings);
   3) switchgear technology (air blast, minimum oil, SF_6, vacuum);
   4) location (indoor, outdoor);
   5) enclosure;
   6) drive mechanism, if applicable (hydraulic, pneumatic, spring, motor, manual).

b) History of the switchgear:
   1) date of commissioning of the equipment;
   2) date of failure/defect;
   3) total number of operating cycles, if applicable;
   4) date of last maintenance;
   5) details of any changes made to the equipment since manufacture;
   6) total number of operating cycles since last maintenance;
   7) condition of the switchgear when the failure/defect was discovered (in service, maintenance, etc.).

c) Identification of the subassembly/component responsible for the primary failure/defect:
   1) high-voltage stressed components;
   2) electrical control and auxiliary circuits;
   3) drive mechanism, if applicable;
   4) other components.

d) Stresses presumed to contribute to the failure/defect:
   1) operation mistake or misuse of the equipment;
   1) environmental conditions (temperature, wind, rain, snow, ice, pollution, lightning, etc.).

e) Classification of the failure/defect:
   1) major failure;
   2) minor failure;
   3) defect.

f) Origin and cause of the failure/defect:
   1) origin (mechanical, electrical, tightness if applicable);
   2) cause (design, manufacture, inadequate instructions, incorrect mounting, incorrect maintenance, stresses beyond those specified, etc.)
   3) operation mistake or misuse.

g) Consequences of the failure or defect:
   1) switchgear down-time, which is time interval during which an item is in a down state;
   2) time consumption for repair;
   3) labour cost;
   4) cost of spare parts.

A failure report may include the following information:

– drawings, sketches;
– photographs of defective components;
– single-line station diagram;
– operation and timing sequences;
– records or plots;
– references to maintenance or operating manuals.

The cable termination manufacturer should ensure that during manufacture, handling, storage and installation of the cable termination, provisions should be made to ensure that the requirements given in 6.2 of IEC 62271-1:2017 can be satisfied after final assembly of the connection. The cable termination manufacturer should supply the necessary information to enable these requirements to be satisfied, if the cable termination is to be installed by others.

11.2 Tests after cable system installation

If required by the user of the switchgear, the manufacturer shall make special provisions for the testing of the cable system, such as disconnecting facilities, earthing facilities and/or increasing gas pressure within the given design limits of the cable connection enclosure. This applies also if parts of the switchgear directly connected to the cable connection assembly cannot withstand the test voltage specified in IEC 60141 (all parts) or IEC 60840 or IEC 62067 for the cable test at rated gas density. It also applies if in the judgment of the switchgear manufacturer, it is not acceptable to apply the test voltage to the affected switchgear components.

If required by the user, the switchgear manufacturer shall provide the location for a suitable test bushing and provide the user with all necessary information for mounting such a bushing to the cable connection enclosure. If necessary to achieve adequate electrical clearances, the test bushing shall include a suitable insulated connection and test terminal. The requirement for the test bushing shall be specified by the user in the enquiry.

NOTE Increasing the gas pressure is not a reliable method of improving the electrical strength at the surface of an insulator when tested with DC voltage.

12 Safety practices and constraints during installation of cable connection to switchgear

The following practices should be considered for handling electrical equipment in the field:

- before commencing any work on the equipment in the field, make sure that the cable, the switchgear and all adjacent electrical equipment are de-energized and properly grounded.
- the preparation of the cable, the installation of cable terminations and the connections to the switchgear are intended to be performed by qualified personnel and jointers that are trained and experienced in installing these or similar products in the field.
- instructions and precautions depending on individual design and local regulations, such as gas pressure reduction in the neighboring compartment, have to be considered.

13 Influence of the product on the environment

The manufacturer shall be prepared to provide on request, the following relevant information about the environmental impact of the switchgear.

When fluids are used in switchgear and controlgear, as far as is practicable, instructions should be provided in order to allow the user to

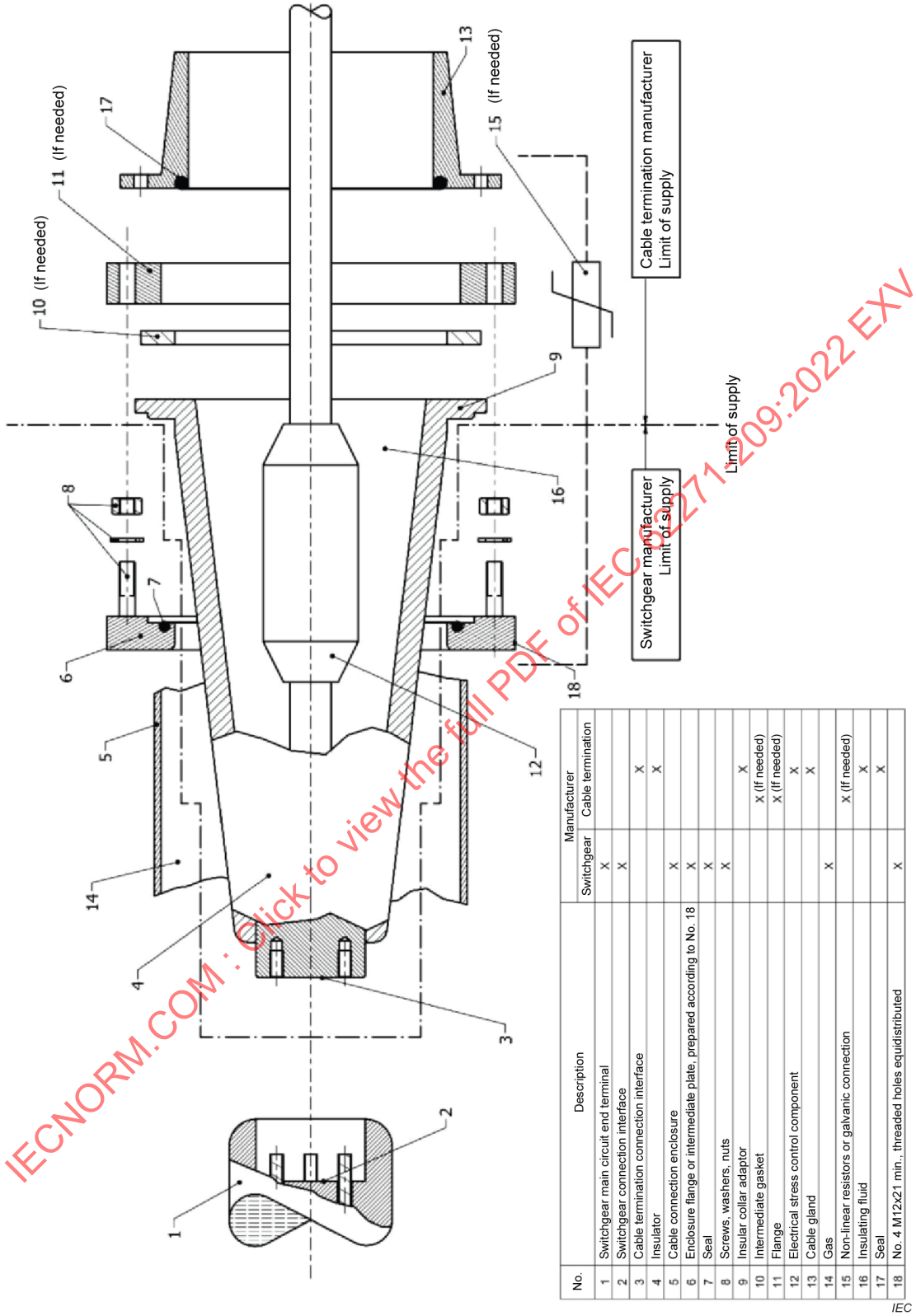
– minimize the leakage rate;

– control the handling of the new and used fluids.

The manufacturer shall give guidance on request, concerning disassembly and end-of-life procedures for the different materials of the equipment and indicate the possibility to recycle.

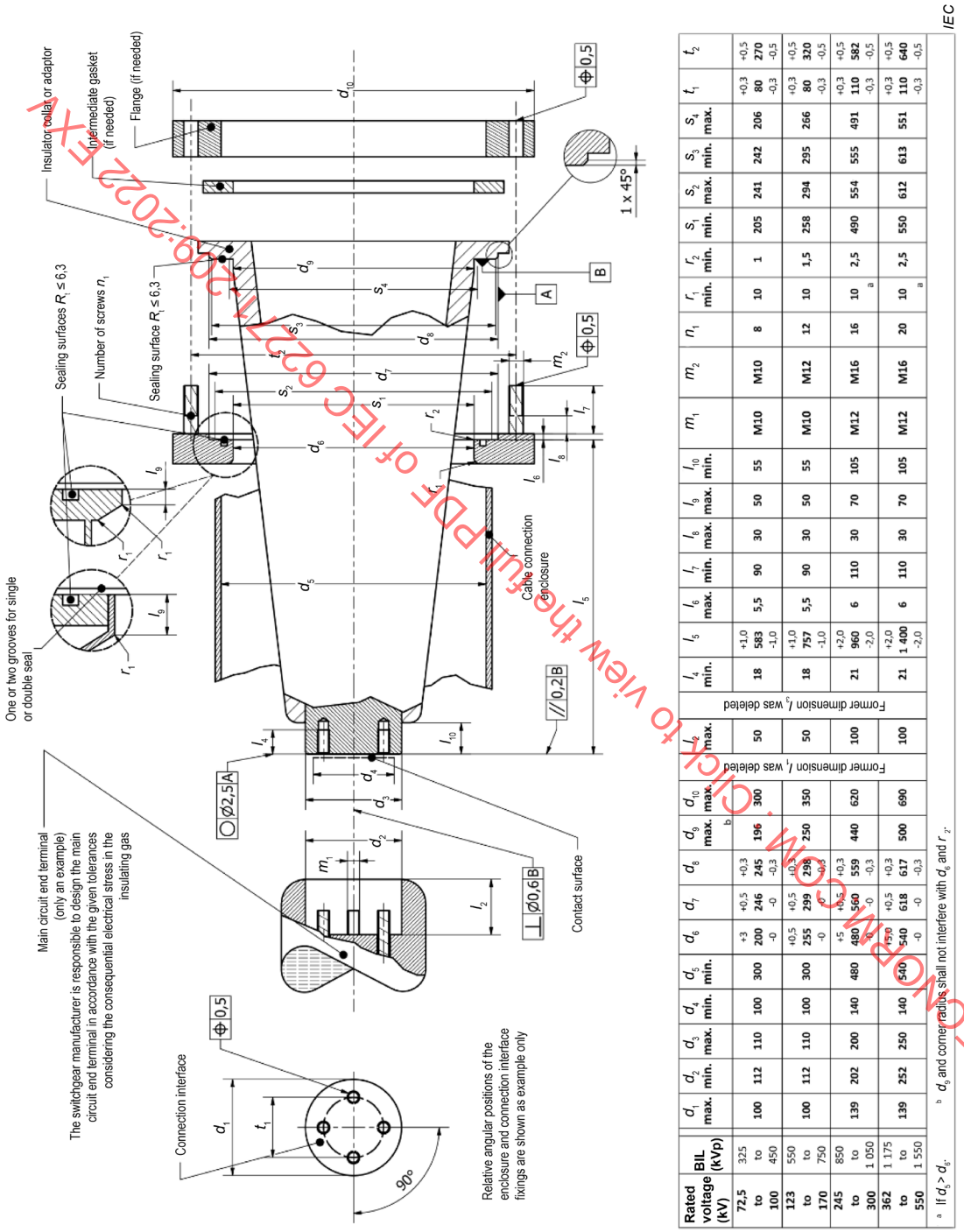
Handling losses during installation, on-site tests and maintenance shall be recorded.

Each refilling shall be recorded with indication of additional SF_6 mass filled in the compartment.



No.	Description	Manufacturer	
		Switchgear	Cable termination
1	Switchgear main circuit end terminal	X	
2	Switchgear connection interface	X	
3	Cable termination connection interface		X
4	Insulator		X
5	Cable connection enclosure	X	
6	Enclosure flange or intermediate plate, prepared according to No. 18	X	
7	Seal	X	
8	Screws, washers, nuts	X	
9	Insular collar adaptor		X
10	Intermediate gasket		X (If needed)
11	Flange		X (If needed)
12	Electrical stress control component		X
13	Cable gland		X
14	Gas	X	
15	Non-linear resistors or galvanic connection		X (If needed)
16	Insulating fluid		X
17	Seal		X
18	No. 4 M12x21 min., threaded holes equidistributed	X	

Figure 2 – Fluid-filled cable connection assembly – Typical arrangement

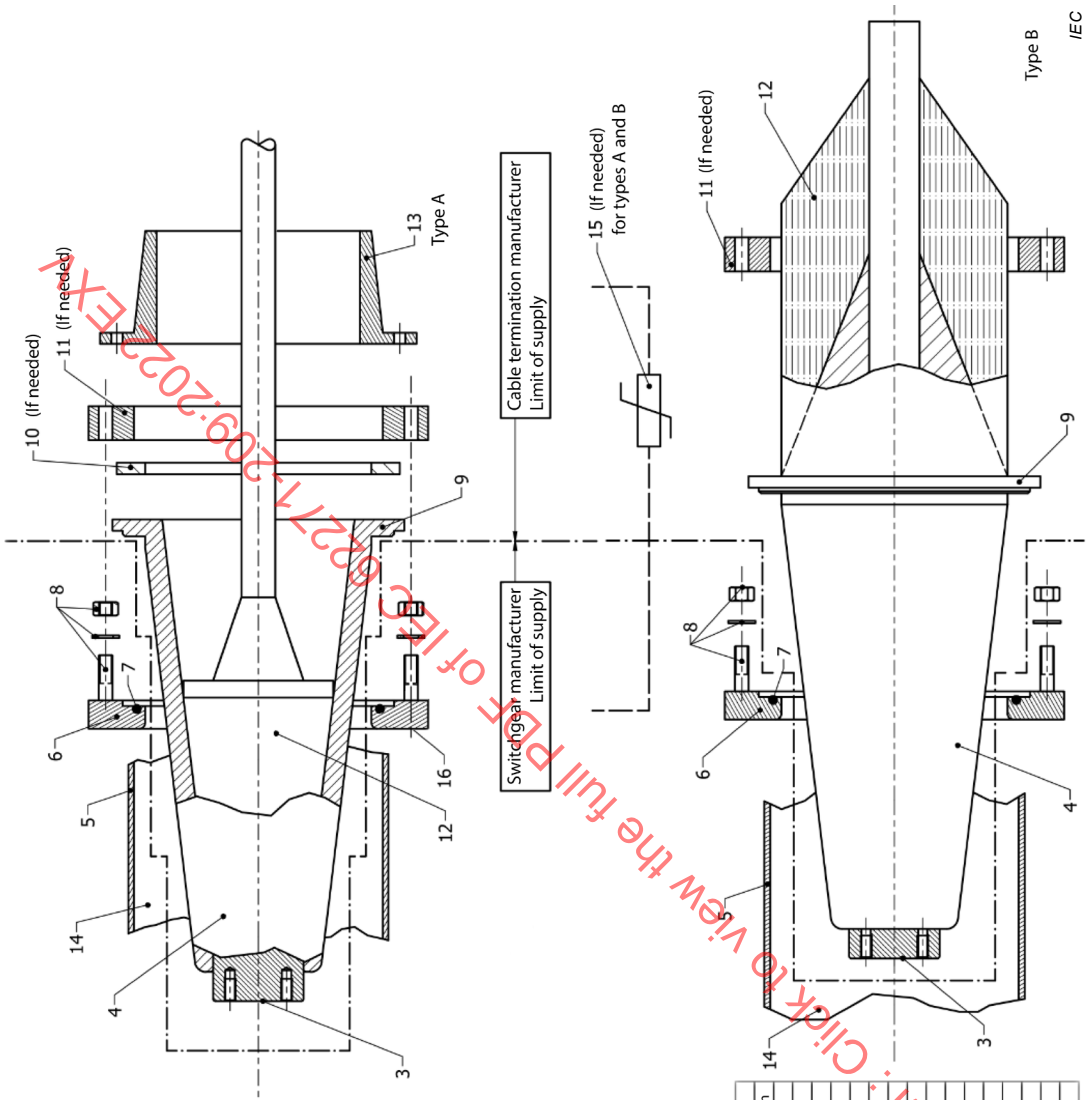


Rated voltage (kV)	BIL (kVp)	d_1 max.	d_2 min.	d_3 max.	d_4 min.	d_5 min.	d_6	d_7	d_8	d_9 max.	d_{10} max.	l_3 max.	l_4 min.	l_5	l_6 max.	l_7 min.	l_8 max.	l_9 max.	l_{10} min.	m_1	m_2	n_1	r_1 min.	r_2 min.	s_1 min.	s_2 max.	s_3 min.	s_4 max.	t_1	t_2
72,5 to 100	325 to 450	100	112	110	100	300	+3 -0	+0,5 -0	+0,3 -0,3	196	300	Former dimension l_3 was deleted	18	+1,0 -1,0	5,5	90	30	50	55	M10	M10	8	10	1	205	241	242	206	+0,3 -0,3	+0,5 -0,5
123 to 170	550 to 750	100	112	110	100	300	+0,5 -0	+0,5 -0	+0,3 -0,3	250	350		18	+1,0 -1,0	5,5	90	30	50	55	M10	M12	12	10	1,5	258	294	295	266	+0,3 -0,3	+0,5 -0,5
245 to 300	850 to 1 050	139	202	200	140	480	+5 -0	+0,5 -0	+0,3 -0,3	440	620	100	21	+2,0 -2,0	6	110	30	70	105	M12	M16	16	10 [a]	2,5	490	554	555	491	+0,3 -0,3	+0,5 -0,5
362 to 550	1 175 to 1 550	139	252	250	140	540	+5 -0	+0,5 -0	+0,3 -0,3	500	690	100	21	+2,0 -2,0	6	110	30	70	105	M12	M16	20	10 [a]	2,5	550	612	613	551	+0,3 -0,3	+0,5 -0,5

[a] If $d_5 > d_6$.
[b] d_9 and corner radius shall not interfere with d_6 and r_2.

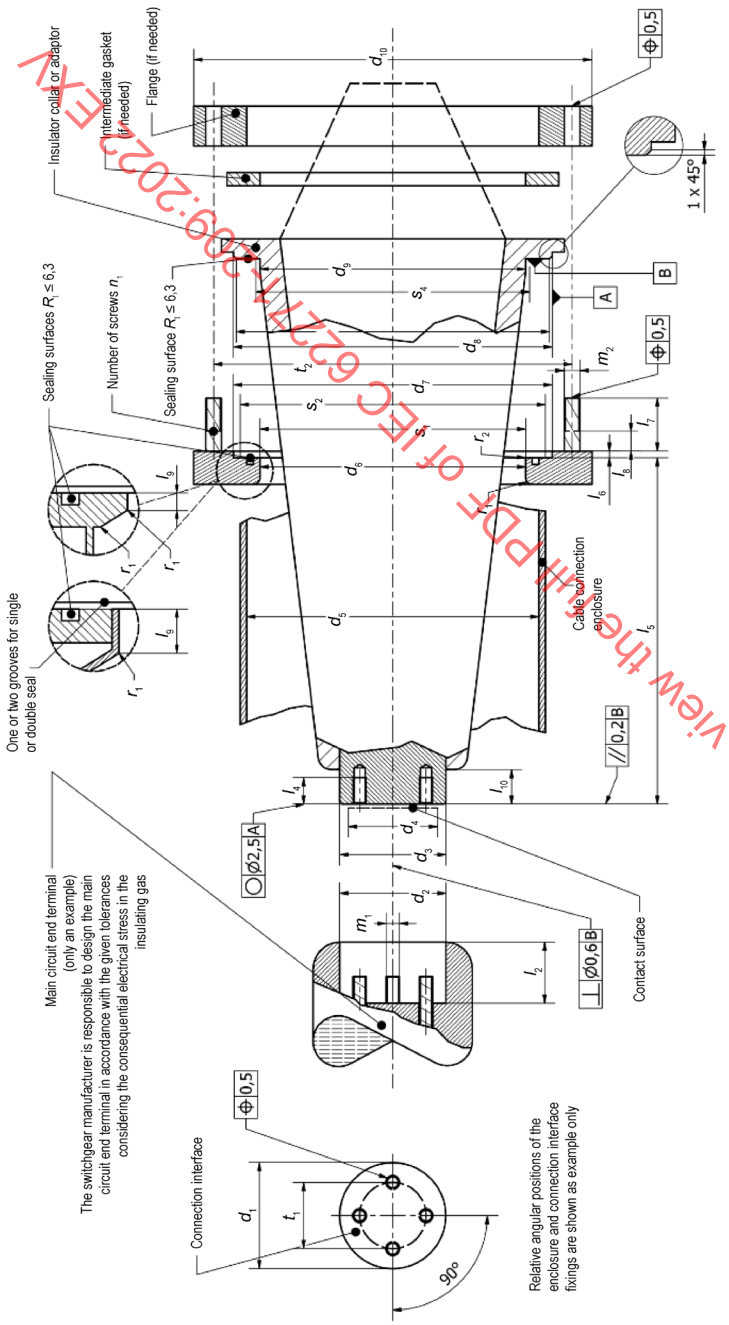
IEC

Figure 3 – Fluid-filled cable connection – Assembly dimensions



Number	Description	Manufacturer	
		Switchgear	Cable termination
1	Switchgear main circuit end terminal	X	
2	Switchgear connection interface	X	
3	Cable termination connection interface		X
4	Insulator		X
5	Cable connection enclosure	X	
6	Enclosure flange or intermediate plate, prepared according to No. 16	X	
7	Seal	X	
8	Screws, washers, nuts	X	
9	Insular collar or adaptor		X
10	Intermediate gasket		X (If needed)
11	Flange		X (If needed)
12	Electrical stress control component (elastomeric)		X
13	Cable gland		X
14	Gas	X	
15	Non-linear resistors or galvanic connection		X (If needed)
16	No.4 M12x21 min., threaded holes equidistributed	X	

Figure 4 – Dry-type cable connection assembly – Typical arrangement



Rated voltage (kV)	BIL (kVp)	d_1 max.	d_2 min.	d_3 max.	d_4 min.	d_5 min.	d_6	d_7	d_8	d_9 max. [b]	d_{10} max.	Former dimension l_3 was deleted	l_4 min.	l_5	l_6 max.	l_7 min.	l_8 max.	l_9 max.	l_{10} min.	m_1	m_2	n_1	r_1 min.	r_2 min.	s_1 min.	s_2 max.	s_3 min.	s_4 max.	t_1	t_2
72,5 to 100	325 to 450	100	112	110	100	300	+3 200 -0	+0,5 246 -0	+0,3 245 -0,3	196	300	50	18	+1,0 310 -1,0	5,5	90	30	50	55	M10	M10	8	10	1	205	241	242	206	+0,3 80 -0,3	+0,5 270 -0,5
123 to 170	550 to 750	100	112	110	100	300	+0,5 255 -0	+0,5 299 -0	+0,3 298 -0,3	250	350	50	18	+1,0 470 -1,0	5,5	90	30	50	55	M10	M12	12	10	1,5	258	294	295	266	+0,3 80 -0,3	+0,5 320 -0,5
245 to 300	850 to 1 050	139	202	200	140	400	+5 385 -0	+0,5 455 -0	+0,3 454 -0,3	375	500	100	21	+2,0 620 -2,0	6	110	30	70	105	M12	M12	16	10	2,5	390	450	451	391	+0,3 110 -0,3	+0,5 475 -0,5
362 to 550	1 175 to 1 550	139	252	250	140	540	+5,0 540 -0	+0,5 618 -0	+0,3 617 -0,3	500	690	100	21	+2,0 960 -2,0	6	110	30	70	105	M12	M16	20	10 [a]	2,5	550	612	613	551	+0,3 110 -0,3	+0,5 640 -0,5

[a] If $d_5 > d_6$.
[b] d_9 and corner radius shall not interfere with d_8 and r_2.

Figure 5 – Dry-type cable connection assembly – Assembly dimensions

Annex A
(normative)

Identification of test objects

A.1 General

For identification of a test object, the following topics shall be covered.

A.2 Data

– Manufacturer's name;
– Type designation, ratings and serial number of apparatus;
– Outline description of apparatus (including number of poles, interlocking system, busbar system, earthing system, and the arc extinguishing process);
– Make, type, serial numbers, ratings of essential parts, where applicable (for example, drive mechanisms, interrupters, shunt impedances, relays, fuse links, insulators);
– Rated characteristics of fuse links and protective devices;
– Whether the apparatus is intended for operation in the vertical and horizontal plane.

A.3 Drawings

Drawings to be submitted	Drawing content (as applicable)
Single-line diagram of main circuit	Type designation of principal components
General layout NOTE For an assembly it may be necessary to provide drawings of the complete assembly and of each switching device.	Overall dimensions Supporting structure and mounting points Enclosure(s) Pressure-relief devices Conducting parts of main circuit Earthing conductors and earthing connections Electrical clearances: – to earth, between open contacts; – between poles. Location and dimensions of barriers between poles Location of earthed metallic screens, shutters or partitions in relation to live parts Liquid insulation level Location and type designation of insulators Location and type designation of instrument transformers
Detailed drawings of insulators	Material Dimensions (including profile and creepage distances)
Arrangement drawings of cable boxes	Electrical clearances Principal dimensions Terminals Level or quantity and specifications of insulant in filled boxes Cable termination details

Drawings to be submitted	Drawing content (as applicable)
Detailed drawings of parts of the main circuit and associated components	Dimensions and material of principal parts Cross-sectional view through the axis of main and arcing contacts Travel of moving contacts Electrical clearance between open contacts Distance between point of contact separation and end of travel Assembly of fixed and moving contacts Details of terminals (dimensions, materials) Identity of springs Material and creepage distances of insulating parts
Detailed drawings of mechanisms (including coupling and drive mechanisms)	Arrangement and identity of main components of the kinematic chains to: – main contacts; – auxiliary switches; – pilot switches; – position indication. Latching device Assembly of drive mechanism Interlocking devices Identity of springs Control and auxiliary devices
Electrical diagram of auxiliary and control circuits (if applicable)	Type designation of all components

Annex B
(informative)

Determination of the equivalent RMS value of a short-time current during a short-circuit of a given duration

The method illustrated in Figure B.1 could be used to determine the short-time current, if no digital equipment provides the proper computation (refer to 7.6.3).

The total time t_t of the test is divided into 10 equal parts by verticals 0 – 0,1... 1 and the RMS value of the AC component of the current is measured at these verticals.

These values are designated: Z_0, Z_1... Z_{10}

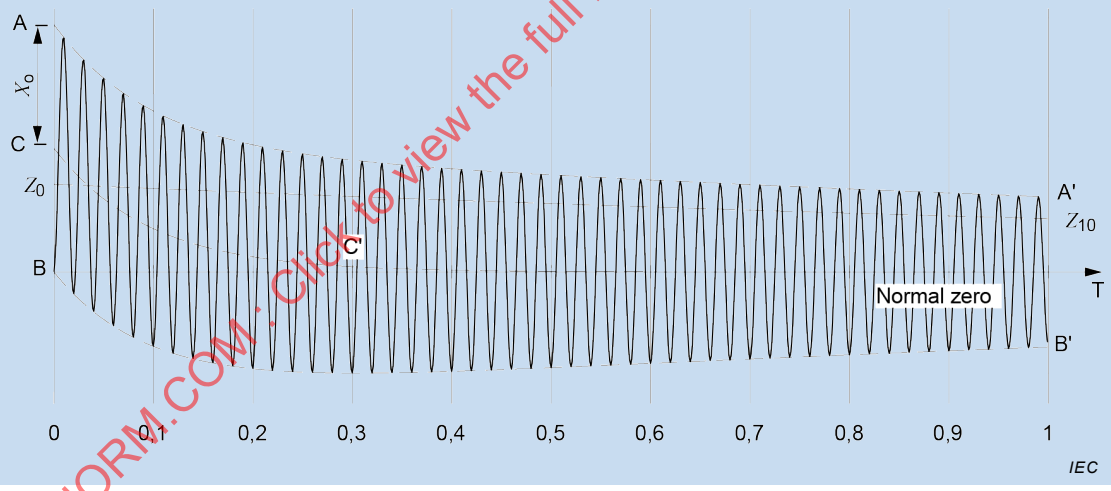
where

$Z = X/\sqrt{2}$ and X is the peak value of AC component of current.

The equivalent RMS current during the time t_t is given by:

$$I_t = \sqrt{\frac{1}{30}\left[Z_0^2 + 4\left(Z_1^2 + Z_3^2 + Z_5^2 + Z_7^2 + Z_9^2\right) + 2\left(Z_2^2 + Z_4^2 + Z_6^2 + Z_8^2\right) + Z_{10}^2\right]}$$

The DC component of current represented by CC' is not taken into account.



Key	
AA'	Envelopes of current wave
BB'	
CC'	Displacement of current wave zero line from normal zero line at any instant
Z_0...Z_{10}	RMS value of AC component of current at any instant measured from normal zero
X_0	Peak value of AC component of current at instant of initiating short-circuit
BT	Duration of short-circuit, t_t

Figure B.1 – Determination of short-time current

Annex C
(normative)

Method for the weatherproofing test for outdoor switchgear and controlgear

The switchgear and controlgear to be tested shall be fully equipped and complete with all covers, screens, bushings, etc., and placed in the area to be subjected to with artificial precipitation. For switchgear and controlgear comprising several functional units a minimum of two units shall be used to test the joints between them.

The artificial precipitation shall be supplied by a sufficient number of nozzles to produce a uniform spray over the surfaces under test. The various parts of the switchgear and controlgear may be tested separately, provided that a uniform spray is simultaneously applied also to both of the following:

a) the top surfaces from nozzles located at a suitable height;

b) the floor outside the equipment for a distance of 1 m in front of the parts under test with the equipment located at the minimum height above the floor level specified by the manufacturer.

Where the width of the equipment exceeds 3 m, the spray may be applied to 3 m wide sections in turn. Pressurized enclosures need not be submitted to artificial precipitation.

Each nozzle used for this test shall deliver a square-shaped spray pattern with uniform spray distribution and shall have a capacity of 30 l/min ± 3 l/min at a pressure of 460 kPa ± 46 kPa and a spray angle of 60° to 80°. The centre lines of the nozzles shall be inclined downwards so that the top of the spray is horizontal as it is directed towards the surfaces being tested. It is convenient to arrange the nozzles on a vertical stand-pipe and to space them about 2 m apart (refer to test arrangement in Figure C.1).

The pressure in the feed pipe of the nozzles shall be 460 kPa ± 46 kPa under flow conditions. The rate at which water is applied to each surface under test shall be about 5 mm/min, and each surface so tested shall receive this rate of artificial precipitation for duration of 5 min. The spray nozzles shall be at a distance between 2,5 m and 3 m from the nearest vertical surface under test.

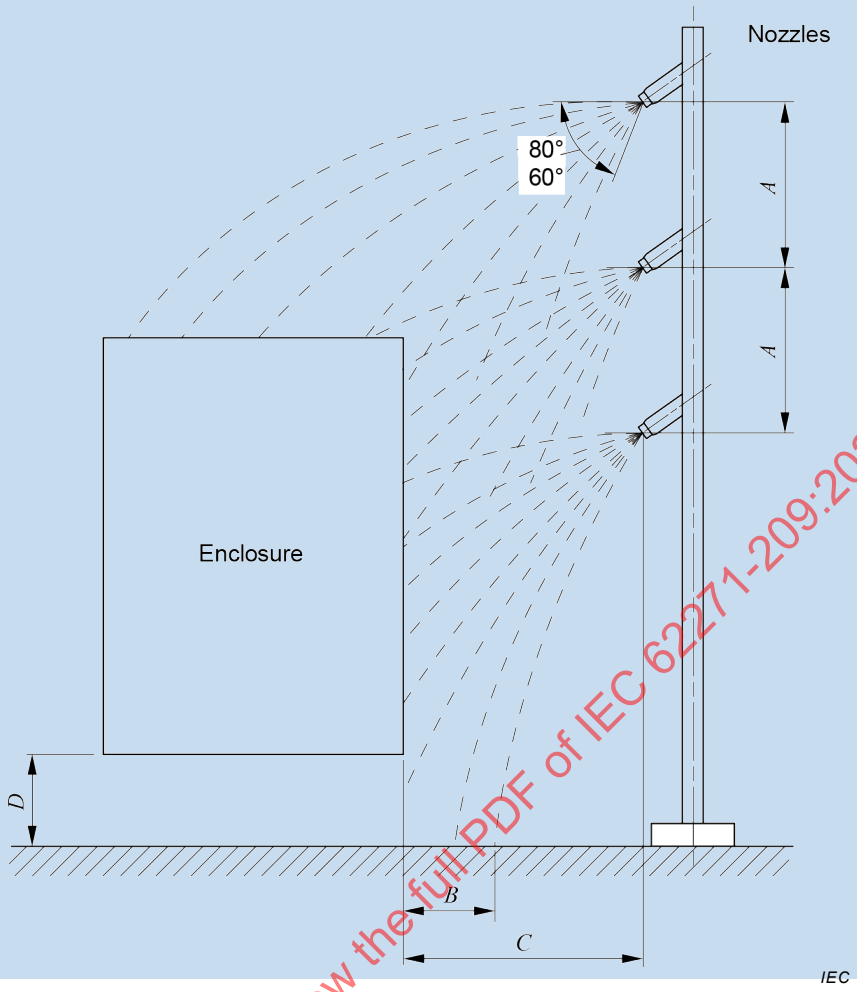
NOTE When a nozzle in accordance with Figure C.2 is used, the quantity of water is considered to be in accordance with this standard when the pressure is 460 kPa ±10 %.

After the test is completed, the equipment shall be inspected promptly to determine whether the following requirements have been met:

a) no water shall be visible on the insulation of the main and auxiliary circuits;

b) no water shall be visible on any internal electrical components and drive mechanisms of the equipment;

c) no significant accumulation of water shall be retained by the structure or other non-insulating parts (to minimize corrosion).



A	About 2 m
B	1 m
C	2,5 m to 3 m
D	Minimum height above floor

Figure C.1 – Arrangement for weatherproofing test

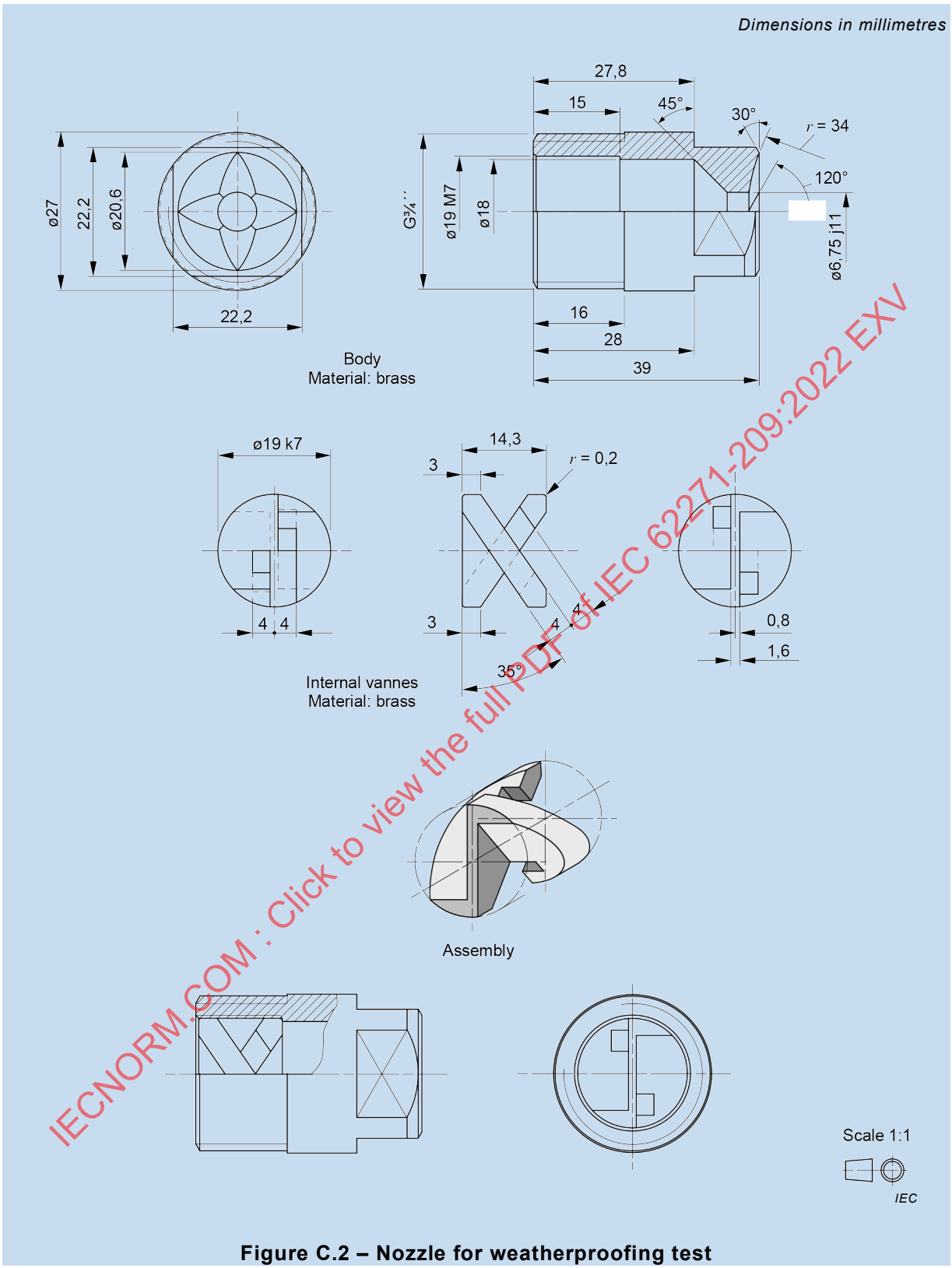


Figure C.2 – Nozzle for weatherproofing test

Annex D
(informative)

References for auxiliary and control circuit components

Table D.1 is provided as a quick reference to many of the component standards. The latest editions should be used.

Table D.1 – List of reference documents for auxiliary and control circuit components *(1 of 2)*

Device		IEC standard
Cables and wiring	Insulation of PVC wiring	IEC 60227 (all parts) [36]
	Size and area of conductors	IEC 60228 [37]
	Insulation of rubber cable	IEC 60245 (all parts)[38]
	Identification	IEC 60445 [39]
Terminals	Terminal blocks for round wire	IEC 60947-7-1 [40]
	Protective terminal blocks for round wire	IEC 60947-7-2 [41]
	Identification	IEC 60445 [39]
Relays	All-or-nothing relays	IEC 61810 (all parts) [42]
	Voltage ratings and operating range of all-or-nothing relays	IEC 61810-1 [43]
	Performance of relay contacts	IEC 61810-2 [44]
Contactors and motor starters	Electromechanical contactors for closing and opening electrical circuit	IEC 60947-4-1 [45]
	Electromechanical contactors combined with relay for short-circuit protection	IEC 60947-2 [46]
	Motor starters (AC)	IEC 60947-4-1 [45]
	AC semiconductor motor controllers	IEC 60947-4-2 [47]
	Motor protective overload relays	IEC 60947-4-1 [45]
Low-voltage switches	Low-voltage switches for motor circuits and distribution circuits	IEC 60947-3 [48]
	Manual control switches and push-buttons	IEC 60947-5-1 [49]
	Pilot switches: pressure, temperature switches etc.	IEC 60947-5-1 [49]
	Household humidity sensing controls	IEC 60730-2-13 [50]
	Household switches	IEC 60669-1 [51]
	Household thermostats	IEC 60730-2-9 [52]
	Lever (toggle) switch	IEC 61020-1 [53]
	Graphical symbols for manual switches	IEC 60417 [26]
	Colours of lights for manual switches	IEC 60073 [25]

Table D.1 *(2 of 2)*

Device		IEC standard
Low-voltage circuit-breakers and low-voltage circuit-breakers with residual current protection	Requirements	IEC 60947-2 [46]
Low-voltage fuses	General requirements	IEC 60269-1 [54]
	Supplementary requirements for fuses for use by authorized persons (fuses mainly for industrial application) – Examples of standardized systems of fuses A to K	IEC 60269-2 [55]
Low-voltage disconnectors	Requirements	IEC 60947-3 [48]
Motors	Requirements	IEC 60034-1 [56]
Meters	Analogue meters	IEC 60051-1 [57]
	Ammeters and voltmeters	IEC 60051-2 [58]
	Frequency meters	IEC 60051-4 [59]
	Phase-angle and power-factor meters	IEC 60051-5 [60]
Lamp used as an indicator	Requirements	IEC 60947-5-1 [49]
	Graphical symbols	IEC 60417 [26]
	Colour lights	IEC 60073 [25]
Plugs, socket-outlets, and couplers	Requirements for plugs, sockets-outlet, industrial cable couplers, appliance couplers	IEC 60309-1 [61]
	Dimensional and interchangeability	IEC 60309-2 [62]
	Household plugs, socket-outlets and couplers	IEC TR 60083 [63]
	Other couplers and plugs	IEC 60130 (all parts) [64]
Printed circuit-boards	Requirements	IEC 62326-1 [65]
Resistors	Potentiometers	IEC 60393-1 [66]
	Resistors 1 W to 1 000 W	IEC 60115-4 (all parts) [67]
Illumination	Illumination fluorescents	IEC 60081 [68]
	Tungsten filament lamps	IEC 60064 [69]
NOTE For electronic components used in auxiliary and control equipment additional information can be found in IEC TR 62063 [70].		

Annex E
(normative)

Tolerances on test quantities during tests

During type tests, the following types of tolerances may normally be distinguished:

– tolerances on test quantities which directly determine the stress of the test object;
– tolerances concerning features or the behaviour of the test object before and after the test;
– tolerances on test conditions;
– tolerances concerning parameters of measurement devices to be applied.

A tolerance is defined as the range of the test value specified in the standard within which the measured test value shall lie for a test to be valid. In certain cases the test may remain valid even if the measured value falls outside the range: this is the case when it results in a more severe test condition.

Any deviation between the measured test value and the true test value caused by the uncertainty of the measurement are not taken into account in this respect.

The basic rules for application of tolerances on test quantities during type tests are as follows:

a) testing stations shall aim wherever possible for the test value specified;
b) the tolerances on test quantities specified shall be observed by the testing station. Higher stresses exceeding those tolerance are permitted only with the consent of the manufacturer;
c) where, for any test quantity, no tolerance is given within this standard, or the standard to be applied, the type test shall be not less severe than specified. The upper stress limits are subject to the consent of the manufacturer.

Table E.1 – Tolerances on test quantities for type test

Subclause	Description of the test	Test quantity	Specified test value	Test tolerances / limits of test values	Reference to
7.2 up to 7.2.12	Dielectric tests				
7.2.7.2, 7.2.8.2, 7.2.12, 7.10.5	Power-frequency voltage tests	Test voltage (RMS value)	Rated short-duration power frequency withstand voltage	±1 %	IEC 60060-1:2010
		Frequency	–	45 Hz to 65 Hz	
		Wave shape	Peak value / RMS value = √2	±5 %	
7.2.7.3 and 7.2.8.4	Lightning impulse voltage tests	Peak value	Rated lightning impulse withstand voltage	±3 %	IEC 60060-1:2010
		Front time	1,2 µs	±30 %	
		Time to half-value	50 µs	±20 %	
7.2.8.3	Switching impulse voltage tests	Peak value	Rated switching impulse withstand voltage	±3 %	IEC 60060-1:2010
		Front time	250 µs	±20 %	
		Time to half-value	2 500 µs	±60 %	
7.3 and 7.9.1.1	Radio interference voltage tests	Test voltage		±1 %	
		Tune frequency of measurement circuit		Within +10 % of 0,5 MHz or between 0,5 MHz to 2 MHz	
7.4.4	Measurement of the resistance of circuits	DC test current, I_{DC}	–	50 A < I_{DC} ≤ rated continuous current , or −20 %, +0 % of I_r ≤ 50 A	
7.5	Continuous current tests	Ambient air velocity	–	≤ 0,5 m/s	
		Test current frequency	Rated frequency	−5 %, +2 %	
		Test current	Rated continuous current	−0 %, +2 % These limits shall be kept only for the last two hours of testing period	
		Ambient air temperature T_a	--	10 °C < T_a ≤ 40 °C	
7.6	Short-time withstand current and peak withstand current tests	Test frequency	Rated frequency	±10 % at the beginning of the test, −20 %, +10 % at the end	
		Peak current (in one of the outer phases)	Rated peak withstand current	−0 %, +5 %	

Subclause	Description of the test	Test quantity	Specified test value	Test tolerances / limits of test values	Reference to
		Average of AC component of three-phase test current	Rated short-time withstand current	See tolerances for I^2t in 7.6.3	7.6.3
		Ratio of AC component of test current in any phase versus average of the three phases	1	±10 %	
		Short-circuit current duration	Rated short-circuit duration	Maximum 5 s	7.6.3
		Value of I^2t	Value I^2t Derived from rated values short-time withstand current and duration.	−0 %, +10 %	
7.9.2.3	Oscillatory wave immunity test	Damped oscillatory wave tests	Test frequency 100 kHz, 1 MHz	±30 %	IEC 61000-4-18
7.10.3.3	Auxiliary contact rated short-time withstand current	Test current amplitude		−0 %, +5 %	
		Test current duration		−0 %, +10 %	
7.10.3.4	Auxiliary contact breaking capability	Test voltage amplitude		−0 %,+10 %	
		Test current amplitude		−0 %, +5 %	
		Circuit time constant		−0 %, +20 %	
7.10.4.2	Cold tests	Minimum and maximum ambient air temperature during tests	–	±3 K	IEC 60068-2-1: 2007
7.10.4.3	Dry heat test	Minimum and maximum ambient air temperature during tests	–	±3 K	IEC 60068-2-2: 2007
7.10.4.4	Cyclic humidity test	Minimum temperature of cycle		±3 K	IEC 60068-2-30: 2005
		Maximum temperature of cycle		± 2 K	
7.10.4.5	Vibration response and seismic tests				IEC 60255-21-1: 1988
7.11.1.3	Radiation instrument	Accuracy measurement of radiation		±25 %	
	Energy response	Accuracy measurement of energy		±15 %	

Annex F
(informative)

Information and technical requirements to be given with enquiries, tenders and orders

F.1 General

This annex provides a list of useful technical information items in a tabular form to be considered for possible exchange between user and supplier during contracting stage.

When in the table "supplier information" is mentioned, this means that only the supplier needs to deliver this information.

Attention should be paid to the fact that such table should be complemented with information and characteristics relevant for the type of switchgear and controlgear considered; see product standards.

F.2 Normal and special service conditions (refer to Clause 4)

		User requirements	Supplier proposals
Service condition	Indoor or outdoor		
Ambient air temperature: Minimum Maximum	 °C °C		
Solar radiation	W/m^2		
Altitude	m		
Pollution	Class		
Excessive dust or salt			
Ice coating	mm		
Wind	m/s		
Humidity	%		
Condensation or precipitation			
Vibration	Class		
Induced electromagnetic disturbance in auxiliary and control circuits	kV		

F.3 Ratings (refer to Clause 5)

		User requirements	Supplier proposals
Rated voltage for equipment (U_r)	kV		
Rated insulation levels phase to earth and between phases			
Rated short-duration power-frequency withstand voltage (U_d)	kV		
Rated switching impulse withstand voltage (U_s)	kV		
– phase to earth	kV		
– between phases	kV		
Rated lightning impulse withstand voltage (U_p)	kV		
Rated frequency (f_r)	Hz		
Rated continuous current (I_r)	A	According single line	
Rated short-time withstand current (I_k)	kA		
Rated peak withstand current (I_p)	kA		
Rated duration of short-circuit (t_k)	s		
Rated supply voltage of closing and opening devices and of auxiliary and control circuits (U_a)	V		
Rated supply frequency of closing and opening devices and of auxiliary circuits	Hz	DC or 50 or 60	

F.4 Design and construction (refer to Clause 6)

To be complemented with information provided by relevant product standards.

		User requirements	Supplier proposals
Number of phases	Three- or single-phase encapsulation		
Mass of the heaviest transport unit			
Mounting provisions			
Type of gas-pressure or liquid-pressure system			
Overall dimensions of the installation			
Description by name and category of the various compartments			
Rated filling level and minimum functional level			
Low- and high-pressure interlocking and monitoring devices			
Interlocking devices			
Degrees of protection			
Arrangement of the external connections			
Accessible sides			
Volume of liquid or mass of gas or liquid for the different compartments			
Facilities for transport and mounting			

		User requirements	Supplier proposals
Instructions for operation and maintenance			
Specification of gas or liquid condition			

F.5 System information

		User information
Nominal voltage of system	kV	
Highest voltage of system	kV	
Number of phases		
Type of system neutral earthing		Effectively or non-effectively

F.6 Documentation for enquiries and tenders

	User requirements	Supplier proposals
Scope of supply (training, technical and layout studies and requirements for co-operation with other parties)		
Single-line diagram		
General arrangement drawings of substation layout		
Provisions for transport and mounting to be given by the user		
Foundation loading	Supplier information	
Gas schematic diagrams	Supplier information	
List of type test reports	Supplier information	
List of recommended spare parts	Supplier information	

Annex G
(informative)

List of symbols

Description	Symbol	Subclause
Absolute leakage rate	F	3.6.6.4
Absolute leakage rate	F_{liq}	3.6.7.1
Alarm pressure (or density) for insulation and/or switching	p_{ae} (ρ_{ae})	3.6.5.3
Alarm pressure for operation (or density)	p_{am} (ρ_{am})	3.6.5.4
Filling pressure	p_r	7.8.2
Filling pressure (or density) for insulation and/or switching	p_{re} (ρ_{re})	3.6.5.1
Filling pressure (or density) for operation	p_{rm} (ρ_{rm})	3.6.5.2
Main circuit resistance measured before continuous current test	R_u	8.4
Measured pressure	p_m	7.8.2
Minimum functional pressure (or density) for insulation and/or switching	p_{me} (ρ_{me})	3.6.5.5
Minimum functional pressure for operation (or density)	p_{mm} (ρ_{mm})	3.6.5.6
Number of replenishments per day	N	3.6.6.8
Number of replenishments per day	N_{liq}	3.6.7.3
Partial voltage with respect to earth	U_f	7.2.6.3 b)
Permissible leakage rate	F_p	3.6.6.5
Permissible leakage rate	$F_{p(liq)}$	3.6.7.2
Pressure drop	Δp	3.6.6.9
Pressure drop	Δp_{liq}	3.6.7.4
Protection against ingress of water coding	IP	6.14.3
Protection of equipment against mechanical impact under normal service conditions coding	IK	6.14.4
Radio interference voltage test	RIV	7.3
Rated continuous current	I_r	5.5
Rated duration of short-circuit	t_k	5.8
Rated frequency	f_r	5.4
Rated lightning impulse withstand voltage	U_p	5.3
Rated peak withstand current	I_p	5.7
Rated short-duration power-frequency withstand voltage	U_d	5.3
Rated short-time withstand current	I_k	5.6
Rated supply voltage	U_a	5.9.2
Rated supply voltage of closing and opening devices and of auxiliary and control circuits	U_a	5.9
Rated switching impulse withstand voltage	U_s	5.3
Rated voltage	U_r	5.2
Relative leakage rate	F_{rel}	3.6.6.6
Time between replenishments	t_r	3.6.6.7
Total test voltage	U_t	7.2.6.3 b)

Annex H
(informative)

Electromagnetic compatibility on site

EMC site measurements are not type tests but may be performed in special situations:

– where it is deemed necessary to verify that actual stresses are covered by the EMC severity class of the auxiliary and control circuits;

– in order to evaluate the electromagnetic environment;

– in order to apply proper mitigation methods, if necessary;

– to record the electromagnetically induced voltages in auxiliary and control circuits, due to switching operations both in the main circuit and in the auxiliary and control circuits. It is not considered necessary to test all auxiliary and control circuits in a substation under consideration. A typical configuration should be chosen.

Measurement of the induced voltages should be made at representative ports in the interface between the auxiliary and control circuits and the surrounding network, for example, at the input terminals of control cubicles, without disconnection of the system. Instrumentation for recording induced voltages should be connected as outlined in IEC TR 60816 [71].

Switching operations should be carried out at normal operating voltage, both in the main circuit and in the auxiliary and control circuits. Induced voltages will vary statistically and thus a representative number of both making and breaking operations should be chosen, with random operating instants.

The switching operations in the main circuit are to be made under no-load conditions. The tests will thus include the switching of parts of the substation but no switching of load currents and no fault currents.

The making operations in the main circuit should be performed with trapped charge on the load side corresponding to normal operating voltage. This condition may be difficult to obtain at testing, and, as an alternative, the test procedure may be as follows:

– discharge the load side before the making operation, to assure that the trapped charge is zero;

– multiply recorded voltage values at the making operation by 2, in order to simulate the case with trapped charge on the load side.

The switching device in the primary system shall preferably be operated at rated pressure and auxiliary voltage.

NOTE 1 The most severe cases, with regard to induced voltages, will normally occur when only a small part of a substation is switched.

NOTE 2 The most severe electromagnetic disturbances are expected to occur at disconnector switching, especially for GIS installations.

The recorded or calculated peak value of induced common-mode voltage, due to switching in the main circuit, should not exceed 1,6 kV for interfaces of the auxiliary and control circuits.

Annex I
(informative)

List of notes concerning certain countries

With reference to Annex SC of *IEC/ISO Directives Supplement – Procedures specific to IEC*, (2016), an IEC National Committee may provide a statement to be included in an International Standard, informing the user of the standard of particular conditions existing in its country.

Clause	Text
6.14.1	NOTE In addition to IEC 60529 enclosures are to be designed to prevent unauthorized access by provided provisions for locking or requiring a special tool to open doors. Doors, hinges and access panels are not externally removable (US).
6.14.2	NOTE The minimum default code is IP2XB (US)
7.2.12	NOTE The required test voltage for disconnectors and switch disconnectors of all rated voltages is 100 % of the tabulated voltage in columns (3) of Tables 1 or 2 and 3 or 4 (Canada).

Annex J
(informative)

Extension of validity of type tests

J.1 General

An individual type test need not be repeated in some situations e.g.:

– for a change of construction detail, if the manufacturer can establish that this change does not influence the result of that individual type test;

– for a change in the installation instructions, provided that the test conditions are not invalidated by the new instructions (e.g. see J.2);

– for covering other values of ratings for the same switchgear and controlgear, if these new ratings are covered by the tests already performed (e.g. see J.3 or when lower performances are requested).

Particular examples where extension of a type test may be used to validate design changes or other similar equipment, without repeating type tests, are given in the following subclauses. It should be noted that supporting evidence should be provided to validate such extensions of type tests.

More details may be given in the product standards and/or technical reports, e.g. IEC TR 62271-307 [72].

J.2 Dielectric tests

For non-enclosed conductors, the dielectric tests performed cover other dispositions having equal or higher clearances to surroundings (e.g. height above ground) and between conductors, if the insulating materials and shapes of conductors and insulators are the same.

J.3 Short-time withstand current tests

Short-time withstand current and peak withstand current tests performed at 50 Hz or 60 Hz, using a peak factor of 2,6, cover both frequencies for networks having a DC time constant of 45 ms or smaller.

Short-time withstand current and peak withstand current tests performed at 50 Hz or 60 Hz using a peak factor of 2,7, cover both frequencies for any DC time constants.

J.4 Continuous current test

A test performed on a single pole, or on a single unit, covers larger arrangements (i.e. three pole or multiple units) provided that the influence with other poles or other units is negligible, as it is generally the case for non-enclosed switchgear and controlgear; this provision is applicable, for instance, to some outdoor transmission devices.

As stated in 7.5.3.1:

– for switchgear and controlgear rated for both frequencies at 50 Hz and 60 Hz and having no ferrous components adjacent to the current-carrying parts, test can be performed at 50 Hz and cover both frequencies provided that the temperature-rise values recorded during the tests at 50 Hz do not exceed 95 % of the maximum permissible values;

– tests performed at 60 Hz cover both frequencies.

J.5 Electromagnetic immunity test on auxiliary and control circuits

Subassemblies may be positioned in different places within the auxiliary and control circuits, without invalidating the type test of the complete system, provided that the overall wiring length and the number of individual wires connecting the subassembly to the auxiliary and control circuits is not greater than in the tested system.

Interchangeable subassemblies may be replaced by similar subassemblies, without invalidating the original type test, provided that:

– rules for design and installation given in IEC 61000-6-5 are followed;
– type tests have been performed on the most complete subassembly applicable to the type of switchgear and controlgear;
– manufacturer's design rules are the same as for the type-tested subassembly.

J.6 Environmental tests on auxiliary and control circuits

Environmental tests on auxiliary and control circuits need not be repeated if performance requirements are validated during environmental tests on a whole switchgear and controlgear.

Parts, or pieces of equipment, of auxiliary and control circuits validated in a given arrangement are validated also when used in a different arrangement of auxiliary and control circuits belonging to the same range of switchgear and controlgear equipment.

Tests performed with a given supply voltage for auxiliary and control circuit cover similar auxiliary and control circuits designed for lower supply voltages.

Annex K
(informative)

Exposure to pollution

K.1 General

The quality of ambient air with respect to pollution by dust, smoke, corrosive and/or flammable gases, vapours, or salt is a consideration under normal and special service conditions (refer to Clause 4 of this document). This annex defines levels of pollution as well as recommendations for the minimum specific creepage distance across external insulation.

K.2 Pollution levels

For purposes of standardization, the levels of pollution, very light, light and medium, are qualitatively defined. The qualitative examples given in Table K.1 are approximate descriptions of some typical corresponding environments. Other more extreme environmental conditions may merit further consideration, e.g., snow and ice in heavy pollution, heavy rain, and arid areas. For these special conditions, reference is given to IEC TS 60815-1:2008, IEC TS 60815-2:2008 and IEC TS 60815-3:2008.

K.3 Minimum requirements for switchgear

The minimum creepage distance expressed as a specific creepage in mm/kV are for the normal service conditions of atmospheric contamination and altitudes up to 1 000 m. This minimum creepage provides generally satisfactory service operation under these conditions.

For each level of pollution described in Table K.1, the corresponding minimum recommended nominal unified specific creepage distance (USCD) in mm/kV across the insulator is given in Table K.2.

NOTE The information in Table K.1 is adapted from IEC TS 60815-1:2008; the values in Table K.2 are taken from IEC TS 60815-2:2008.

Table K.1 – Environmental examples by site pollution severity (SPS) class

SPS Class	Example of typical environments
Very light	Example 1: > 50 km[a] from any sea, desert, or open dry land > 10 km from man-made pollution sources [b] Within a shorter distance than mentioned above of pollution sources, but: • prevailing wind not directly from these pollution sources • and/or with regular monthly rain washing
Light	Example 2: 10 km to 50 km[a] from the sea, a desert, or open dry land 5 km to 10 km from man-made pollution sources [b] Within a shorter distance than example 1 from pollution sources, but: • prevailing wind not directly from these pollution sources • and/or with regular monthly rain washing
Medium	Example 3: 3 km to 10 km[c] from the sea, a desert, or open dry land 1 km to 5 km from man-made pollution sources [b] Within a shorter distance than mentioned above of pollution sources, but: • prevailing wind not directly from these pollution sources • and/or with regular monthly rain washing Example 4: Further away from pollution sources than mentioned in example 3, but: • dense fog (or drizzle) often occurs after a long (several weeks or months) dry pollution accumulation season • and/or heavy, high conductivity rain occurs • and/or there is a high non-soluble deposit level (refer to IEC TS 60815-1:2008)
Heavy and Very heavy	Refer to IEC TS 60815-1:2008.

[a] During a storm, the ESDD level at such a distance from the sea may reach a much higher level.

[b] The presence of a major city will have an influence over a longer distance, i.e. the distance specified for sea, desert and dry land.

[c] Depending on the topography of the coastal area and the wind intensity.

Table K.2 – Minimum nominal specific creepage distance by pollution level

SPS class	Minimum recommended nominal unified specific creepage distance (USCD) [a] mm/kV
Very light	22
Light	27,8
Medium	34,7
Heavy and Very heavy	Refer to IEC TS 60815-1:2008, IEC TS 60815-2:2008, and IEC TS 60815-3:2008

[a] The unified specific creepage distance (USCD) is the creepage distance of an insulator divided by the RMS value of the highest operating voltage across the insulator.

[SOURCE: IEC TS 60815-2:2008, 3.2]

Annex A
(informative)

Mechanical forces applied on the flange of the cable connection enclosure

A.1 General

The switchgear manufacturer should coordinate with the cable manufacturer on the cable system design. For both single-phase and three-phase connections, additional forces and movements from the switchgear and the cable system can be experienced due to temperature variations in service. These forces can act on both switchgear and cable system and depend largely on the switchgear layout, termination installation, cable design and the methods of mechanical support of the switchgear and cable system. The design of any support structure should take into account these forces and movements.

A.2 Recommendation when connecting cable systems to switchgear

The switchgear system should be considered as a system allowing limited moving tolerances during all occurring operation conditions concerning its connection to the cable system. The cable system should be considered as a system allowing limited movement tolerances during service concerning its connection to the switchgear. The switchgear designer should specify the movement tolerances, forces and loads covering all operational conditions, and document them in the relevant arrangement drawings. These data should be taken into account by the cable system designer.

The switchgear supplier should provide the supporting structure for the cable connection enclosure comprising a sliding point, to allow movement of the cable connection enclosure, to allow switchgear expansion or contraction due to the temperature variations.

The supporting structure of a cable connection enclosure of the switchgear, should be designed where possible, in such a way, that an adjacent cable centring fixation point can be added to that structure and there will be no relative movement between the cable connection enclosure and the centring fixation point.

A cable connection enclosure may need to be engineered as a fixed point. This occurs in the case of an installation of e.g. a high pressure oil cable system which due to its design is not able to absorb thermal displacement caused by the switchgear. In this case the switchgear manufacturer has to absorb the thermal displacement by appropriate measures, e.g. compensating equipment. It is the responsibility of the user to inform the switchgear manufacturer about the installation of such a cable system together with the inquiry.

It is also particularly important that the support for the switchgear housings should neither be affixed to the insulator collar and/or clamping flange (parts 9 and 11 of Figures 2 or 4), nor to the flange of the cable connection enclosure (part 6 in Figures 2 or 4).

NOTE 1 The assembly of parts 6 and 11 in Figures 2 or 4 has the purpose of a tight gas connection and is reserved for the loads originated by the cable termination and attached cable connection.

Preferably part 6 in Figure 2 and 4 should be reserved for the fixing of an anti-kink construction (bending protection), if needed, having the task to avoid bending forces and axial forces onto the sealing end, and fixing the position of the cable in relation to the cable connection enclosure flange. Attention should be brought to the type of ground connection to the cable sheath, in case of insulated screen the anti-kink centring should not short circuit this insulation. Snaking of the cable may be performed to lower the conductor thrust on the insulator. The supply of an anti-kink construction is the responsibility of the cable system supplier.

In addition to the load arising from maximum operating gas pressure specified in 6.103 the flange of the cable connection enclosure (part 6 in Figures 2 or 4) attached to the cable termination is subject to the following normal and exceptional forces during service:

– forces originated from the transversal movement of the cable connection enclosure due to temperature variations of the switchgear;
– part of weight of the attached cable termination, the potential anti-kink construction and part of the weight of the cable system in dependency of the rated voltage and cable conductor type;
– short circuit forces between the attached cables;
– seismic forces originating from the cable termination, cable connection and supporting structures of the cable system or parts thereof, if applicable.

Forces during normal operation arising as described above have to be limited by appropriate measures to the values listed in Table A.1.

Forces originating from the expansion or contraction of the cable, due to the temperature variation, which are transferred to the cable connection enclosure of the switchgear should be minimized by the use of appropriate means like fixing and snaking of the cables. However, these forces result in the simultaneous application of:

– a bending moment M_0;
– a shearing force F_t;
– a tensile or compressive force F_a

at the cable connection enclosure (part 6 of Figures 2 or 4). The cable connection enclosure flange should be capable of withstanding the values of M_0, F_t and F_a specified in Table A.1, and it should be the responsibility of the cable system designer to ensure that these values are not exceeded.

In case of exceptional loads, such as a short circuit or seismic, the total load should not exceed a maximum of 200 % of the given normal loads in Table A.1.

NOTE 2 The requirement concerning the ratio between normal and exceptional load is in accordance with the ratio of the service and cantilever test loads in IEC 60137:2017, Table 1 [1].

Table A.1 – Moment and forces applied on the flange of the cable connection enclosure attached to the cable termination during normal operation

Rated voltage U_{rm} (kV)	Tensile or compressive force F_a (kN)	Shearing force F_t (kN)	Bending moment M_0 (kNm)
> 52 to 100	1,0	1,0	1,2
123 to 170	1,5	1,5	1,8
245 to 300	2,5	2,5	3,0
362 to 550	4,5	4,5	5,4
NOTE 1 F_a acts in the axial direction of the cable, F_t in transverse direction. NOTE 2 M_0 results from F_t acting in a distance of 1,2 m from the lower flange of the cable connection enclosure (part 6). NOTE 3 Forces in Table A.1 are per cable and apply for single-phase and three-phase connections.			

In order to ensure that the requirements mentioned above in relation to normal and exceptional forces and loads are in no case exceeded, design coordination between the GIS manufacturer and the cable system provider is required.

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[61] IEC 60309-1, *Plugs, socket-outlets and couplers for industrial purposes – Part 1: General requirements*

[62] IEC 60309-2, *Plugs, socket-outlets and couplers for industrial purposes – Part 2: Dimensional interchangeability requirements for pin and contact-tube accessories*

[63] IEC TR 60083, *Plugs and socket-outlets for domestic and similar general use standardized in member countries of IEC*

[64] IEC 60130 (all parts), *Connectors for frequencies below 3 MHz*

[65] IEC 62326-1, *Printed boards – Part 1: Generic specification*

[66] IEC 60393-1, *Potentiometers for use in electronic equipment – Part 1: Generic specification*

[67] IEC 60115-4 (all parts), *Fixed resistors for use in electronic equipment – Part 4: Sectional specification: Fixed power resistors*

[68] IEC 60081, *Double-capped fluorescent lamps – Performance specifications*

[69] IEC 60064, *Tungsten filament lamps for domestic and similar general lighting purposes – Performance requirements*

[70] IEC TR 62063, *High-voltage switchgear and controlgear – The use of electronic and associated technologies in auxiliary equipment of switchgear and controlgear*

[71] IEC TR 60816:1984, *Guide on methods of measurement of short duration transients on low-voltage power and signal lines*

[72] IEC TR 62271-307, *High-voltage switchgear and controlgear – Part 307: Guidance for the extension of validity of type tests of AC metal and solid-insulation enclosed switchgear and controlgear for rated voltages above 1 kV and up to and including 52 kV*

[73] IEEE C37.100.1, *IEEE Standard of Common Requirements for High Voltage Power Switchgear Rated Above 1000 V*

[74] IEC 60059, *IEC standard current ratings*

[75] IEC 60068-2 (all parts), *Environmental testing – Part 2: Tests*

[1] IEC 60137:2017, *Insulated bushings for alternating voltages above 1 000 V*

[2] IEC 62271-207, *High-voltage switchgear and controlgear – Part 207: Seismic qualification for gas-insulated switchgear assemblies for rated voltages above 52 kV*

[3] IEEE Std 1300:2011, *IEEE Guide for Cable Connections for Gas-Insulated Substations*

[4] CIGRE brochure 89:1995, *Accessories for HV Extruded Cables*

[5] CIGRE TB 44:1993, *Earthing of GIS – An Application Guide*

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High-voltage switchgear and controlgear – Part 209: Cable connections for gas-insulated metal-enclosed switchgear for rated voltages above 52 kV – Fluid-filled and extruded insulation cables – Fluid-filled and dry-type cable-terminations

Appareillage à haute tension – Partie 209: Raccordement de câbles pour appareillage sous enveloppe métallique à isolation gazeuse de tension assignée supérieure à 52 kV – Câbles remplis d'un fluide ou à isolation extrudée – Extrémité de câble de type sec ou remplie d'un fluide

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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FOREWORD

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This consolidated version of the official IEC Standard and its amendment has been prepared for user convenience.

IEC 62271-209 edition 2.1 contains the second edition (2019-02) [documents 17C/696/FDIS and 17C/701/RVD] and its amendment 1 (2022-03) [documents 17C/833/FDIS and 17C/841/RVD].

In this Redline version, a vertical line in the margin shows where the technical content is modified by amendment 1. Additions are in green text, deletions are in strikethrough red text. A separate Final version with all changes accepted is available in this publication.

International Standard IEC 62271-209 has been prepared by subcommittee 17C: Assemblies, of IEC technical committee 17: High-voltage switchgear and controlgear.

This second edition constitutes a technical revision.

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

a) New numbering in accordance with ISO/IEC directives, Part 2 (2016) and to IEC 62271-1:2017;
b) Clause 3: addition of a definition for plug-in cable termination, filling pressure and minimum function pressure for insulation;
c) Clause 7: An additional dielectric type test for plug-in cable termination was added; also a pressure type test as well as a leak rate test on the insulator of a cable termination was implemented;
d) Clause 12: New clause about safety practices;
e) Clause 13: New clause about influence of the product on the environment;
f) New informative Annex A: Mechanical forces applied on the flange of the cable connection enclosure.

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

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

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

The committee has decided that the contents of the base publication and its amendment will remain unchanged until the stability date indicated on the IEC web site under webstore.iec.ch in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

INTRODUCTION TO Amendment 1

This amendment includes the following modifications:

a) In accordance with the decision taken at IEC Plenary Meeting October 2019 in Shanghai (17C/Shanghai/Sec07) Subclause 6.103, Figure 1 and Figure 2 have been modified;

b) The CDV was modified in accordance with the above-mentioned documents and based on the decision taken at the virtual IEC Plenary Meeting in October 2021 (17C/823/RM).

NOTE CIGRE has published TB 784 “Standard design of a common, dry type plug-in interface for GIS and power cables up to 145 kV describing the basis for further standardisation of such a common interface. The matter will be dealt with during the next revision of IEC 62271-209.

HIGH-VOLTAGE SWITCHGEAR AND CONTROLGEAR –

Part 209: Cable connections for gas-insulated metal-enclosed switchgear for rated voltages above 52 kV – Fluid-filled and extruded insulation cables – Fluid-filled and dry-type cable terminations

1 Scope

This part of IEC 62271 covers the connection assembly of fluid-filled and extruded cables to gas-insulated metal enclosed switchgear (GIS), in single- or three-phase arrangements where the cable terminations are fluid-filled or dry-type and there is a separating insulating barrier between the cable insulation and the gas insulation of the switchgear.

The purpose of this document is to establish electrical and mechanical interchangeability between cable terminations and the gas-insulated metal-enclosed switchgear and to determine the limits of supply. It complements and amends, if applicable, the relevant IEC standards. For the purpose of this document the term "switchgear" is used for "gas-insulated metal enclosed switchgear".

It does not cover directly immersed cable terminations, as described in CIGRE brochure 89 [4][1].

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, *IEC standard voltages*

IEC 60068-2-17:1994, *Basic environmental testing procedures – Part 2-17:Tests – Test Q: Sealing*

IEC 60141 (all parts), *Tests on oil-filled and gas-pressure cables and their accessories*

IEC 60376, *Specification of technical grade sulphur hexafluoride (SF_6) and complementary gases to be used in its mixtures for use in electrical equipment*

IEC 60480, *Guidelines for the checking and treatment of sulphur hexafluoride (SF_6) taken from electrical equipment and specification for its re-use*

IEC 60840, *Power cables with extruded insulation and their accessories for rated voltages above 30 kV (U_m = 36 kV) up to 150 kV (U_m = 170 kV) – Test methods and requirements*

IEC 62067, *Power cables with extruded insulation and their accessories for rated voltages above 150 kV (U_m = 170 kV) up to 500 kV (U_m = 550 kV) – Test methods and requirements*

[1] Numbers in square brackets refer to the Bibliography.

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

IEC 62271-203:2011, *High-voltage switchgear and controlgear – Part 203:Gas-insulated metal-enclosed switchgear for rated voltages above 52 kV*

3 Terms and definitions

For the purposes of this document, the following terms and definitions 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

3.1
cable termination
equipment fitted to the end of a cable to ensure electrical connection with other parts of the system and to maintain the insulation up to the point of connection

3.1.1
fluid-filled cable termination
cable termination which comprises a separating insulating barrier between the cable insulation and the gas insulation of switchgear, including a fluid

3.1.2
dry-type cable termination
cable termination which comprises an elastomeric electrical stress control component in direct contact with a separating insulating barrier (insulator) between the cable insulation and the gas insulation of the switchgear, not requiring any fluid

3.2
main circuit end terminal
part of the main circuit of a gas-insulated metal enclosed switchgear forming part of the connection interface

3.3
cable connection enclosure
part of the gas-insulated metal-enclosed switchgear which houses the cable termination and the main circuit end terminal

3.4
cable connection assembly
combination of a cable termination, a cable connection enclosure and a main circuit end terminal, which mechanically and electrically connects the cable to the gas-insulated metal enclosed switchgear

3.5
plug-in cable termination
cable termination where cable/stress cone assembly can be engaged into the insulator assembly that is already installed into switchgear enclosure

3.6
design pressure
pressure used to determine the design of the enclosure and the components of the cable termination subjected to that pressure

Note 1 to entry: It is at least equal to the maximum pressure in the enclosure at the highest temperature that the gas used for insulation can reach under specified maximum service conditions.

3.7
fluid
liquid or gas for insulation purposes

3.8
cable system
cable with installed accessories

3.9
filling pressure p_{re} for insulation
filling density ρ_{re} for insulation
pressure (in Pa), for insulation, referred to the standard atmospheric air conditions of 20 °C and 101,3 kPa, which may be expressed in relative or absolute terms (or density), to which the assembly is filled before being put into service

3.10
minimum functional pressure p_{me} for insulation
minimum functional density ρ_{me} for insulation
pressure (in Pa), for insulation, referred to the standard atmospheric air conditions of 20 °C and 101,3 kPa, which may be expressed in relative or absolute terms (or density), at which and above which the characteristics of the switchgear-cable connection are maintained and at which replenishment becomes necessary

4 Normal and special service conditions

4.1 General

Clause 2 of IEC 62271-203:2011 is applicable.

4.2 Normal service conditions

Subclause 2.1 of IEC 62271-203:2011 is applicable.

4.3 Special service conditions

Subclause 2.2 of IEC 62271-203:2011 is applicable.

5 Ratings

5.1 General

When dimensioning the cable connection assembly, the following rated values shall apply:

a) rated voltage of the equipment of the cable connection (U_{rm});
b) rated insulation level (U_p, U_d and U_s where applicable);
c) rated frequency (f_r)
d) rated continuous current (I_r);
e) rated short-time withstand current (I_k);
f) rated peak withstand current (I_p);
g) rated duration of short circuit (t_k).

5.2 Rated voltage of the equipment of the cable connection (U_{rm})

The rated voltage for the equipment of the cable connection (U_{rm}) is equal to the lower of the values U_m for the cable system and U_r for the gas-insulated metal-enclosed switchgear and shall be selected from the following standard values:

72,5 kV – 100 kV – 123 kV – 145 kV – 170 kV – 245 kV – 300 kV – 362 kV – 420 kV – 550 kV

NOTE 1 Values above U_r = 550 kV are not considered.

NOTE 2 U_m = 100 kV is not defined in IEC 60840.

5.3 Rated insulation level (U_d, U_p, U_s)

The rated insulation level for the cable connection assembly shall be selected from the values given in IEC 60038 as well as IEC 62271-203.

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)

The connection interface of the main circuit shown in Figures 2 and 3 for fluid-filled cable terminations and Figures 4 and 5 for dry-type cable terminations is applicable at rated continuous currents up to 3 150 A.

The connection interface shall be designed so that at a current equal to the cable rated current corresponding to a maximum temperature of 90 °C, no heat transfer from the switchgear main circuit end terminal to the cable termination will occur.

NOTE As the maximum conductor temperature for cables is limited by the maximum operating temperature for the insulation, there are certain cable dielectrics which cannot withstand the maximum temperature specified for gas-insulated metal-enclosed switchgear if there is heat transfer across the connection interface to the cable terminations.

For cases when the above design requirement of 90 °C at rated continuous current of the cable system cannot be allowed because of cable design limitations, the manufacturer of the switchgear should provide the necessary data on temperature rise of the main circuit end terminal and of the insulating gas as a function of current.

5.6 Rated short-time withstand current (I_k)

Short-time currents of short circuit shall refer to the levels provided by the cable system, not exceeding the values defined for the switchgear in line with IEC 62271-1.

5.7 Rated peak withstand current (I_p)

Peak withstand currents of short circuit shall refer to the levels provided by the cable system, not exceeding the values defined for the switchgear in line with IEC 62271-1.

5.8 Rated duration of short circuit (t_k)

The duration of short circuit shall refer to the levels provided by the cable system, not exceeding the values given in IEC 62271-1.

6 Design and construction

6.1 Gas and vacuum tightness

Subclause 6.16 of IEC 62271-1:2017 is applicable with the following addition:

For conditions up to the maximum occurring gas operating pressure, the cable termination shall prevent insulating gas from the switchgear diffusing into the interior of the cable termination and into the cable. The cable termination shall prevent insulating fluid from the cable termination entering the switchgear. The insulator (part 4 in Figures 2 and 4) shall be capable of withstanding the vacuum conditions when the cable connection enclosure is evacuated, as part of the gas filling process.

In the case of a gas insulated cable or a gas insulated termination, the gas compartment of the cable or of the gas insulated termination shall be treated independently from the switchgear with respect to tightness.

6.101 Limits of supply

6.101.1 General

The limits of supply of gas-insulated metal-enclosed switchgear and the cable termination shall be in accordance with Figure 2 for fluid-filled cable terminations and Figure 4 for dry-type cable terminations.

6.101.2 Over-voltage protection and earthing

It is necessary to have either a direct low resistance connection or an insulated section bridged by non-linear resistors between part 6 and part 13 of Figure 2 for fluid-filled cable terminations and Figure 4 for dry-type cable terminations. To enable suitable connections to be made to the switchgear, for the purposes of this direct connection or installation of any sheath voltage limiting device, the switchgear manufacturer shall provide four connection points per phase (evenly spaced around each phase) each comprising an M12 threaded hole of minimum 21 mm length (for all voltage levels). The position of these 4 connection points is different from the mechanical connection points used for fixing the cable termination insulator. The number of connection points used shall be determined by the cable system designer.

Where applicable, the number and characteristics of the non-linear resistors shall be determined by the cable system designer, and they shall be supplied by the cable termination manufacturer, taking into consideration the requirements of the user and the switchgear manufacturer. Reference is made to CIGRE TB 44, 1993 [5], as well as to IEEE 1300-2011, Clause 11 [3].

In addition, the installation design of the area around the cable termination shall take into account the space required to install any non-linear resistors, including adequate clearances to earth.

For three phases in one enclosure arrangements special clarification between the GIS manufacturer, the cable termination manufacturer and the cable system designer may be necessary because of limited space between the three phases.

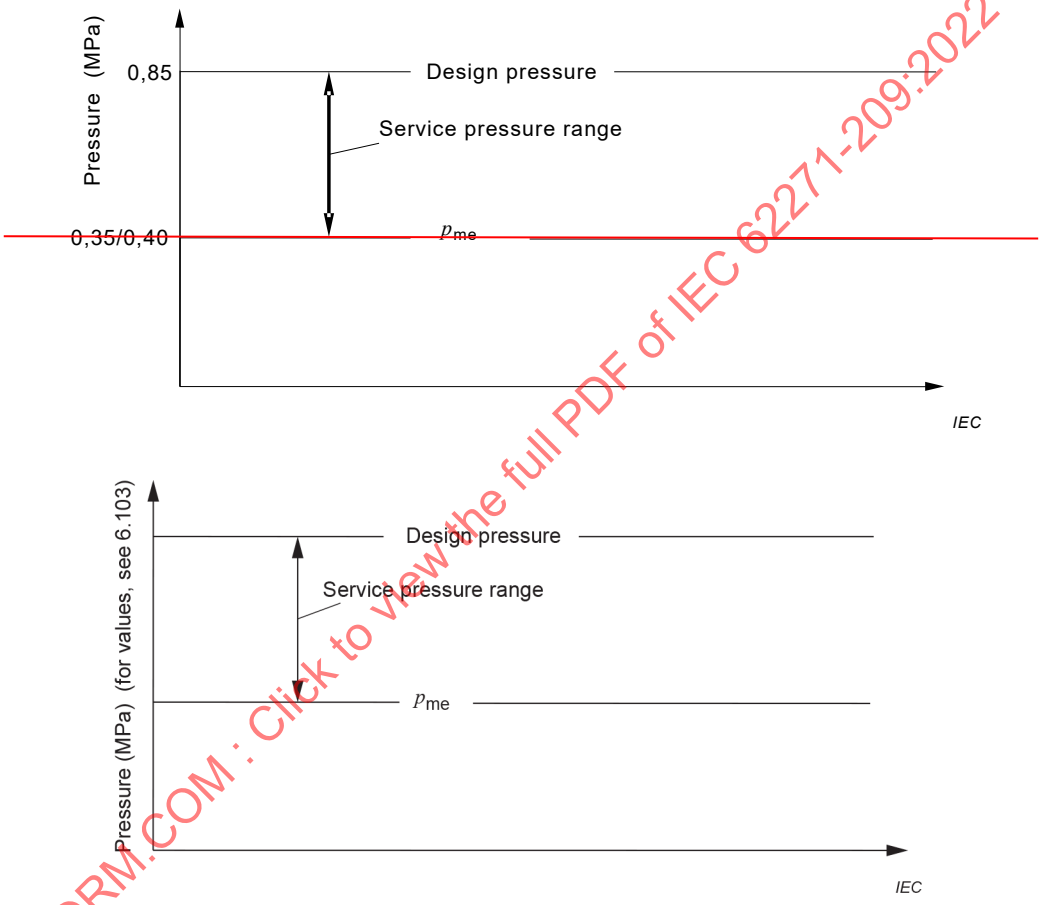
The overvoltage protection elements, i.e. connections between part 6 and part 13 of Figure 2 for fluid-filled cable terminations and Figure 4 for dry-type cable terminations as described above, are not meant to serve as the cable system grounding connection.

Earthing of enclosures shall be in accordance with the relevant subclause of IEC 62271-203:2011.

6.102 Filling pressure of insulating gas in the cable connection enclosure

If SF_6 is used as the insulating gas, the minimum functional pressure for insulation p_{me} used to determine the design of the cable termination insulation shall not exceed p_{me} = 0,35 MPa (absolute) at 20 °C for maximum rated voltages up to 300 kV. For maximum rated voltages exceeding 300 kV the minimum functional pressure for insulation p_{me} used to determine the design of the cable termination insulation shall not exceed p_{me} = 0,4 MPa (absolute) at 20°C (see Figure 1).

The filling pressure p_{re} of insulating gas is assigned by the switchgear manufacturer but shall in no case be lower than p_{me}. The service pressure is in no case higher than the design pressure as per 6.103.



p_{me} minimal functional pressure for insulation depending on rated voltage

Figure 1 – Operating pressure of the ~~SF_6~~ gas insulation in the cable connection enclosure

If a gas other than SF_6 or a gas mixture is used, the minimum functional pressure shall be chosen to provide the same dielectric performance as in case of SF_6. The minimum functional pressure shall be below the maximum service pressure and design pressure of the enclosure as per 6.103.

6.103 Pressure withstand requirements

The design pressure for the outside of the cable termination is ~~0,85 MPa (absolute) at 20°C independent from the GIS design pressure applied~~ determined by the particular GIS design around the GIS/cable interface. Typical maximum gas pressures in service are up to 1,1 MPa (absolute) for SF_6 and up to 1,5 MPa (absolute) for other gases and gas mixtures.

The particular pressure withstand requirements coming from the specific gas and GIS design shall be thoroughly coordinated between GIS and cable termination manufacturer as well as the user.

NOTE Due to the lower service current of a HV-cable connection than the rated current of a GIS, the related temperature and pressure rise within the cable compartment can be lower. The design pressure of the GIS could be higher than the design pressure of the cable termination.

6.104 Mechanical forces on cable terminations

The manufacturer of the cable termination in a three-phase connection shall take into account the total dynamic forces generated during short circuit conditions. These forces consist of those generated within the cable termination and those coming from the main circuit of the switchgear. The maximum additional force applied from the switchgear to the connection interface (Figures 2 or 4) transversely and then being transferred from the main circuit end terminal shall not exceed 5 kN for a three phase arrangement. For single-phase connections, the maximum additional force applied from the switchgear to the connection interface (Figures 2 or 4) transversely and then being transferred from the main circuit end terminal shall not exceed 2 kN. It is the responsibility of the manufacturer of the switchgear to ensure that the specified forces are not exceeded or to agree with the cable termination manufacturer that the cable termination shall withstand the higher forces.

For both single-phase and three-phase connections, additional forces and movements from the switchgear can be experienced due to temperature variations and vibrations in service. These forces can act on both switchgear and cable termination and depend largely on the switchgear layout, termination installation, cable design and the methods of mechanical support. The design of any support structure shall take into account these forces and movements. It is particularly important that the support for the switchgear shall not be affixed to the insulator collar and/or clamping flange, parts 9 and 11 of Figures 2 or 4. Further information regarding mechanical forces on the flanges of the cable connection enclosure are given in Annex A.

For seismic requirements, the switchgear manufacturer carries out a seismic calculation in order to identify the location of mechanical reinforcements; reference is made to IEC 62271-207 [2].

6.105 Switchgear connection interface and cable termination connection interface

The normal current-carrying contact surfaces of the switchgear and cable termination connection interface (refer to parts 2 and 3 of Figures 2 and 4) shall be silver coated or copper coated or non-coated solid copper.

7 Type tests

7.1 General

For type tests as per IEC 62271-1:2017, 7.1 applies. If SF_6 is used, technical grade SF_6 in accordance with IEC 60376 or used SF_6 in accordance with IEC 60480 shall be used.

7.2 Electrical type tests of cable terminations

7.2.1 General

The electric type tests of the cable termination shall be carried out according to the electrical type tests defined in IEC 60141 (all parts) or IEC 60840 or IEC 62067 as relevant for the cable design. Where applicable the insulator shall be tested to 7.2.4.

The cable termination shall be installed in an enclosure as per 7.2.2, filled with insulating gas at the pressure not exceeding p_{me}+0,02 MPa with filling pressure specified in 6.102.

The design of the main circuit end terminal (part 1 in Figures 2 or 4 respectively) used in the test as connection to part 3 of the cable connection assembly shall comply with Figures 2 and 4 respectively of this document.

7.2.2 Electrical type test of cable terminations in a single-phase enclosure

The cable termination is surrounded by a metal cylinder connected to earth, the maximum internal diameter is equal to d_5 for the four standard sizes of cable connection enclosure (d_5 in Figure 3 for fluid-filled cable terminations and Figure 5 for dry-type cable terminations). The minimum length of the metal cylinder shall be in accordance with the dimension l_5 given in Figures 3 and 5.

7.2.3 Electrical type test of cable termination in a three-phase enclosure

The single-phase test arrangement using the single-phase cable connection enclosure from the switchgear covers the test requirements of the cable termination in a three-phase enclosure as it imposes a more severe dielectric stress to the test object. It is therefore the referenced type test arrangement.

7.2.4 Additional electrical type tests on the insulator to be installed by switchgear manufacturer (plug in cable termination)

In some applications the termination insulator is installed in the switchgear enclosure by the switchgear manufacturer and is consequently subject to routine and on site test procedures applicable to the switchgear. In order to cover this application the following test shall be carried out.

The insulator shall be installed as specified by the cable termination manufacturer in order to cover later routine test at the switchgear manufacturer's works and on site tests. Because the cable will not be fitted to the termination, any special devices required shall be fitted on the cable side of the insulator. Such devices shall be provided by the cable termination supplier. The test shall be done at ambient temperature (20 ± 15) °C. Test voltages shall be applied as specified in Table 1:

Table 1 – Test voltages for additional electrical type tests according to 7.2.4

Rated voltage of the equipment of cable connection	**Power-frequency voltage tests** U_d kV (RMS value)		**Switching impulse withstand voltage** U_{ss} kV (peak value)	**Lightning impulse withstand voltage** U_{ps} kV (peak value)
U_{rm} kV (RMS value) (NOTE 1)	Phase-to-earth withstand voltage test (t = 1 min) IEC 62271-203:2011 Cl. 7.1.101 (NOTE 2)	Test voltage for PD measurement $U_{pd\text{-}test}$ (>1 min) IEC 62271-203:2011, 7.1.102 (NOTE 2)	Phase-to-earth IEC 62271-203:2011, 10.2.101.2.4 (NOTE 3)	Phase-to-earth IEC 62271-203:2011, 10.2.101.2.4 (NOTE 3)
(1)	(2)	(3)	(4)	(5)
72,5	140	1,2 U_r	-	260
100	185	1,2 U_r	-	360
123	230	1,2 U_r	-	440
145	275	1,2 U_r	-	520
170	325	1,2 U_r	-	600
245	460	1,2 U_r	-	840
300	460	1,2 U_r	680	840
362	520	1,2 U_r	760	940
420	650	1,2 U_r	840	1 140
550	710	1,2 U_r	940	1 240

NOTE 1 The rated voltage for equipment U_{rm} applies as per 5.2.

NOTE 2 The AC type test voltages cover the switchgear routine test, which the insulator can be subjected to.

NOTE 3 The impulse voltage type tests cover the switchgear on site test, which the insulator can be subjected to.

For further details and test procedure regarding dielectric tests on the insulator, reference is made in Table 1 to the applicable clauses of IEC 62271-203:2011.

7.3 Pressure test on the insulator of a cable termination

The insulator shall be secured in exactly the same manner as in service. The test shall be carried out at ambient temperature (20 ± 15) °C. Hydraulic pressure shall be applied to the switchgear side of the insulator with the cable side open to atmosphere. The pressure shall be increased at a rate of not more than 0,4 MPa/min until it reaches three times the design pressure (e.g. design pressure of 0,85 MPa absolute leads to a test pressure of 3 x 0,75 MPa = 2,25 MPa relative), which shall be held for 1 min.

7.4 Leak rate type test on the insulator of a cable termination

The test shall be performed at ambient temperature (20 ± 15) °C on an insulator of a cable termination installed in a suitable chamber. The insulator shall be installed in a manner close to the service conditions. The test shall be carried out in accordance with IEC 60068-2-17:1994, Clause 8 (the test method Qm is the preferred method to determine the relative leakage rate).

The measured leak rate shall not exceed 10^{-7} Pa x m^3/s at minimal functional pressure for insulation p_{me} (see Figure 1).

NOTE The volume of the cable termination compartment is unknown during type test, therefore a leak rate flux instead of leak rate percentage is given.

8 Routine tests

8.1 General

Routine tests of a cable termination shall be carried out according to IEC 60141 (all parts) or IEC 60840 or IEC 62067 as applicable. In addition the tests in the following 8.2 and 8.3 shall be carried out.

If the cable termination insulator is pre-installed during switchgear manufacturing, this insulator will be subject to routine tests and on site tests specified in IEC 62271-203 when these are carried out on the switchgear. For these tests the insulator shall be installed and special devices shall be fitted if required for the test, as specified by the cable termination manufacturer. Such devices shall be provided by the cable termination supplier.

8.2 Pressure test

Routine pressure tests of the insulator of a cable termination shall be carried out at 2 times design pressure (relative) for one minute. The insulator shall be secured in exactly the same manner as in service and the pressure shall be applied from the switchgear side. The insulator shall not show any signs of overstress or leakage.

8.3 Visual inspection

The visual inspection shall be made of all surfaces and shall not show any signs of significant defects. Critical machined dimensions shall be confirmed by measurements.

9 Standard dimensions

9.1 General

Standard dimensions are specified in order to ensure compatibility between switchgear and cable terminations conforming to this document.

9.2 Fluid-filled cable terminations

Standard dimensions for fluid-filled cable connection enclosures, main circuit end terminals and cable terminations applied to single-phase enclosures are shown in Figure 3. Four standard sizes cover the voltage range (U_r) from 72,5 kV to 550 kV.

9.3 Dry-type cable terminations

Standard dimensions for dry-type cable-connection enclosures, main circuit end terminals and cable terminations applied to single-phase enclosures are shown in Figure 5. Four standard sizes cover the voltage range (U_r) from 72,5 kV to 550 kV. Figure 4 shows the two types of dry-type cable termination. Type A incorporates an elastomeric electrical stress control component inside the insulating barrier. Type B incorporates the insulating barrier inside the elastomeric electrical stress control component.

For use of dry type cable terminations according to Figure 5 in enclosures for fluid-filled terminations according to Figure 3, suitable interface adaptor(s) shall be supplied by the cable termination manufacturer.

9.4 Three-phase cable connection enclosure

The minimum dimensions of the three-phase cable connection enclosure are defined by the minimum phase to phase distance arising out of d_{10} and the minimum phase to ground distance arising out of $d_5/2$ in accordance with Figures 3 and 5 respectively.

10 Information to be given with enquiries, tenders and orders

Refer to IEC 60840 or IEC 62067 or IEC 60141 (all parts), and IEC 62271-203. In addition, the user and the manufacturers shall consider the installation requirements of the equipment. Manufacturers shall state the specific requirements for civil, electrical and installation clearances applicable to the switchgear, cable termination and cable. Information shall be provided in particular and if required in relation to switchgear/cable termination installation sequence as well as positioning and temporary fixing of the relevant components.

At the time of ordering or manufacturing a switchgear, it is very often not known whether and how the foreseen cable systems will be tested at site. In order to improve this situation, the user of the switchgear has to identify in his inquiry each cable feeder and which testing method will be applied. It is assumed that generally an AC or DC test will be executed at site. The following main test methods are defined:

a) in case that one end of the cable is installed outdoors, the outdoor located accessible cable end may be used to apply the test voltage;

b) in case of a cable connection between two switchgears or between switchgear and transformer, the cable connection enclosure in the switchgear may be used to apply the test voltage.

It is the responsibility of the user to indicate in the enquiry for the switchgear which feeders of the switchgear shall be foreseen for cable testing and which test method is required.

11 Rules for transport, storage, erection, service and maintenance

11.1 General

Refer to IEC 62271-1:2017, Clause 11.

The cable termination manufacturer should ensure that during manufacture, handling, storage and installation of the cable termination, provisions should be made to ensure that the requirements given in 6.2 of IEC 62271-1:2017 can be satisfied after final assembly of the connection. The cable termination manufacturer should supply the necessary information to enable these requirements to be satisfied, if the cable termination is to be installed by others.

11.2 Tests after cable system installation

If required by the user of the switchgear, the manufacturer shall make special provisions for the testing of the cable system, such as disconnecting facilities, earthing facilities and/or increasing gas pressure within the given design limits of the cable connection enclosure. This applies also if parts of the switchgear directly connected to the cable connection assembly cannot withstand the test voltage specified in IEC 60141 (all parts) or IEC 60840 or IEC 62067 for the cable test at rated gas density. It also applies if in the judgment of the switchgear manufacturer, it is not acceptable to apply the test voltage to the affected switchgear components.

If required by the user, the switchgear manufacturer shall provide the location for a suitable test bushing and provide the user with all necessary information for mounting such a bushing to the cable connection enclosure. If necessary to achieve adequate electrical clearances, the test bushing shall include a suitable insulated connection and test terminal. The requirement for the test bushing shall be specified by the user in the enquiry.

NOTE Increasing the gas pressure is not a reliable method of improving the electrical strength at the surface of an insulator when tested with DC voltage.

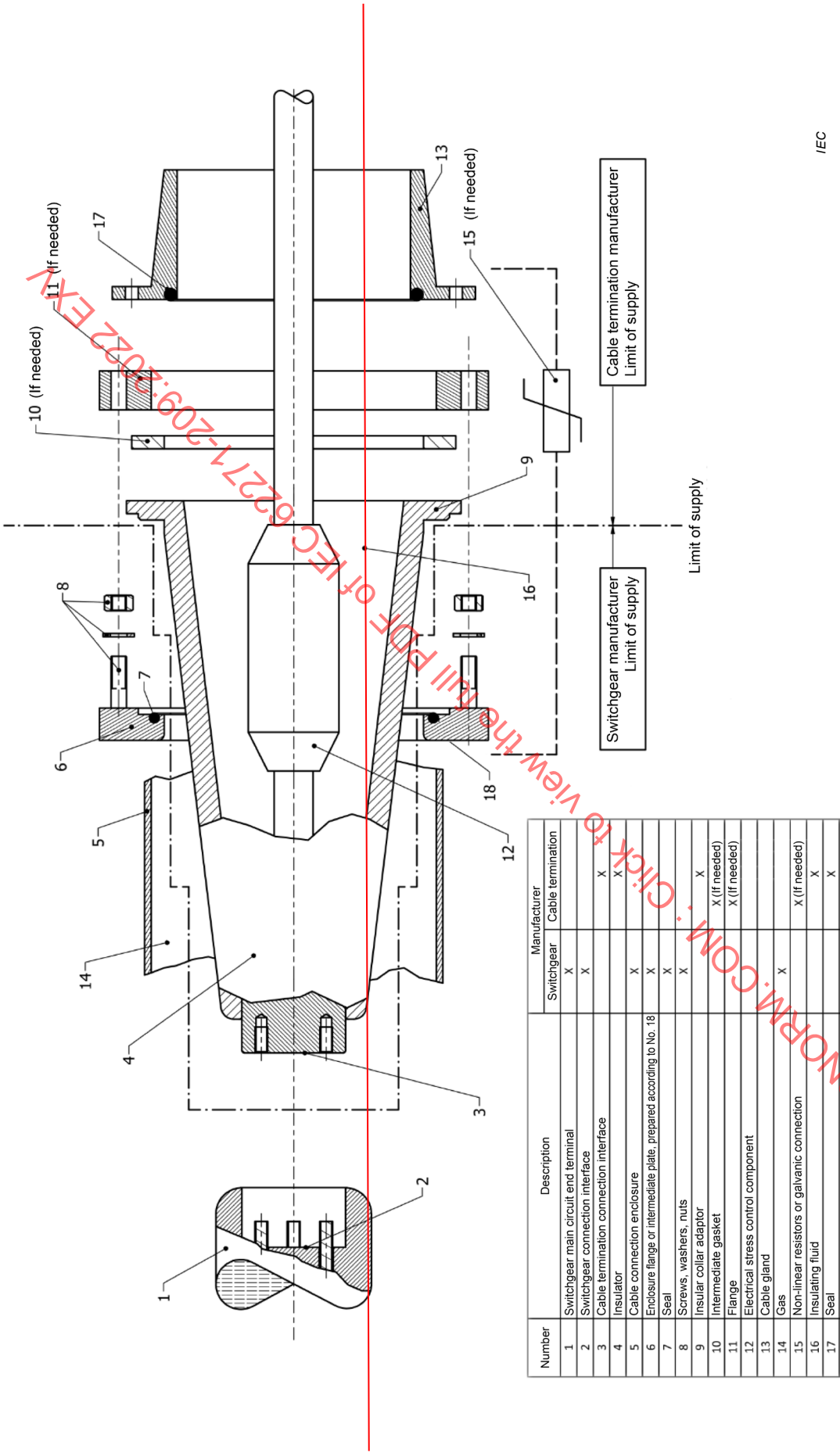
12 Safety practices and constraints during installation of cable connection to switchgear

The following practices should be considered for handling electrical equipment in the field:

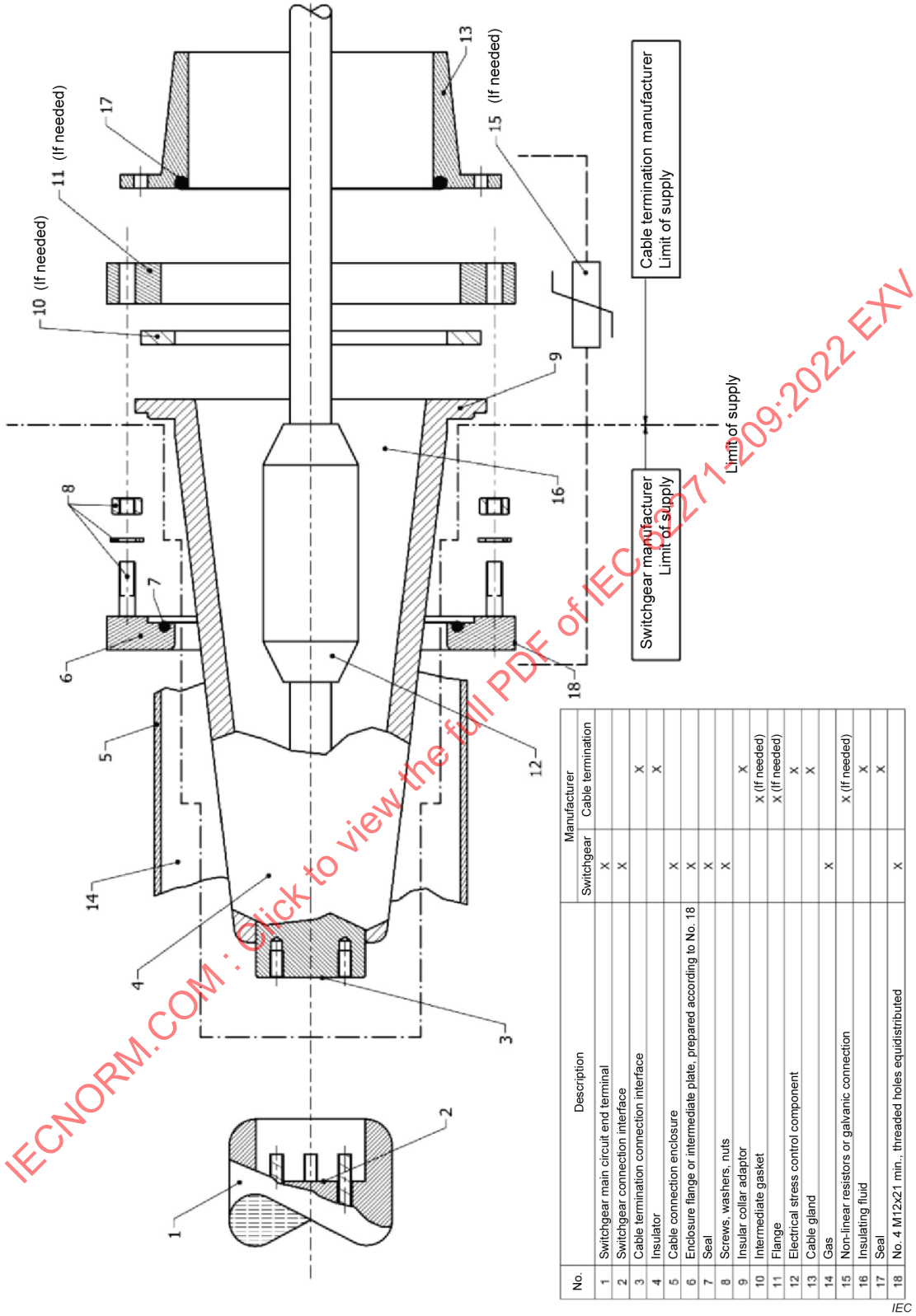
- before commencing any work on the equipment in the field, make sure that the cable, the switchgear and all adjacent electrical equipment are de-energized and properly grounded.
- the preparation of the cable, the installation of cable terminations and the connections to the switchgear are intended to be performed by qualified personnel and jointers that are trained and experienced in installing these or similar products in the field.
- instructions and precautions depending on individual design and local regulations, such as gas pressure reduction in the neighboring compartment, have to be considered.

13 Influence of the product on the environment

Clause 12 of IEC 62271-203:2011 is applicable.

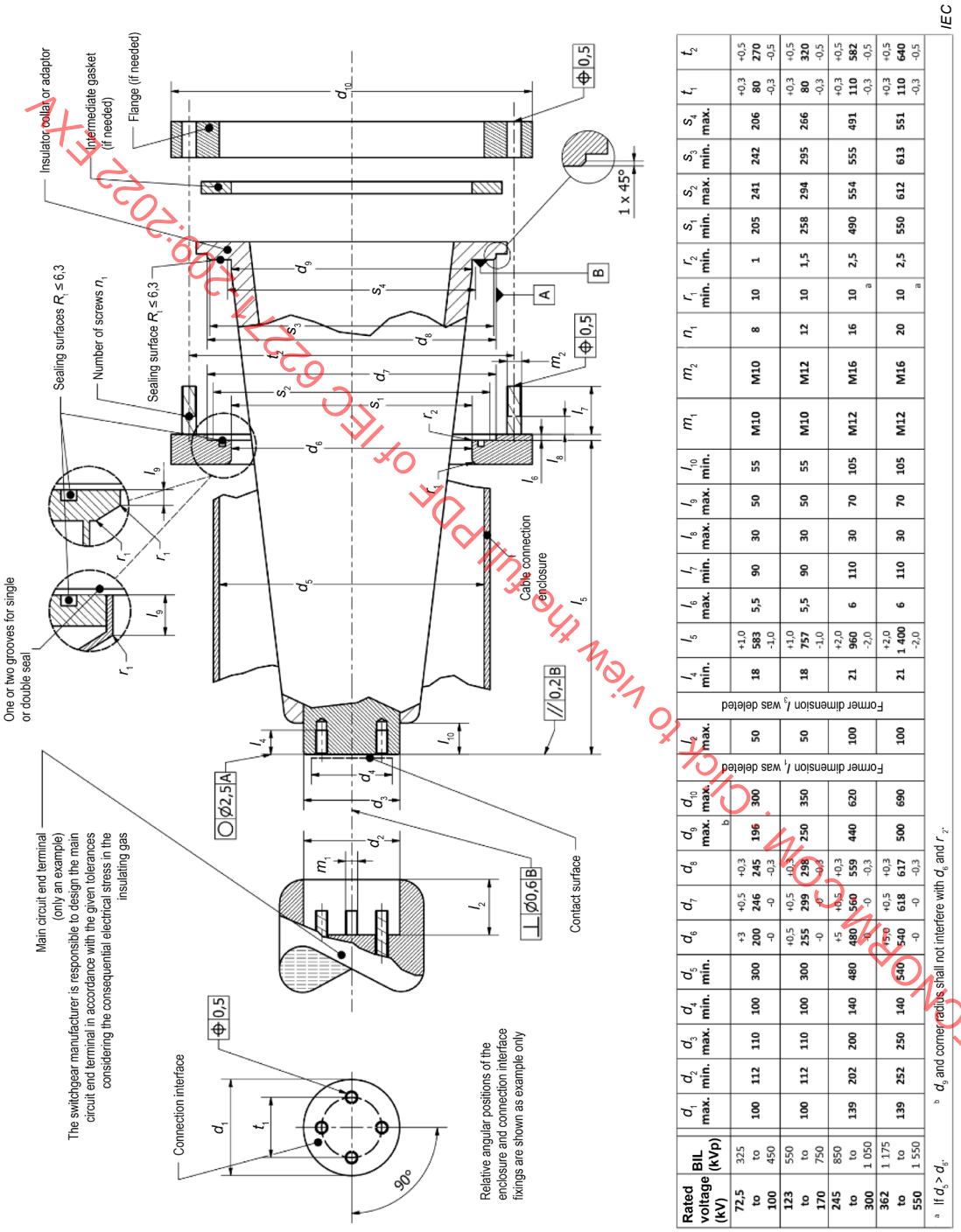


Number	Description	Manufacturer	
		Switchgear	Cable termination
1	Switchgear main circuit end terminal	X	
2	Switchgear connection interface	X	
3	Cable termination connection interface		X
4	Insulator		X
5	Cable connection enclosure	X	
6	Enclosure flange or intermediate plate, prepared according to No. 18	X	
7	Seal	X	
8	Screws, washers, nuts	X	X
9	Insular collar adaptor		X (If needed)
10	Intermediate gasket		X (If needed)
11	Flange		X (If needed)
12	Electrical stress control component		
13	Cable gland		
14	Gas	X	
15	Non-linear resistors or galvanic connection		X (If needed)
16	Insulating fluid		X
17	Seal		X
18	No. 4 M12x21 min., threaded holes equidistributed	X	



No.	Description	Manufacturer	
		Switchgear	Cable termination
1	Switchgear main circuit end terminal	X	
2	Switchgear connection interface	X	
3	Cable termination connection interface		X
4	Insulator		X
5	Cable connection enclosure	X	
6	Enclosure flange or intermediate plate, prepared according to No. 18	X	
7	Seal	X	
8	Screws, washers, nuts	X	
9	Insular collar adaptor		X
10	Intermediate gasket		X (If needed)
11	Flange		X (If needed)
12	Electrical stress control component		X
13	Cable gland		X
14	Gas	X	
15	Non-linear resistors or galvanic connection		X (If needed)
16	Insulating fluid		X
17	Seal		X
18	No. 4 M12x21 min., threaded holes equidistributed	X	

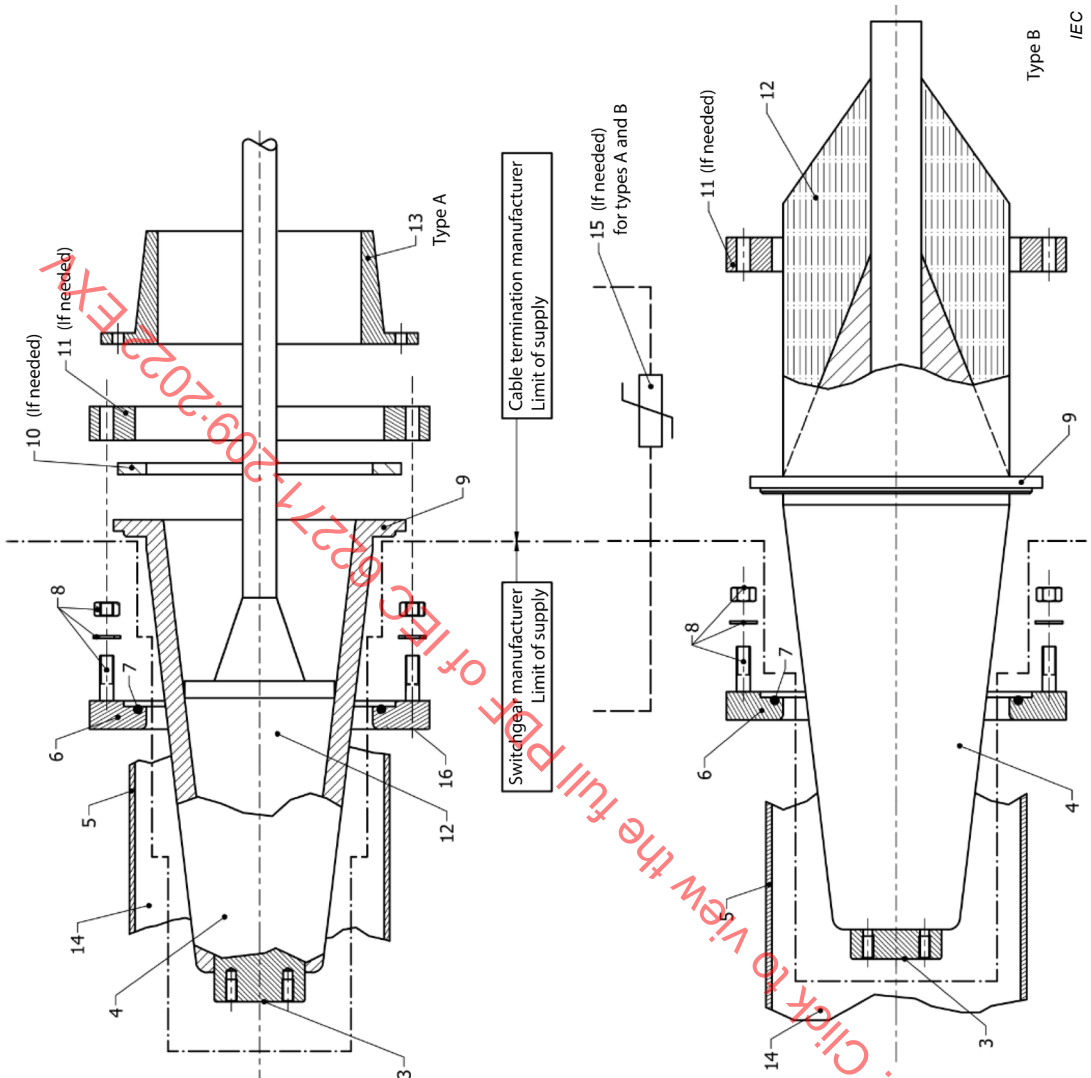
Figure 2 – Fluid-filled cable connection assembly – Typical arrangement



Rated voltage (kV)	BIL (kVp)	d_1 max.	d_2 min.	d_3 max.	d_4 min.	d_5 min.	d_6	d_7	d_8	d_9 max. [b]	d_{10} max. [b]	Former dimension l_1 was deleted l_4 max.	Former dimension l_3 was deleted l_4 min.	l_5	l_6 max.	l_7 min.	l_8 max.	l_9 max.	l_{10} min.	m_1	m_2	n_1	r_1 min.	r_2 min.	s_1 min.	s_2 max.	s_3 min.	s_4 max.	t_1	t_2
72,5 to 100	325 to 450	100	112	110	100	300	+3 -0 200	+0,5 -0 246	+0,3 -0,3 245	196	300	50	18	+1,0 -1,0 583	5,5	90	30	50	55	M10	M10	8	10	1	205	241	242	206	+0,3 -0,3 80	+0,5 -0,5 270
123 to 170	550 to 750	100	112	110	100	300	+0,5 -0 255	+0,5 -0 299	+0,3 -0,3 298	250	350	50	18	+1,0 -1,0 757	5,5	90	30	50	55	M10	M12	12	10	1,5	258	294	295	266	+0,3 -0,3 80	+0,5 -0,5 320
245 to 300	850 to 1 050	139	202	200	140	480	+5 -0 480	+0,5 -0 560	+0,3 -0,3 559	440	620	100	21	+2,0 -2,0 960	6	110	30	70	105	M12	M16	16	10 [a]	2,5	490	554	555	491	+0,3 -0,3 110	+0,5 -0,5 582
362 to 550	1 175 to 1 550	139	252	250	140	540	+0,5 -0 540	+0,5 -0 618	+0,3 -0,3 617	500	690	100	21	+2,0 -2,0 1 400	6	110	30	70	105	M12	M16	20	10 [a]	2,5	550	612	613	551	+0,3 -0,3 110	+0,5 -0,5 640

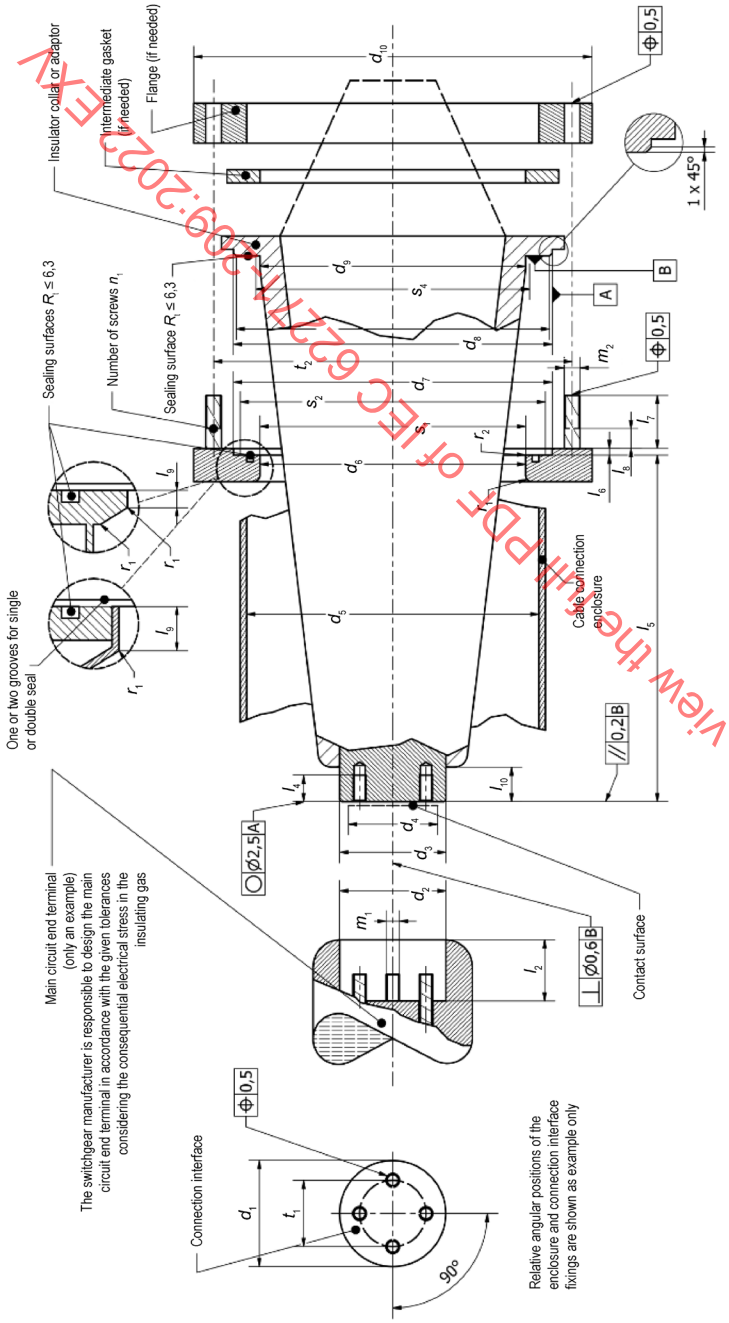
[a] If $d_5 > d_6$, d_9 and corner radius shall not interfere with d_6 and r_2.

Figure 3 – Fluid-filled cable connection – Assembly dimensions



Number	Description	Manufacturer	
		Switchgear	Cable termination
1	Switchgear main circuit end terminal	X	
2	Switchgear connection interface	X	
3	Cable termination connection interface		X
4	Insulator		X
5	Cable connection enclosure	X	
6	Enclosure flange or intermediate plate, prepared according to No. 16	X	
7	Seal	X	
8	Screws, washers, nuts	X	
9	Insular collar or adaptor		X
10	Intermediate gasket		X (If needed)
11	Flange		X (If needed)
12	Electrical stress control component (elastomeric)		X
13	Cable gland		X
14	Gas	X	
15	Non-linear resistors or galvanic connection		X (If needed)
16	No. 4 M12x21 min., threaded holes equidistributed	X	

Figure 4 – Dry-type cable connection assembly – Typical arrangement



Rated voltage (kV)	BIL (kVp)	d_1 max.	d_2 min.	d_3 max.	d_4 min.	d_5 min.	d_6	d_7	d_8	d_9 max. [b]	d_{10} max.	Former dimension l_3 was deleted	l_4 min.	l_5	l_6 max.	l_7 min.	l_8 max.	l_9 max.	l_{10} min.	m_1	m_2	n_1	r_1 min. [a]	r_2 min.	s_1 min.	s_2 max.	s_3 min.	s_4 max.	t_1	t_2
72,5 to 100	325 to 450	100	112	110	100	300	+3 -0	+0,5 -0	+0,3 -0,3	196	300	50	18	+1,0 -1,0 310	5,5	90	30	50	55	M10	M10	8	10	1	205	241	242	206	+0,3 -0,3 80	+0,5 -0,5 270
123 to 170	550 to 750	100	112	110	100	300	+0,5 -0 255	+0,5 -0 299	+0,3 -0,3 248	250	350	50	18	+1,0 -1,0 470	5,5	90	30	50	55	M10	M12	12	10	1,5	258	294	295	266	+0,3 -0,3 80	+0,5 -0,5 320
245 to 300	850 to 1 050	139	202	200	140	400	+5 -0 385	+0,5 -0 455	+0,3 -0,3 454	375	500	100	21	+2,0 -2,0 620	6	110	30	70	105	M12	M12	16	10	2,5	390	450	451	391	+0,3 -0,3 110	+0,5 -0,5 475
362 to 550	1 175 to 1 550	139	252	250	140	540	+5,0 -0 540	+0,5 -0 618	+0,3 -0,3 617	500	690	100	21	+2,0 -2,0 960	6	110	30	70	105	M12	M16	20	10	2,5	550	612	613	551	+0,3 -0,3 110	+0,5 -0,5 640

[a] If $d_5 > d_6$, r_1 = a

[b] d_9 and corner radius shall not interfere with d_6 and r_2.

Figure 5 – Dry-type cable connection assembly – Assembly dimensions

Annex A
(informative)

Mechanical forces applied on the flange of the cable connection enclosure

A.1 General

The switchgear manufacturer should coordinate with the cable manufacturer on the cable system design. For both single-phase and three-phase connections, additional forces and movements from the switchgear and the cable system can be experienced due to temperature variations in service. These forces can act on both switchgear and cable system and depend largely on the switchgear layout, termination installation, cable design and the methods of mechanical support of the switchgear and cable system. The design of any support structure should take into account these forces and movements.

A.2 Recommendation when connecting cable systems to switchgear

The switchgear system should be considered as a system allowing limited moving tolerances during all occurring operation conditions concerning its connection to the cable system. The cable system should be considered as a system allowing limited movement tolerances during service concerning its connection to the switchgear. The switchgear designer should specify the movement tolerances, forces and loads covering all operational conditions, and document them in the relevant arrangement drawings. These data should be taken into account by the cable system designer.

The switchgear supplier should provide the supporting structure for the cable connection enclosure comprising a sliding point, to allow movement of the cable connection enclosure, to allow switchgear expansion or contraction due to the temperature variations.

The supporting structure of a cable connection enclosure of the switchgear, should be designed where possible, in such a way, that an adjacent cable centring fixation point can be added to that structure and there will be no relative movement between the cable connection enclosure and the centring fixation point.

A cable connection enclosure may need to be engineered as a fixed point. This occurs in the case of an installation of e.g. a high pressure oil cable system which due to its design is not able to absorb thermal displacement caused by the switchgear. In this case the switchgear manufacturer has to absorb the thermal displacement by appropriate measures, e.g. compensating equipment. It is the responsibility of the user to inform the switchgear manufacturer about the installation of such a cable system together with the inquiry.

It is also particularly important that the support for the switchgear housings should neither be affixed to the insulator collar and/or clamping flange (parts 9 and 11 of Figures 2 or 4), nor to the flange of the cable connection enclosure (part 6 in Figures 2 or 4).

NOTE 1 The assembly of parts 6 and 11 in Figures 2 or 4 has the purpose of a tight gas connection and is reserved for the loads originated by the cable termination and attached cable connection.

Preferably part 6 in Figure 2 and 4 should be reserved for the fixing of an anti-kink construction (bending protection), if needed, having the task to avoid bending forces and axial forces onto the sealing end, and fixing the position of the cable in relation to the cable connection enclosure flange. Attention should be brought to the type of ground connection to the cable sheath, in case of insulated screen the anti-kink centring should not short circuit this insulation. Snaking of the cable may be performed to lower the conductor thrust on the insulator. The supply of an anti-kink construction is the responsibility of the cable system supplier.

In addition to the load arising from maximum operating gas pressure specified in 6.103 the flange of the cable connection enclosure (part 6 in Figures 2 or 4) attached to the cable termination is subject to the following normal and exceptional forces during service:

– forces originated from the transversal movement of the cable connection enclosure due to temperature variations of the switchgear;
– part of weight of the attached cable termination, the potential anti-kink construction and part of the weight of the cable system in dependency of the rated voltage and cable conductor type;
– short circuit forces between the attached cables;
– seismic forces originating from the cable termination, cable connection and supporting structures of the cable system or parts thereof, if applicable.

Forces during normal operation arising as described above have to be limited by appropriate measures to the values listed in Table A.1.

Forces originating from the expansion or contraction of the cable, due to the temperature variation, which are transferred to the cable connection enclosure of the switchgear should be minimized by the use of appropriate means like fixing and snaking of the cables. However, these forces result in the simultaneous application of:

– a bending moment M_0;
– a shearing force F_t;
– a tensile or compressive force F_a

at the cable connection enclosure (part 6 of Figures 2 or 4). The cable connection enclosure flange should be capable of withstanding the values of M_0, F_t and F_a specified in Table A.1, and it should be the responsibility of the cable system designer to ensure that these values are not exceeded.

In case of exceptional loads, such as a short circuit or seismic, the total load should not exceed a maximum of 200 % of the given normal loads in Table A.1.

NOTE 2 The requirement concerning the ratio between normal and exceptional load is in accordance with the ratio of the service and cantilever test loads in IEC 60137:2017, Table 1 [1].

Table A.1 – Moment and forces applied on the flange of the cable connection enclosure attached to the cable termination during normal operation

Rated voltage U_{rm} (kV)	Tensile or compressive force F_a (kN)	Shearing force F_t (kN)	Bending moment M_0 (kNm)
> 52 to 100	1,0	1,0	1,2
123 to 170	1,5	1,5	1,8
245 to 300	2,5	2,5	3,0
362 to 550	4,5	4,5	5,4
NOTE 1 F_a acts in the axial direction of the cable, F_t in transverse direction.			
NOTE 2 M_0 results from F_t acting in a distance of 1,2 m from the lower flange of the cable connection enclosure (part 6).			
NOTE 3 Forces in Table A.1 are per cable and apply for single-phase and three-phase connections.			

In order to ensure that the requirements mentioned above in relation to normal and exceptional forces and loads are in no case exceeded, design coordination between the GIS manufacturer and the cable system provider is required.

Bibliography

[1] IEC 60137:2017, *Insulated bushings for alternating voltages above 1 000 V*

[2] IEC 62271-207, *High-voltage switchgear and controlgear – Part 207: Seismic qualification for gas-insulated switchgear assemblies for rated voltages above 52 kV*

[3] IEEE Std 1300:2011, *IEEE Guide for Cable Connections for Gas-Insulated Substations*

[4] CIGRE brochure 89:1995, *Accessories for HV Extruded Cables*

[5] CIGRE TB 44:1993, *Earthing of GIS – An Application Guide*

SOMMAIRE

COMMISSION ÉLECTROTECHNIQUE INTERNATIONALE

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APPAREILLAGE À HAUTE TENSION –

Partie 209: Raccordement de câbles pour appareillage sous enveloppe métallique à isolation gazeuse de tension assignée supérieure à 52 kV – Câbles remplis d'un fluide ou à isolation extrudée – Extrémité de câble de type sec ou remplie d'un fluide

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Cette version consolidée de la Norme IEC officielle et de son amendement a été préparée pour la commodité de l'utilisateur.

L'IEC 62271-209 édition 2.1 contient la deuxième édition (2019-02) [documents 17C/696/FDIS et 17C/701/RVD] et son amendement 1 (2022-03) [documents 17C/833/FDIS et 17C/841/RVD].

Dans cette version Redline, une ligne verticale dans la marge indique où le contenu technique est modifié par l'amendement 1. Les ajouts sont en vert, les suppressions sont en rouge, barrées. Une version Finale avec toutes les modifications acceptées est disponible dans cette publication.

La Norme internationale IEC 62271-209 a été établie par le sous-comité 17C: Ensembles, du comité d'études 17 de l'IEC: Appareillage haute tension.

Cette deuxième édition constitue une révision technique.

Cette édition inclut les modifications majeures suivantes par rapport à l'édition précédente:

a) Nouvelle numérotation conformément aux directives ISO/IEC, Partie 2 (2016) et à l'IEC 62271-1:2017;

b) Article 3: ajout des définitions d'extrémité de câble embrochable, de pression de remplissage et de pression minimale de fonctionnement;

c) Article 7: Un essai diélectrique de type complémentaire pour les extrémités de câbles embrochables a été ajouté; un essai de pression de type ainsi qu'un essai de taux de fuite type pour l'isolateur des extrémités de câble ont également été appliqués;

d) Article 12: Nouvel article relatif aux pratiques en matière de sécurité;

e) Article 13: Nouvel article relatif à l'influence du produit sur l'environnement;

f) Nouvelle Annexe A informative: Forces mécaniques appliquées sur la bride de l'enveloppe du raccordement de câble.

Ce document a été rédigé selon les Directives ISO/IEC, Partie 2.

La présente Norme doit être lue conjointement à l'IEC 62271-1:2017, à laquelle elle fait référence et qui est applicable, sauf indication contraire dans la présente Norme. Pour faciliter le repérage des exigences correspondantes, cette norme utilise une numérotation identique des articles et des paragraphes à celle de l'IEC 62271-1. Les modifications de ces articles et de ces paragraphes ont des références identiques; les paragraphes supplémentaires qui n'ont pas d'équivalent dans l'IEC 62271-1, sont numérotés à partir de 101.

Une liste de toutes les parties de la série IEC 62271, publiées sous le titre général *Appareillage à haute tension*, peut être consultée sur le site web de l'IEC.

Le comité a décidé que le contenu de la publication de base et de son amendement ne sera pas modifié avant la date de stabilité indiquée sur le site web de l'IEC sous webstore.iec.ch dans les données relatives à la publication recherchée. A cette date, la publication sera

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- supprimée,
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- amendée.

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INTRODUCTION à l'Amendement 1

Le présent amendement inclut les modifications suivantes:

a) conformément à la décision prise lors de la réunion plénière de l'IEC qui s'est tenue en octobre 2019 à Shanghai (17C/Shanghai/Sec07), le paragraphe 6.103, la Figure 1 et la Figure 2 ont été modifiés;

b) le CDV a été modifié conformément aux documents mentionnés ci-dessus et d'après la décision prise lors de la réunion plénière virtuelle de l'IEC en octobre 2021 (17C/823/RM).

NOTE Le CIGRE a publié la TB 784 "Standard design of a common, dry type plug-in interface for GIS and power cables up to 145 kV", décrivant le fondement de la normalisation approfondie d'une telle interface commune. Ce sujet sera traité au cours de la prochaine révision de l'IEC 62271-209.

APPAREILLAGE À HAUTE TENSION –

Partie 209: Raccordement de câbles pour appareillage sous enveloppe métallique à isolation gazeuse de tension assignée supérieure à 52 kV – Câbles remplis d'un fluide ou à isolation extrudée – Extrémité de câble de type sec ou remplie d'un fluide

1 Domaine d'application

La présente partie de l'IEC 62271 est applicable à l'assemblage de raccordement de câbles remplis d'un fluide ou à isolation extrudée au poste sous enveloppe métallique (PSEM), dans une disposition unipolaire ou tripolaire. Les extrémités de câble sont remplies d'un fluide ou de type sec et une séparation isolante se trouve entre le fluide d'isolation du câble et l'isolation gazeuse de l'appareillage.

Le but du présent document est d'établir une interchangeabilité électrique et mécanique entre les extrémités de câble et l'appareillage sous enveloppe métallique à isolation gazeuse et de déterminer les limites de fourniture. Elle complète et modifie, le cas échéant, les normes particulières de l'IEC. Dans le cadre du présent document, le terme «appareillage» est utilisé pour «appareillage sous enveloppe métallique à isolation gazeuse».

Il ne s'applique pas aux extrémités de câble du type directement immergées telles que décrites dans la brochure 89 du CIGRÉ [14][1].

2 Références normatives

Les documents suivants cités dans le texte constituent, pour tout ou partie de leur contenu, des exigences du présent document. Pour les références datées, seule l'édition citée s'applique. Pour les références non datées, la dernière édition du document de référence s'applique (y compris les éventuels amendements).

IEC 60038, *Tensions normales de la CEI*

IEC 60068-2-17:1994, *Essais fondamentaux climatiques et de robustesse mécanique – Partie 2-17:Essais – Essai Q:Étanchéité*

IEC 60141 (toutes les parties), *Essais de câbles à huile fluide, à pression de gaz et de leurs dispositifs accessoires*

IEC 60376, *Specification of technical grade sulphur hexafluoride (SF_6) and complementary gases to be used in its mixtures for use in electrical equipment* (disponible en anglais seulement)

IEC 60480, *Lignes directrices relatives au contrôle et au traitement de l'hexafluorure de soufre (SF_6) prélevé sur le matériel électrique et spécification en vue de sa réutilisation*

IEC 60840, *Câbles d'énergie à isolation extrudée et leurs accessoires pour des tensions assignées supérieures à 30 kV (U_m = 36 kV) et jusqu'à 150 kV (U_m = 170 kV) – Méthodes et exigences d'essai*

[1] Les chiffres entre crochets renvoient à la Bibliographie.

IEC 62067, *Câbles d'énergie à isolation extrudée et leurs accessoires pour des tensions assignées supérieures à 150 kV (U_m = 170 kV) et jusqu'à 500 kV (U_m = 550 kV) – Méthodes et exigences d'essai*

IEC 62271-1:2017, *Appareillage à haute tension – Partie 1: Spécifications communes pour appareillage à courant alternatif*

IEC 62271-203:2011, *Appareillage à haute tension – Partie 203: Appareillage sous enveloppe métallique à isolation gazeuse de tensions assignées supérieures à 52 kV*

3 Termes et définitions

Pour les besoins du présent document, les termes et définitions suivants s'appliquent.

L'ISO et l'IEC tiennent à jour des bases de données terminologiques destinées à être utilisées en normalisation, consultables aux adresses suivantes:

- IEC Electropedia: disponible à l'adresse http://www.electropedia.org/
- ISO Online browsing platform: disponible à l'adresse http://www.iso.org/obp

3.1
extrémité de câble
équipement prévu au bout d'un câble pour assurer le raccordement électrique avec d'autres parties du réseau et pour maintenir l'isolement jusqu'au point de raccordement

3.1.1
extrémité de câble remplie d'un fluide
extrémité de câble qui comprend un écran isolant de séparation entre le fluide d'isolation du câble et l'isolation gazeuse de l'appareillage, y compris un fluide

3.1.2
extrémité de câble de type sec
extrémité de câble n'exigeant aucun fluide comprenant un composant élastomère par effluve électrique en contact direct avec un isolateur qui fait frontière entre le câble et le PSEM

3.2
borne d'extrémité du circuit principal
partie du circuit principal de l'appareillage sous enveloppe métallique à isolation gazeuse faisant partie de l'interface de raccordement

3.3
enveloppe du raccordement de câble
partie de l'appareillage sous enveloppe métallique à isolation gazeuse qui contient l'extrémité de câble et la borne d'extrémité du circuit principal

3.4
assemblage de raccordement de câble
combinaison d'une extrémité de câble, d'une enveloppe du raccordement de câble et d'une borne d'extrémité du circuit principal qui relie mécaniquement et électriquement le câble à l'appareillage sous enveloppe métallique à isolation gazeuse

3.5
extrémité de câble embrochable
extrémité de câble où l'assemblage câble/cône déflecteur peut être encliqueté dans l'assemblage de l'isolateur déjà installé dans l'enveloppe de l'appareillage

3.6
pression de calcul
pression retenue pour la conception de l'enveloppe et des composants de l'extrémité de câble sujette à cette pression

Note 1 à l'article: Elle est au moins égale à la pression maximale de l'enveloppe lorsque la température du gaz utilisé pour l'isolation a atteint son maximum sous les conditions de service maximales spécifiées.

3.7
fluide
liquide ou gaz pour l'isolation

3.8
système de câble
câble avec ses accessoires installés

3.9
pression de remplissage p_{re} d'isolation
masse volumique de remplissage ρ_{re} d'isolation
pression (en Pa) d'isolation, rapportée aux conditions atmosphériques normales de 20 °C et de 101,3 kPa, qui peuvent être exprimées en termes (ou masse volumique) relatifs ou absolus, à laquelle le dispositif d'accumulation d'énergie est rempli avant la mise en service

3.10
pression minimale de fonctionnement p_{me} d'isolation
masse volumique minimale de fonctionnement ρ_{me} d'isolation
pression (en Pa) d'isolation, rapportée aux conditions atmosphériques normales de 20 °C et de 101,3 kPa, qui peuvent être exprimées en termes (ou masse volumique) relatifs ou absolus, auxquelles et au-dessus de laquelle les caractéristiques du raccordement de câble de l'appareillage sont conservées à laquelle le remplissage devient nécessaire

4 Conditions normales et spéciales de service

4.1 Généralités

L'Article 2 de l'IEC 62271-203:2011 s'applique.

4.2 Conditions normales de service

Le 2.1 de l'IEC 62271-203:2011 s'applique.

4.3 Conditions spéciales de service

Le 2.2 de l'IEC 62271-203:2011 s'applique.

5 Caractéristiques assignées

5.1 Généralités

Pour le dimensionnement de l'assemblage de raccordement de câble, les valeurs assignées suivantes doivent s'appliquer:

a) tension assignée de l'équipement du raccordement de câble (U_{rm});
b) niveau d'isolement assigné (U_p, U_d et U_s le cas échéant);
c) fréquence assignée (f_r);
d) courant permanent assigné (I_r);
e) courant de courte durée admissible assigné (I_k);

f) valeur de crête du courant admissible assignée (I_p);

g) durée de court-circuit assignée (t_k).

5.2 Tension assignée de l'équipement du raccordement de câble (U_{rm})

La tension assignée pour l'équipement du raccordement de câble (U_{rm}) est égale à la plus faible des valeurs U_m retenues pour le système de câble et U_r pour l'appareillage sous enveloppe métallique à isolation gazeuse et doit être choisie parmi les valeurs normalisées suivantes:

72,5 kV – 100 kV – 123 kV – 145 kV – 170 kV – 245 kV – 300 kV – 362 kV – 420 kV – 550 kV

NOTE 1 Les valeurs supérieures à U_r = 550 kV ne sont pas prises en compte.

NOTE 2 U_m = 100 kV n'est pas définie dans l'IEC 60840.

5.3 Niveau d'isolement assigné (U_d, U_p, U_s)

Le niveau d'isolement assigné pour l'assemblage de raccordement de câble doit être choisi parmi les valeurs de l'IEC 60038 ainsi que dans l'IEC 62271-203.

5.4 Fréquence assignée (f_r)

Les valeurs préférentielles de la fréquence assignée sont 16,7 Hz, 25 Hz, 50 Hz et 60 Hz.

5.5 Courant permanent assigné (I_r)

L'interface de raccordement du circuit principal indiquée aux Figures 2 et 3 pour les extrémités de câble remplies d'un fluide et aux Figures 4 et 5 pour les extrémités de câble de type sec est applicable à des courants permanents assignés jusqu'à 3 150 A.

L'interface de raccordement doit être conçue afin qu'avec un courant égal au courant assigné du câble pour une température maximale de 90 °C, aucun transfert de chaleur de la borne d'extrémité du circuit principal de l'appareillage vers l'extrémité de câble ne se produise.

NOTE La température maximale de l'âme du câble étant limitée par la température maximale de fonctionnement de l'isolation, il existe certains isolants pour câble qui ne peuvent supporter les températures maximales spécifiées pour l'appareillage métallique sous isolation gazeuse à cause du transfert de chaleur par l'interface de raccordement vers l'extrémité du câble.

Pour les cas où l'exigence de conception ci-dessus de 90 °C au courant permanent assigné ne peut être admise à cause des limites de conception du câble, il convient que le fabricant de l'appareillage donne les données nécessaires concernant l'échauffement de la borne d'extrémité du circuit principal et du gaz isolant en fonction du courant.

5.6 Courant de courte durée admissible assigné (I_k)

Les courants de courte durée d'un court-circuit doivent se reporter aux niveaux fournis par le système de câble, en ne dépassant pas les valeurs définies pour l'appareillage conformément à l'IEC 62271-1.

5.7 Valeur de crête du courant admissible assignée (I_p)

Les valeurs de crête du courant admissible assignées d'un court-circuit doivent se reporter aux niveaux fournis par le système de câble, en ne dépassant pas les valeurs définies pour l'appareillage conformément à l'IEC 62271-1.

5.8 Durée de court-circuit assignée (t_k)

Les durées de court-circuit doivent se reporter aux niveaux fournis par le système de câble, en ne dépassant pas les valeurs définies dans l'IEC 62271-1.

6 Conception et construction

6.1 Étanchéité au gaz et au vide

Le 6.16 de l'IEC 62271-1:2017 s'applique avec l'ajout suivant:

Pour des conditions au niveau de la pression de service maximale du gaz, l'extrémité de câble doit empêcher la diffusion du gaz isolant de l'appareillage dans l'extrémité de câble et dans le câble. L'extrémité de câble doit empêcher la pénétration du fluide isolant depuis l'extrémité de câble vers l'appareillage. L'isolateur (élément 4 des Figures 2 et 4) doit être capable de supporter les conditions de vide lorsque l'enveloppe du raccordement de câble est mise sous vide lors du processus de remplissage de gaz.

Dans le cas d'un câble à isolation gazeuse ou d'une extrémité à isolation gazeuse, et en ce qui concerne l'étanchéité, le compartiment à gaz du câble ou l'extrémité à isolation gazeuse doivent être traités indépendamment de l'appareillage.

6.101 Limites de fourniture

6.101.1 Généralités

Les limites de fourniture de l'appareillage sous enveloppe métallique à isolation gazeuse et d'extrémité de câble doivent être celles indiquées à la Figure 2 pour les extrémités de câble remplies d'un fluide et à la Figure 4 pour les extrémités de câble de type sec.

6.101.2 Protection contre la surtension et mise à la terre

Il est nécessaire d'avoir un raccordement direct à faible résistance ou une portion isolée avec des résistances non linéaires montées en pont entre l'élément 6 et l'élément 13 de la Figure 2 pour les extrémités de câble remplies d'un fluide, et de la Figure 4 pour les extrémités de câble de type sec. Afin de permettre des raccordements appropriés aux appareillages, et pour les besoins de ce raccordement ou de l'installation direct(e) de n'importe quel dispositif de limitation de tension de gaine, le fabricant de l'appareillage doit fournir quatre points de fixation par phase (répartis uniformément autour de chaque phase), chacun comprenant un trou taraudé M12 de longueur minimale de 21 mm (pour tous les niveaux de tension). La position de ces quatre points de fixation diffère de celle des points de fixation mécanique utilisés pour fixer l'isolateur de l'extrémité de câble. Le nombre de points de fixation utilisé doit être déterminé par le concepteur du système de câble.

Le cas échéant, le nombre et les caractéristiques des résistances non linéaires doivent être déterminés par le concepteur du système de câble, et doivent être fournis par le fabricant de l'extrémité de câble, en tenant compte des besoins de l'utilisateur et du fabricant de l'appareillage. Il est fait référence à la CIGRE TB 44, 1993 [5], ainsi qu'à l'IEEE 1300-2011, Article 11 [3].

De plus, la conception de l'installation de la zone autour de l'extrémité de câble doit prendre en considération l'espace exigé pour l'installation de n'importe quelle résistance non linéaire, y compris les distances d'isolement à la terre.

L'espace limité entre les trois phases d'un dispositif d'enveloppe peut nécessiter une clarification particulière entre le fabricant du PSEM, le fabricant de l'extrémité de câble et le concepteur du système de câble.

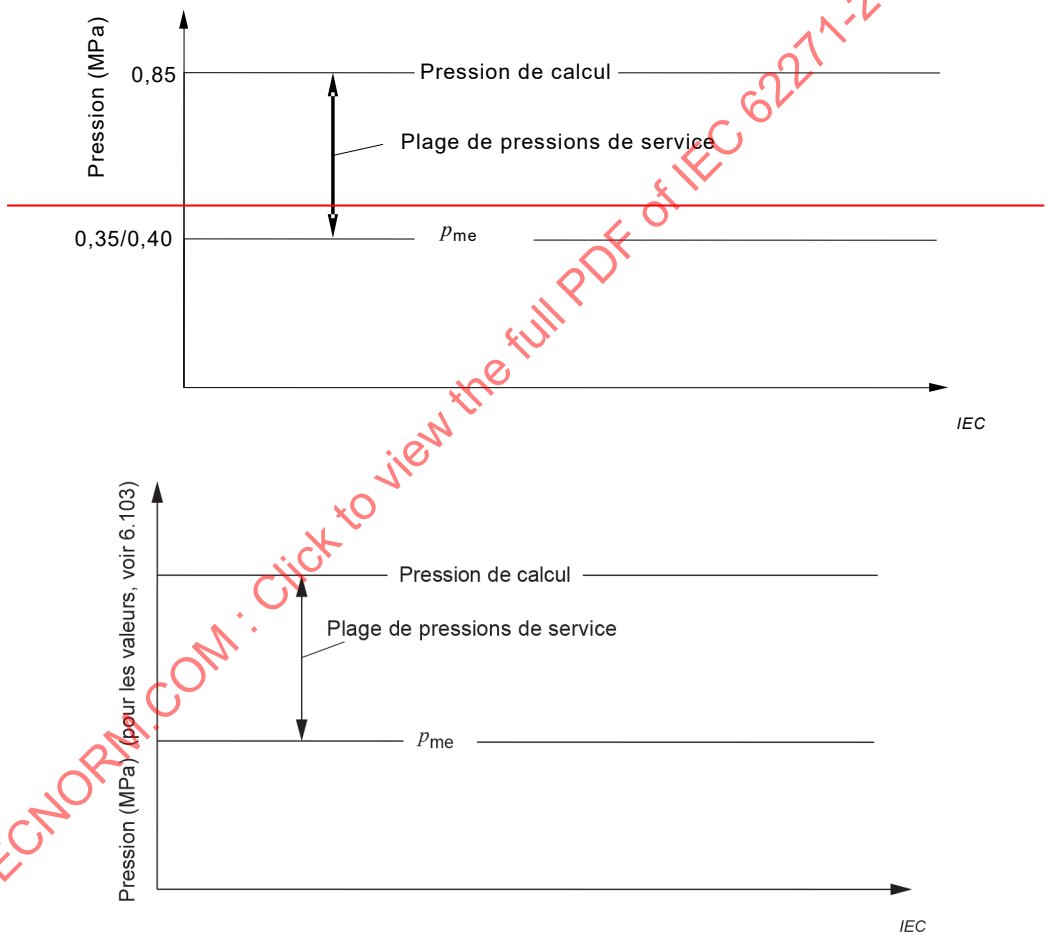
Les éléments de protection contre les surtensions, c'est-à-dire les raccordements entre l'élément 6 et l'élément 13 de la Figure 2 pour les extrémités de câble remplies d'un fluide et de la Figure 4 pour les extrémités de câble de type sec tel que décrit ci-dessus, ne sont pas faits pour raccorder le système de câble à la terre.

La mise à la terre des enveloppes doit se faire conformément au paragraphe applicable de l'IEC 62271-203:2011.

6.102 Pression de remplissage du gaz isolant dans l'enveloppe du raccordement de câble

Si le gaz isolant est du SF_6, la pression minimale de fonctionnement pour l'isolation p_{me} à retenir pour la conception de l'isolation de l'extrémité de câble ne doit pas être supérieure à p_{me} = 0,35 MPa (absolu) à 20 °C pour des tensions assignées maximales allant jusqu'à 300 kV. Pour des tensions assignées maximales supérieures à 300 kV, la pression minimale de fonctionnement pour l'isolation p_{me} à retenir pour la conception de l'isolation de l'extrémité de câble ne doit pas dépasser 0,4 MPa (absolu) à 20 °C (voir Figure 1).

La pression de remplissage p_{re} du gaz d'isolation est déterminée par le fabricant de l'appareillage mais ne doit en aucun cas être inférieure à p_{me}. La pression de service n'est en aucun cas supérieure à la pression de calcul conformément à 6.103.



p_{me} pression minimale de fonctionnement pour l'isolation en fonction de la tension assignée

Figure 1 – Pression de service du gaz isolant ~~SF_6~~ dans l'enveloppe du raccordement de câble

Si un gaz autre que SF_6 ou un mélange de gaz est utilisé, la pression minimale de fonctionnement doit être choisie afin de fournir la même performance diélectrique qu'avec un gaz SF_6. La pression minimale de fonctionnement doit être inférieure à la pression maximale de fonctionnement et à la pression de calcul de l'enveloppe conformément à 6.103.

6.103 Exigences pour la tenue à la pression

La pression de calcul pour l'extérieur de l'extrémité de câble est ~~de 0,85 MPa à 20 °C (absolue) indépendamment de la pression de calcul du PSEM appliquée~~ déterminée par la conception du PSEM autour de l'interface PSEM/câble. Les pressions de gaz maximales types en service peuvent atteindre 1,1 MPa (pression absolue) pour le SF_6 et 1,5 MPa (pression absolue) pour les autres gaz et mélanges de gaz.

Les exigences particulières pour la tenue à la pression provenant de la conception spécifique du gaz et du PSEM doivent faire l'objet d'une coordination approfondie entre le constructeur du PSEM et de l'extrémité de câble et l'utilisateur.

NOTE En raison du courant de service plus faible d'un raccordement de câble HT par rapport au courant assigné d'un PSEM, l'échauffement et l'augmentation de pression associés à l'intérieur du compartiment de câble peuvent être plus faibles. La pression de calcul du PSEM pourrait être supérieure à la pression de calcul de l'extrémité de câble.

6.104 Efforts mécaniques sur les extrémités de câble

Dans le cas d'un raccordement tripolaire, le fabricant d'extrémité de câble doit tenir compte des efforts électrodynamiques totaux produits par les courts-circuits. Ces efforts comprennent ceux qui proviennent de l'extrémité de câble et ceux qui proviennent du circuit principal de l'appareillage. L'effort complémentaire maximal appliqué perpendiculairement de l'appareillage à l'interface de raccordement (Figure 2 ou 4) et provenant de la borne d'extrémité du circuit principal ne doit pas dépasser 5 kN pour un dispositif tripolaire. Pour les raccordements unipolaires, l'effort complémentaire maximal appliqué perpendiculairement de l'appareillage à l'interface de raccordement (Figure 2 ou 4) et provenant de la borne d'extrémité du circuit principal ne doit pas dépasser 2 kN. Il est de la responsabilité du fabricant de l'appareillage de vérifier que les efforts spécifiés ne sont pas dépassés, ou de convenir avec le fabricant de l'extrémité de câble que l'extrémité de câble doit supporter les efforts les plus élevés.

Les vibrations et les variations de température en conditions de service peuvent induire des forces additionnelles à l'appareillage et des mouvements sur les raccordements de câble unipolaire ou tripolaire. Ces forces peuvent agir sur l'appareillage et sur l'extrémité de câble et dépendent principalement de l'implantation de l'appareillage, du type de câble et des moyens de support. La conception de toutes les structures doit prendre en compte ces forces et ces mouvements. Il est particulièrement important de noter que les supports de l'appareillage ne doivent pas être fixés sur le collier de l'isolateur et/ou sur la bride, parties 9 et 11 de la Figure 2 ou 4. Des informations complémentaires concernant les efforts mécaniques sur la bride de l'enveloppe du raccordement de câble sont données à l'Annexe A.

Pour les exigences sismiques, le fabricant de l'appareillage effectue un calcul sismique afin d'identifier la localisation des renforcements mécaniques; il est fait référence à l'IEC 62271-207 [2].

6.105 Interface de raccordement de l'appareillage et de l'extrémité de câble

Les surfaces de contact de l'appareillage conduisant le courant et l'interface de raccordement de l'extrémité de câble (se référer aux parties 2 et 3 des Figures 2 et 4) doivent être recouvertes d'argent, de cuivre ou en cuivre non recouvert.

7 Essais de type

7.1 Généralités

Pour les essais de type de l'IEC 62271-1:2017, le 7.1 s'applique. Si du gaz SF_6 est utilisé, le grade technique du SF_6 doit être conforme à l'IEC 60376 ou, si du SF_6 réutilisé est employé, alors le grade technique doit être conforme à l'IEC 60480.

7.2 Essais électriques de type des extrémités de câble

7.2.1 Généralités

Les essais électriques de type des extrémités de câble doivent être réalisés conformément aux essais électriques de type définis dans l'IEC 60141 (toutes les parties), l'IEC 60840 ou l'IEC 62067 selon la conception du câble. Le cas échéant, l'isolateur doit être soumis à l'essai de 7.2.4.

L'extrémité de câble doit être installée dans une enveloppe selon 7.2.2, remplie de gaz isolant à une pression inférieure à p_{me} + 0,02 MPa avec une pression de remplissage comme spécifié en 6.102.

La conception de la borne d'extrémité du circuit principal (élément 1 des Figures 2 et 4 respectivement) utilisée dans l'essai comme raccordement à l'élément 3 de l'assemblage de raccordement de câble doit satisfaire respectivement aux Figures 2 et 4 du présent document.

7.2.2 Essai électrique de type des extrémités de câble dans une enveloppe unipolaire

L'extrémité de câble est entourée d'un cylindre métallique mis à la terre, dont le diamètre intérieur maximal est égal à d_5 respectivement pour les quatre tailles normalisées de l'enveloppe du raccordement de câble (d_5 de la Figure 3 pour les extrémités de câble remplies d'un fluide et de la Figure 5 pour les extrémités de câble de type sec). La longueur minimale du cylindre métallique doit être conforme à la dimension l_5 donnée aux Figures 3 et 5.

7.2.3 Essai électrique de type des extrémités de câble dans une enveloppe tripolaire

L'essai monophasé utilisant une enveloppe unipolaire de raccordement de câble de l'appareillage couvre les exigences d'essai de l'extrémité de câble dans une enveloppe tripolaire car il impose des contraintes diélectriques plus sévères. L'essai unipolaire est donc l'essai de référence.

7.2.4 Essais électriques complémentaires sur l'isolateur en vue d'une installation par le fabricant de l'appareillage (extrémité de câble embrochable)

Pour certaines applications, l'isolateur de l'extrémité du câble est installé dans l'enveloppe de l'appareillage par le fabricant, et est par conséquent soumis aux essais individuels de série et aux essais applicables sur site. Afin de couvrir cette application, l'essai suivant doit être réalisé.

L'isolateur doit être installé comme spécifié par le fabricant de l'extrémité de câble afin de couvrir l'essai individuel de série réalisé ultérieurement par le fabricant de l'appareillage et les essais sur site. Le câble n'étant pas assemblé à la sortie, n'importe quel dispositif temporaire et nécessaire doit s'adapter du côté câble de l'isolateur. Ces dispositifs doivent être fournis par le fournisseur de l'extrémité de câble. L'essai doit être effectué à une température ambiante de (20 ± 15) °C. Les tensions d'essai doivent s'appliquer comme spécifié dans le Tableau 1:

Tableau 1 – Tensions d'essai des essais de type électriques complémentaires conformément à 7.2.4

Tension assignée de l'équipement du raccordement de câble U_{rm} kV (valeur efficace) (NOTE 1)	**Essais de tension à fréquence industrielle** U_d kV (valeur efficace)		**Tension de tenue du choc de manœuvre** U_{ss} kV (valeur de crête)	**Tension de tenue du choc de foudre** U_{ps} kV (valeur de crête)
	Essai de tension de tenue phase-terre (t = 1 min) IEC 62271-203:2011 Cl. 7.1.101 (NOTE 2)	Tension d'essai pour le mesurage des décharges partielles $U_{dp\text{-}essai}$ (>1 min) IEC 62271-203:2011, 7.1.102 (NOTE 2)	Phase-terre IEC 62271-203:2011, 10.2.101.2.4 (NOTE 3)	Phase-terre IEC 62271-203:2011, 10.2.101.2.4 (NOTE 3)
(1)	(2)	(3)	(4)	(5)
72,5	140	1,2 U_r	-	260
100	185	1,2 U_r	-	360
123	230	1,2 U_r	-	440
145	275	1,2 U_r	-	520
170	325	1,2 U_r	-	600
245	460	1,2 U_r	-	840
300	460	1,2 U_r	680	840
362	520	1,2 U_r	760	940
420	650	1,2 U_r	840	1 140
550	710	1,2 U_r	940	1 240

NOTE 1 La tension assignée de l'équipement U_{rm} s'applique conformément à 5.2.

NOTE 2 Les tensions d'essai de type en courant alternatif couvrent l'essai individuel de série de l'appareillage, auquel l'isolateur peut également être soumis.

NOTE 3 Les essais de type de tension de choc couvrent l'appareillage pour l'essai sur site, auquel l'isolateur peut également être soumis.

Pour des détails supplémentaires et pour la procédure d'essai concernant les essais diélectriques de l'isolateur, il est fait référence au Tableau 1 des articles applicables de l'IEC 62271-203:2011.

7.3 Essai de pression pour l'isolateur d'une extrémité de câble

L'isolateur doit être fixé exactement comme en conditions de service. L'essai doit être effectué à une température ambiante de (20 ± 15) °C. La pression hydraulique doit être appliquée du côté appareillage de l'isolateur, et le côté câble doit être ouvert à l'atmosphère. La pression doit être augmentée à un taux ne dépassant pas 0,4 MPa/min jusqu'à ce qu'elle atteigne trois fois la pression de calcul (par exemple, une pression de calcul de 0,85 MPa absolue génère une pression d'essai de 3 x 0,75 MPa = 2,25 MPa relative) qui doit être maintenue pendant 1 min.

7.4 Essai de type de taux de fuite pour l'isolateur d'une extrémité de câble

L'essai doit être effectué à une température ambiante de (20 ± 15) °C sur un isolateur d'une extrémité de câble installé sur une chambre appropriée. L'isolateur doit être installé en se rapprochant le plus possible des conditions de service. L'essai doit être effectué conformément à l'IEC 60068-2-17:1994, Article 8 (la méthode d'essai Qm est la méthode préférentielle pour déterminer le taux de fuite relatif).

Le taux de fuite mesuré ne doit pas dépasser 10^{-7} Pa x m^3/s à une pression minimale de fonctionnement d'isolation p_{me} (voir Figure 1).

NOTE Le volume du compartiment de l'extrémité de câble n'est pas connu lors de l'essai de type, par conséquent il est donné un flux de taux de fuite plutôt qu'un pourcentage de taux de fuite.

8 Essais individuels de série

8.1 Généralités

Les essais individuels de série d'une extrémité de câble doivent être effectués conformément à l'IEC 60141 (toutes les parties), l'IEC 60840 ou l'IEC 62067 selon le cas. De plus, les essais des 8.2 et 8.3 suivants doivent être réalisés.

Si l'isolateur de l'extrémité de câble est préinstallé à la construction de l'appareillage, il est soumis aux essais individuels de série et aux essais sur site spécifiés dans l'IEC 62271-203 lorsque ces essais sont réalisés sur l'appareillage. Pour ces essais, l'isolateur doit être installé et des dispositifs temporaires doivent être adaptés si l'essai l'exige, comme spécifié par le fabricant de l'extrémité de câble. Ces dispositifs doivent être fournis par le fournisseur de l'extrémité de câble.

8.2 Essai de pression

L'isolateur d'une extrémité de câble doit être soumis à des essais individuels de pression de série de deux fois la pression de calcul (relative) pendant une minute. L'isolateur doit être fixé comme en conditions de service et la pression doit être appliquée depuis le côté appareillage. L'isolateur ne doit présenter aucun signe de surcharge ou de fuite.

8.3 Inspection visuelle

Une inspection visuelle doit être effectuée sur toutes les surfaces qui ne doivent présenter aucun signe de défaut significatif. Les dimensions critiques d'usinage doivent être confirmées par mesurages.

9 Dimensions normalisées

9.1 Généralités

Les dimensions normalisées sont spécifiées afin d'assurer la compatibilité entre l'appareillage et les extrémités de câble conformément au présent document.

9.2 Extrémités de câble remplies d'un fluide

Les dimensions normalisées pour les enveloppes de raccordement d'extrémité de câble remplie d'un fluide, pour les bornes d'extrémité du circuit principal et pour les extrémités de câble appliquées aux enveloppes unipolaires sont indiquées à la Figure 3. Quatre tailles normalisées données couvrent la plage des tensions (U_r) de 72,5 kV à 550 kV.

9.3 Extrémités de câble de type sec

Les dimensions normalisées pour les enveloppes de raccordement d'extrémité de câble de type sec, pour les bornes d'extrémité du circuit principal et pour les extrémités de câble appliquées aux enveloppes unipolaires sont indiquées à la Figure 5. Quatre tailles normalisées données couvrent la plage des tensions (U_r) de 72,5 kV à 550 kV. Les deux types d'extrémités de câble de type sec sont représentés à la Figure 4. Dans le Type A, le composant élastomère par effluve électrique est incorporé dans l'isolateur. Le Type B incorpore l'isolateur dans le composant élastomère par effluve électrique.

Pour l'utilisation des extrémités de câble de type sec conformément à la Figure 5 dans les enveloppes des extrémités de câble remplies d'un fluide conformément à la Figure 3, un ou des adaptateurs d'interface appropriés doivent être fournis par le fabricant de l'extrémité de câble.

9.4 Enveloppe du raccordement de câble tripolaire

Les dimensions minimales d'une enveloppe de raccordement de câble tripolaire sont définies par la distance minimale entre phases issue de d_{10} et par la distance minimale entre phase et terre issue de $d_5/2$ conformément aux Figures 3 et 5 respectivement.

10 Renseignements à donner dans les appels d'offres, les soumissions et les commandes

Se reporter à l'IEC 60840 ou à l'IEC 62067 ou à l'IEC 60141 (toutes les parties) et à l'IEC 62271-203. En outre, l'utilisateur et les fabricants doivent prendre en compte les exigences d'installation de l'équipement. Les fabricants doivent spécifier les exigences spécifiques au génie civil et les distances électriques applicables à l'appareillage, de l'extrémité de câble et du câble. Des informations doivent être fournies en particulier et, si exigé, en relation avec la séquence de montage appareillage/extrémité de câble ainsi que le positionnement et la fixation temporaire des éléments applicables.

Au moment de la commande ou de la conception d'un appareillage, il est difficile de prévoir si et comment les systèmes de câble seront soumis à l'essai sur site. Afin de remédier à ce problème, l'utilisateur de l'appareillage doit identifier dans son appel d'offres chaque câble d'alimentation ainsi que la méthode d'essai correspondante. Un essai en courant continu ou en courant alternatif est par hypothèse généralement réalisé sur site. Les méthodes d'essai principales suivantes sont définies:

a) dans le cas où une extrémité du câble est installée à l'extérieur et si elle est accessible, elle peut être utilisée pour l'application de la tension d'essai;

b) dans le cas d'un raccordement de câble entre deux appareillages ou entre un appareillage et un transformateur, l'enveloppe du raccordement de câble de l'appareillage peut être utilisée pour l'application de la tension d'essai.

Il est de la responsabilité de l'utilisateur d'indiquer dans son appel d'offres les câbles d'alimentation qui doivent être prévus pour les essais et les méthodes d'essai exigées.

11 Règles pour le transport, le stockage, l'installation, le service et la maintenance

11.1 Généralités

Se reporter à l'IEC 62271-1:2017, Article 11.

Il convient que le fabricant de l'extrémité de câble vérifie que, pendant la fabrication, le transport et les manutentions, le stockage et l'installation des extrémités de câble, des dispositions ont été données pour répondre aux exigences du 6.2 de l'IEC 62271-1:2017,

après l'assemblage final du raccordement. Si l'extrémité de câble doit être installée par une autre personne que le fabricant de l'extrémité, il convient que ce dernier indique toutes les informations nécessaires pour satisfaire à ces exigences.

11.2 Essais après pose du système de câble

À la demande de l'utilisateur, le fabricant de l'appareillage doit prévoir des dispositions spéciales pour l'essai du système de câble, comme des possibilités de sectionnement, des possibilités de mise à la terre et/ou l'augmentation de la pression du gaz dans l'enveloppe du raccordement de câble dans les limites de conception. Cela est aussi applicable si des parties de l'appareillage reliées directement à l'assemblage de raccordement de câble ne peuvent pas tenir les tensions d'essai pour l'essai du système de câble spécifiées dans l'IEC 60141 (toutes les parties) ou l'IEC 60840 ou l'IEC 62067 à la masse volumique assignée de remplissage pour l'isolement. Cela s'applique également si, de l'avis du fabricant de l'appareillage, il n'est pas acceptable d'appliquer la tension d'essai aux composants de l'appareillage.

À la demande de l'utilisateur, le fabricant de l'appareillage doit prévoir l'emplacement pour une traversée d'essai adaptée ou indiquer à l'utilisateur tous les renseignements nécessaires pour le montage d'une telle traversée sur l'enveloppe du raccordement de câble. Si nécessaire à l'atteinte de distances d'isolement convenables, la traversée d'essai doit inclure une connexion convenablement isolée et une borne d'essai. L'exigence d'une traversée d'essai doit être spécifiée par l'utilisateur dans son appel d'offres.

NOTE L'augmentation de la pression de gaz n'est pas une méthode fiable pour améliorer l'effort électrique sur la surface d'un isolateur pendant un essai à la tension continue.

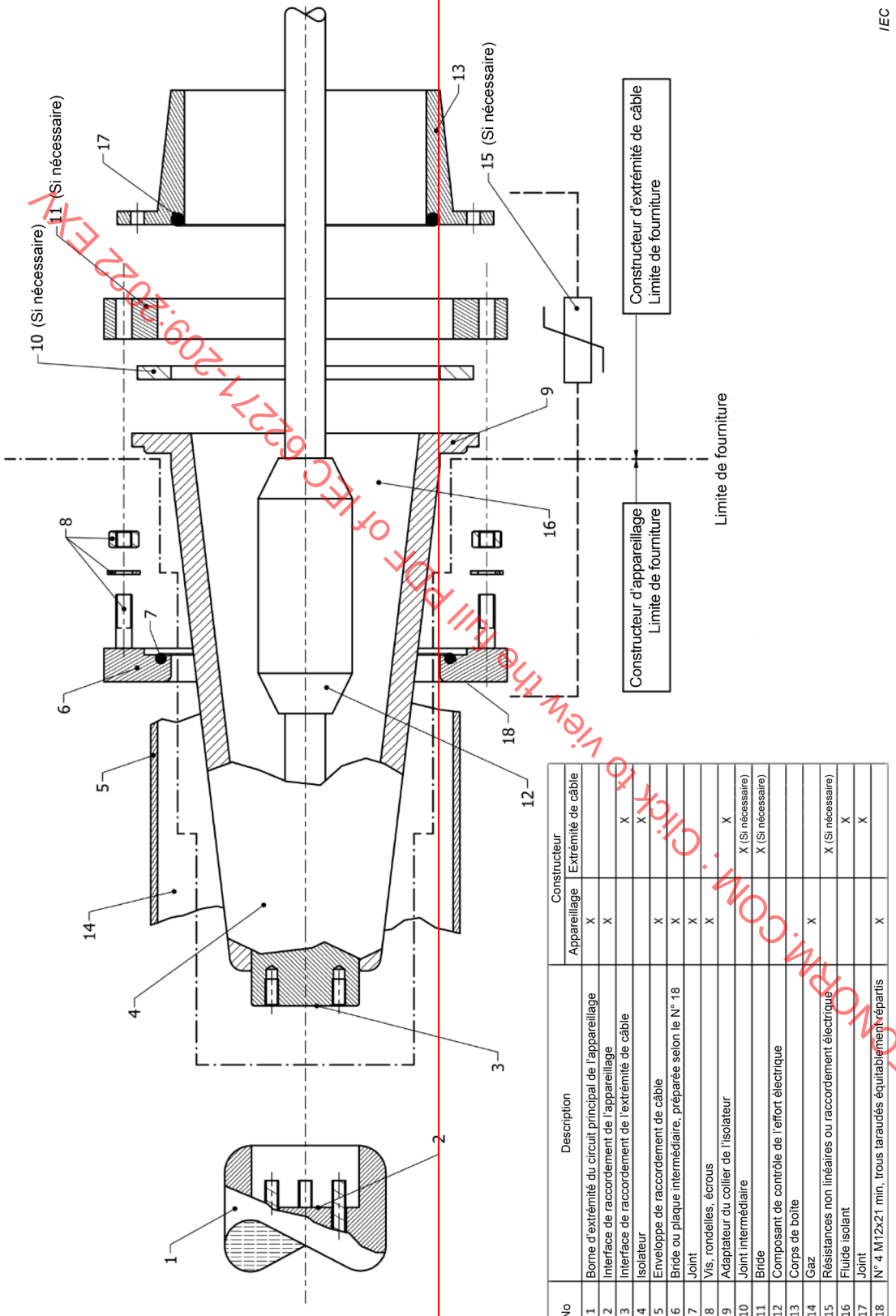
12 Pratiques en matière de sécurité et contraintes à l'installation de raccordement de câble à l'appareillage

Il convient d'étudier les pratiques suivantes lors de la manutention de l'équipement électrique sur le site:

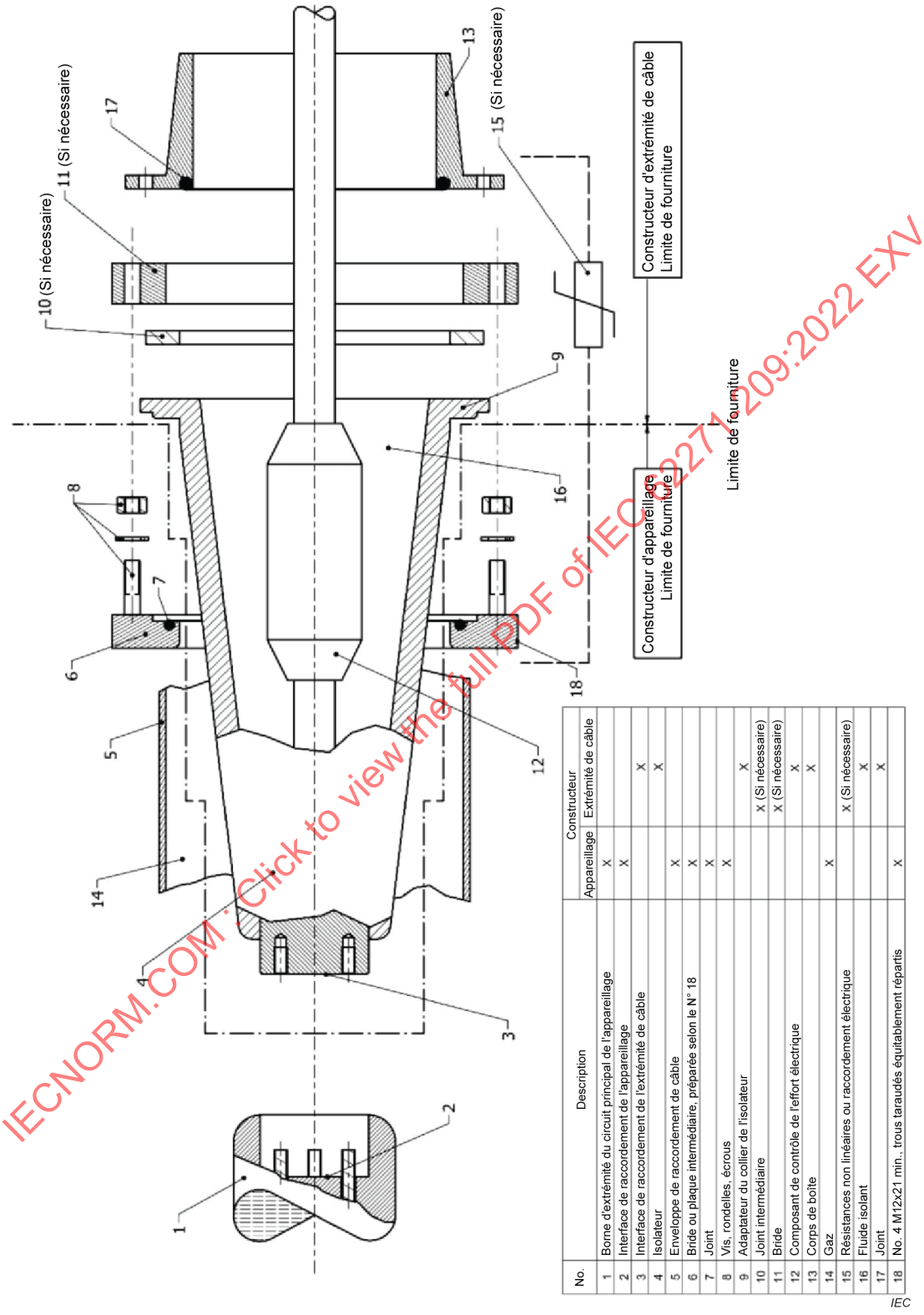
- avant tout travail sur l'équipement sur site, vérifier que le câble, l'appareillage et tous les équipements électriques adjacents sont hors tension et correctement reliés à la terre.
- les opérations de préparation du câble, d'installation des extrémités de câble et des raccordements à l'appareillage doivent être effectuées par du personnel qualifié et des jointoyeurs formés et expérimentés à l'installation sur site de ces produits ou de produits similaires.
- les instructions et précautions qui dépendent de la conception individuelle et des réglementations régionales, comme la réduction de la pression de gaz dans le compartiment limitrophe, doivent être étudiées.

13 Influence du produit sur l'environnement

L'Article 12 de l'IEC 62271-203:2011 s'applique.

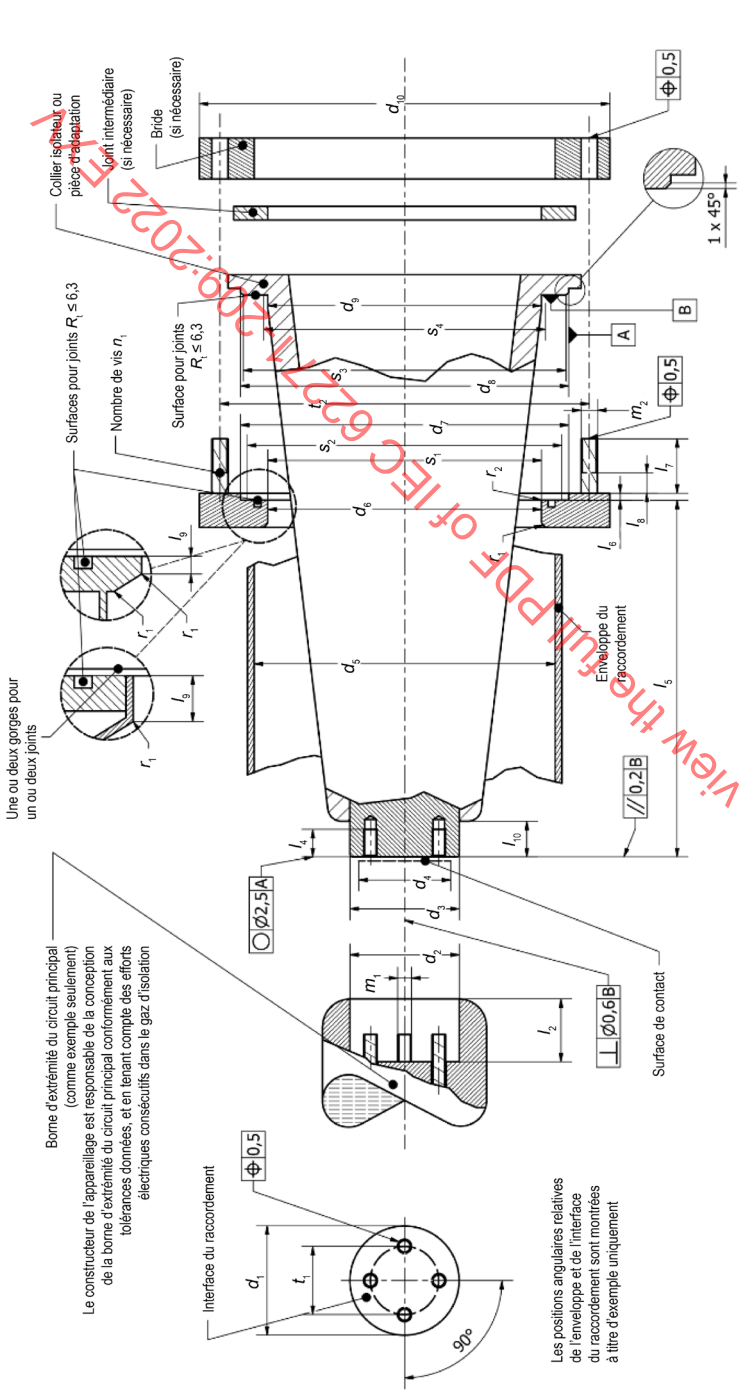


No	Description	Constructeur	
		Appareillage	Extrémité de câble
1	Borne d'extrémité du circuit principal de l'appareillage	X	
2	Interface de raccordement de l'appareillage	X	
3	Interface de raccordement de l'extrémité de câble		X
4	Isolateur		X
5	Enveloppe de raccordement de câble	X	
6	Bride ou plaque intermédiaire, préparée selon le N° 18	X	
7	Joint	X	
8	Vis, rondelles, écrous	X	X
9	Adaptateur du collier de l'isolateur		X (Si nécessaire)
10	Joint intermédiaire		X (Si nécessaire)
11	Bride		X (Si nécessaire)
12	Composant de contrôle de l'effort électrique		
13	Corps de boîte		
14	Gaz	X	
15	Résistances non linéaires ou raccordement électrique		X (Si nécessaire)
16	Fluide isolant		X
17	Joint		X
18	N° 4 M12x21 min, trous taraudés équitablement répartis	X	



No.	Description	Constructeur	
		Appareillage	Extrémité de câble
1	Borne d'extrémité du circuit principal de l'appareillage	X	
2	Interface de raccordement de l'appareillage	X	
3	Interface de raccordement de l'extrémité de câble		X
4	Isolateur		X
5	Enveloppe de raccordement de câble	X	
6	Bride ou plaque intermédiaire, préparée selon le N° 18	X	
7	Joint	X	
8	Vis, rondelles, écrous	X	
9	Adaptateur du collier de l'isolateur		X
10	Joint intermédiaire		X (Si nécessaire)
11	Bride		X (Si nécessaire)
12	Composant de contrôle de l'effort électrique		X
13	Corps de boîte		X
14	Gaz	X	
15	Résistances non linéaires ou raccordement électrique		X (Si nécessaire)
16	Fluide isolant		X
17	Joint		X
18	No. 4 M12x21 min., trous taraudés équitablement répartis	X	

Figure 2 – Assemblage de raccordement de câble rempli d'un fluide – Exemple de disposition

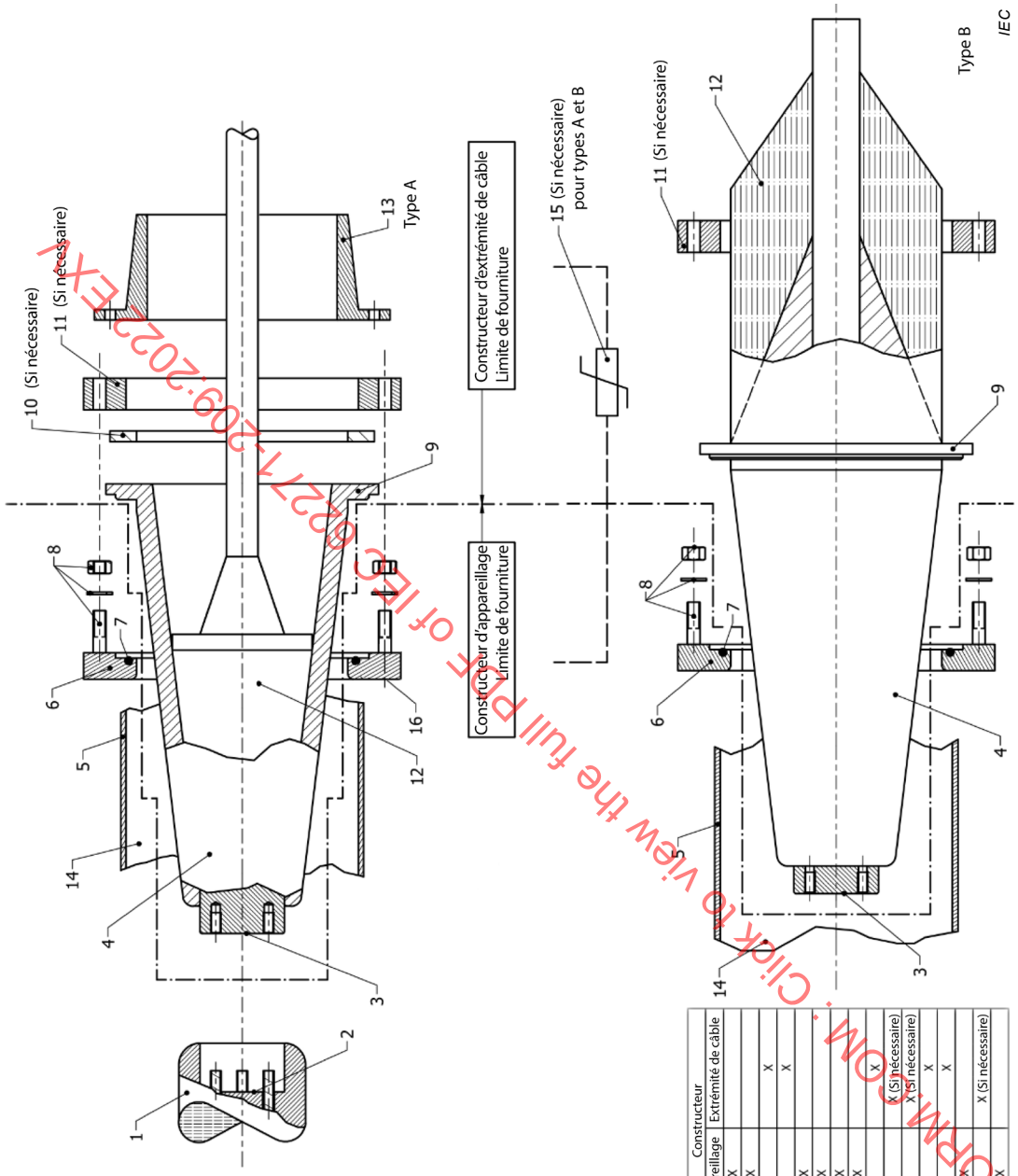


Tension assignée (kV)	Tension de tenue au choc (kVp)	d_1 max.	d_2 min.	d_3 max.	d_4 min.	d_5 min.	d_6	d_7	d_8	d_9 max. [b]	d_{10} max.	Dimension précédente l_3 supprimée l_3 max.	l_4 min.	l_5	l_6 max.	l_7 min.	l_8 max.	l_9 max.	l_{10} min.	m_1	m_2	n_1	r_1 min.	r_2 min.	s_1 min.	s_2 min.	s_3 max.	s_4 min.	s_4 max.	t_1	t_2
72,5 to 100	325 to 450	100	112	110	100	300	+3 -0	+0,5 -0	+0,3 -0,3	196	300	50	18	+1,0 -1,0	583	5,5	90	30	50	55	M10	8	10	10	205	241	242	206	+0,3 -0,3	80	+0,5 -0,5
123 to 170	550 to 750	100	112	110	100	300	+0,5 -0	+0,5 -0	+0,5 -0,3	250	350	50	18	+1,0 -1,0	757	5,5	90	30	50	55	M12	12	10	1,5	258	294	295	266	+0,3 -0,3	80	+0,5 -0,5
245 to 300	850 to 1 050	139	202	200	140	480	+5 -0	+0,5 -0	+0,3 -0,3	440	620	100	21	+2,0 -2,0	960	6	110	30	105	105	M12	16	10 [a]	2,5	490	554	555	491	+0,3 -0,3	110	+0,5 -0,5
362 to 550	1 175 to 1 550	139	252	250	140	540	+5,0 -0	+0,5 -0	+0,3 -0,3	500	690	100	21	+2,0 -2,0	1 400	6	110	30	70	105	M12	20	10 [a]	2,5	550	612	613	551	+0,3 -0,3	110	+0,5 -0,5

[a] Si $d_5 > d_6$.

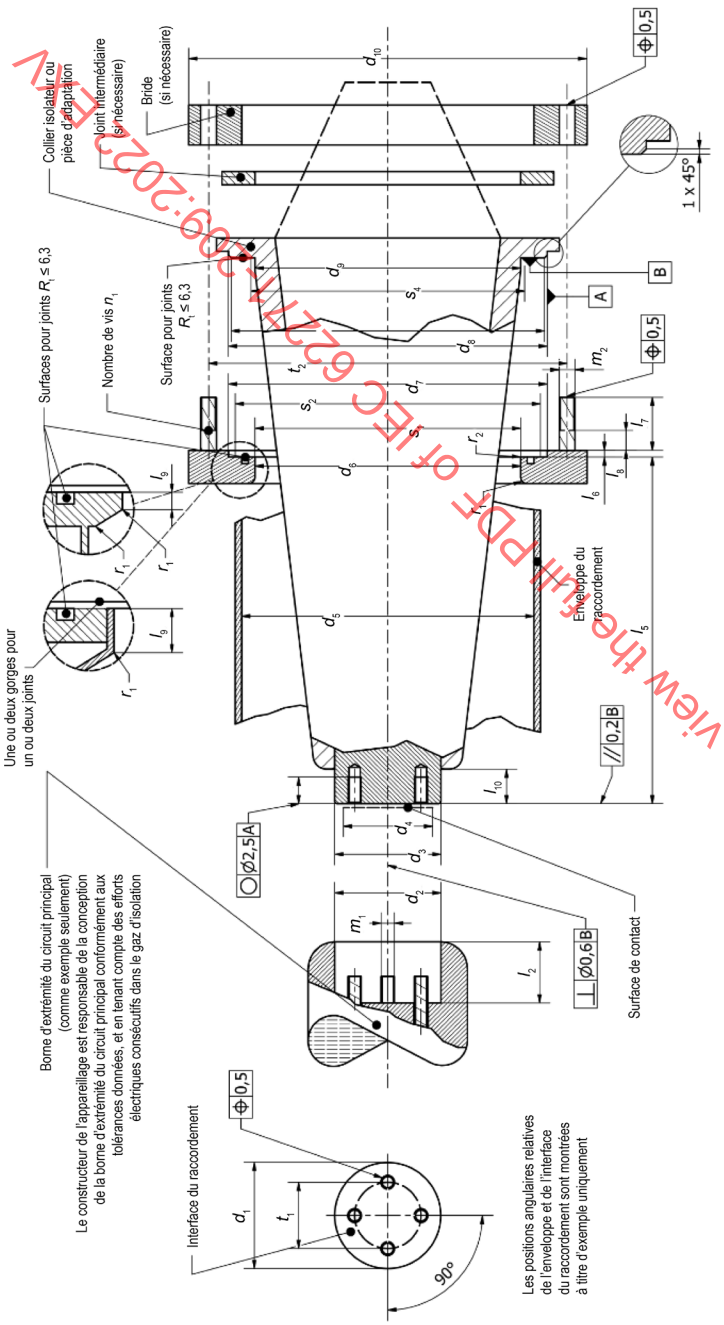
[b] d_9 et le congé de raccordement ne doivent pas interférer avec d_6 et r_2.

Figure 3 – Assemblage de raccordement de câble rempli d'un fluide – Dimensions de l'appareil



No	Description	Constructeur	
		Appareillage	Extrémité de câble
1	Borne d'extrémité du circuit principal de l'appareillage	X	
2	Interface de raccordement de l'appareillage	X	
3	Interface de raccordement de l'extrémité de câble		X
4	Isolateur		X
5	Enveloppe de raccordement de câble	X	
6	Bride ou plaque intermédiaire, préparée selon le N° 16	X	
7	Joint	X	
8	Vis, rondelles, écrous	X	
9	Adaptateur du collier ou de l'isolateur		X
10	Joint intermédiaire		X (Si nécessaire)
11	Bride		X (Si nécessaire)
12	Composant de contrôle de l'effort électrique (élastomère)		X
13	Corps de boîte		X
14	Gaz	X	
15	Résistances non linéaires ou raccordement électrique		X (Si nécessaire)
16	N° 4 M12x21 min, trous taraudés équitablement répartis	X	

Figure 4 – Assemblage de raccordement de câble sec – Exemples de dispositions



Tension assignée (kV)	Tension de tenue au choc (kVp)	d_1 max.	d_2 min.	d_3 max.	d_4 min.	d_5 min.	d_6	d_7	d_8	d_9 max. [b]	d_{10} max.	Dimension précédente l_1 supprimée l_2 max.	Dimension précédente l_3 supprimée l_4 min.	l_5	l_6 max.	l_7 min.	l_8 max.	l_9 max.	l_{10} min.	m_1	m_2	n_1	r_1 min. [a]	r_2 min.	s_1 min.	s_2 max.	s_3 min.	s_4 max.	t_1	t_2
72,5 to 100	325 to 450	100	112	110	100	300	+3 -0	200 +0,5 -0	246 +0,5 -0	245 +0,3 -0,3	196	300	50	18	+1,0 310 -1,0	5,5	90	30	50	M10	M10	8	10	1	205	241	242	206	+0,3 80 -0,3	+0,5 270 -0,5
123 to 170	550 to 750	100	112	110	100	300	+0,5 -0	255 +0,5 -0	299 +0,5 -0	298 +0,3 -0,3	250	350	50	18	+1,0 470 -1,0	5,5	90	30	50	M10	M12	12	10	1,5	258	294	295	266	+0,3 80 -0,3	+0,5 320 -0,5
245 to 300	850 to 1 050	139	202	200	140	400	+5 -0	385 +5,0 -0	455 +0,5 -0	454 +0,3 -0,3	375	500	100	21	+2,0 620 -2,0	6	110	30	70	M12	M12	16	10	2,5	390	450	451	391	+0,3 110 -0,3	+0,5 475 -0,5
362 to 550	1 175 to 1 550	139	252	250	140	540	+5,0 -0	540 +0,5 -0	618 +0,5 -0	617 +0,3 -0,3	500	690	100	21	+2,0 960 -2,0	6	110	30	70	M12	M16	20	10	2,5	550	612	613	551	+0,3 110 -0,3	+0,5 640 -0,5

[a] Si $d_5 > d_6$.
[b] d_9 et le congé de raccordement ne doivent pas interférer avec d_6 et r_2.

Figure 5 – Assemblage de raccordement de câble sec – Dimensions de l'appareillage

Annexe A
(informative)

Forces mécaniques appliquées sur la bride de l'enveloppe du raccordement de câble

A.1 Généralités

Il convient que le fabricant de l'appareillage et le fabricant des câbles travaillent en coordination sur la conception du système de câble. Les variations de température en conditions de service peuvent induire des forces additionnelles à l'appareillage et au système de câble et des mouvements sur les raccordements de câble unipolaire ou tripolaire. Ces forces peuvent agir sur l'appareillage et sur le système de câble et dépendent principalement de l'implantation de l'appareillage, du type de câble et des moyens de support de l'appareillage et du système de câble. Il convient que la conception de toutes les structures prenne en compte ces forces et ces mouvements.

A.2 Recommandation lors du raccordement du système de câble à l'appareillage

Il convient d'envisager le système d'appareillage comme un système qui permet de limiter les tolérances de déplacement lors de toutes les conditions de fonctionnement qui se produisent en ce qui concerne son raccordement au système de câble. Il convient d'envisager le système de câble comme un système qui permet de limiter les tolérances de déplacement lors du service en ce qui concerne son raccordement à l'appareillage. Il convient que le concepteur de l'appareillage spécifie les tolérances, les forces et les charges de déplacement couvrant toutes les conditions de fonctionnement, et les documente dans les plans appropriés. Il convient que ces données soient prises en compte par le concepteur du système de câble.

Il convient que le fournisseur de l'appareillage prévoie la structure de support de l'enveloppe du raccordement de câble. Elle comprend un point coulissant qui permet le déplacement de l'enveloppe du raccordement de câble, ce qui permet la dilatation ou le retrait causé(e) par des variations de température.

Il convient de concevoir la structure de support de l'enveloppe du raccordement de câble de l'appareillage de façon à ce qu'un point de fixation de câble centré adjacent puisse être ajouté à la structure, et qu'il n'y ait pas de déplacement relatif entre l'enveloppe du raccordement de câble et le point de fixation centré, lorsque cela est possible.

Il peut être nécessaire de concevoir une enveloppe de raccordement de câble comme un point de fixation. C'est le cas lorsque par exemple une installation d'un système de câble à huile à haute pression n'est pas capable, en raison de sa conception, d'absorber le déplacement thermique causé par l'appareillage. Dans ce cas le fabricant de l'appareillage doit prévoir des mesures appropriées, par exemple un équipement de compensation. Il est de la responsabilité de l'utilisateur d'informer le fabricant de l'appareillage de l'installation d'un tel système de câble dans l'appel d'offres.

Il est aussi particulièrement important de noter qu'il convient que les supports des enveloppes de l'appareillage ne soient fixés ni sur le collier de l'isolateur et/ou sur la bride (parties 9 et 11 de la Figure 2 ou 4), ni sur la bride de l'enveloppe du raccordement de câble (élément 6 de la Figure 2 ou 4).

NOTE 1 L'assemblage des parties 6 et 11 des Figures 2 ou 4 sert de connexion étanche au gaz et est réservé aux charges issues de l'extrémité de câble et du raccordement de câble fixé.

Il convient de réserver de préférence l'élément 6 des Figures 2 et 4 à la fixation d'une construction anti-déformation (protection contre la flexion), si nécessaire, dont la fonction est d'empêcher les forces de flexion et les forces axiales sur l'extrémité de joint, et de fixer la position du câble par rapport à la bride de l'enveloppe du raccordement de câble. Il convient de porter une attention particulière au type de mise à la terre à la gaine du câble. Dans le cas où un écran d'isolation est présent, il convient que le centrage anti-déformation ne court-circuite pas cette isolation. Le câble peut être posé en serpentin afin de réduire la poussée du conducteur sur l'isolateur. La fourniture d'une construction anti-déformation est de la responsabilité du fournisseur du système de câble.

En plus de la charge émergeant de la pression de gaz maximale de fonctionnement spécifiée au 6.103, la bride de l'enveloppe du raccordement de câble (élément 6 de la Figure 2 ou 4) fixée à l'extrémité de câble est soumise aux forces normales et exceptionnelles suivantes lors du service:

– des forces issues du mouvement transversal de l'enveloppe du raccordement de câble causé par les variations de température de l'appareillage;
– une partie du poids de l'extrémité de câble fixé, la construction anti-déformation (le cas échéant) et une partie du poids du système de câble en fonction de la tension assignée et du type de conducteur de câble;
– des forces de court-circuit entre les câbles fixés;
– des forces sismiques issues de l'extrémité de câble, du raccordement de câble et des structures de support du système de câble ou des parties de celui-ci, le cas échéant.

Les forces lors du fonctionnement normal qui se produisent comme décrit ci-dessus doivent être limitées par des mesures appropriées aux valeurs énumérées dans le Tableau A.1.

Il convient que les forces issues de la dilatation ou du retrait du câble causé(e) par une variation de température transmises à l'enveloppe du raccordement de câble de l'appareillage soient réduites le plus possible via des moyens appropriés, comme la fixation ou la pose des câbles en serpentins. Cependant, ces forces donnent lieu à l'application simultanée:

– d'un moment de flexion M_0;
– d'un effort de cisaillement F_t;
– d'une force de traction ou de compression F_a

à l'enveloppe du raccordement de câble (élément 6 de la Figure 2 ou 4). Il convient que la bride de l'enveloppe du raccordement de câble supporte les valeurs de M_0, F_t et F_a spécifiées dans le Tableau A.1. Il convient que le concepteur du système de câble vérifie que ces valeurs ne sont pas dépassées.

En cas de charges exceptionnelles, comme des forces de court-circuit ou des forces sismiques, il convient que les charges totales ne dépassent pas au maximum 200 % des charges normales données dans le Tableau A.1.

NOTE 2 L'exigence relative au rapport entre les charges normales et exceptionnelles est conforme aux charges d'essai du rapport du service et de la console du Tableau 1 de l'IEC 60137:2017 [1].

Tableau A.1 – Forces et moments appliqués sur la bride de l'enveloppe du raccordement de câble fixée à l'extrémité de câble en fonctionnement normal

Tension assignée U_{rm} (kV)	Force de traction ou de compression F_a (kN)	Effort de cisaillement F_t (kN)	Moment de flexion M_0 (kNm)
> 52 à 100	1,0	1,0	1,2
123 à 170	1,5	1,5	1,8
245 à 300	2,5	2,5	3,0
362 à 550	4,5	4,5	5,4

NOTE 1 F_a agit en direction axiale du câble, F_t en direction transverse.

NOTE 2 M_0 découle de l'action de F_t à une distance de 1,2 m de la bride la plus basse de l'enveloppe du raccordement de câble (élément 6).

NOTE 3 Les forces du Tableau A.1 s'entendent par câble et s'appliquent aux connexions unipolaires et tripolaires.

La coordination de conception entre le fabricant du PSEM et le fournisseur du système de câble est exigée afin de vérifier que les exigences ci-dessus ayant rapport aux forces et charges normales et exceptionnelles ne sont en aucun cas dépassées.

Bibliographie

[1] IEC 60137:2017, *Traversées isolées pour tensions alternatives supérieures à 1 000 V*

[2] IEC 62271-207, *Appareillage à haute tension – Partie 207: Qualification sismique pour ensembles d'appareillages à isolation gazeuse pour des niveaux de tension assignée supérieurs à 52 kV*

[3] IEEE Std 1300:2011, *IEEE Guide for Cable Connections for Gas-Insulated Substations* (disponible en anglais seulement)

[4] CIGRE brochure 89:1995, *Accessories for HV Extruded Cables* (disponible en anglais seulement)

[5] CIGRE TB 44:1993, *Earthing of GIS – An Application Guide* (disponible en anglais seulement)

IEC 62271-209

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CONSOLIDATED VERSION

FINAL VERSION

VERSION FINALE

High-voltage switchgear and controlgear –
Part 209: Cable connections for gas-insulated metal-enclosed switchgear for rated voltages above 52 kV – Fluid-filled and extruded insulation cables – Fluid-filled and dry-type cable-terminations

Appareillage à haute tension –
Partie 209: Raccordement de câbles pour appareillage sous enveloppe métallique à isolation gazeuse de tension assignée supérieure à 52 kV – Câbles remplis d'un fluide ou à isolation extrudée – Extrémité de câble de type sec ou remplie d'un fluide

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Part 209: Cable connections for gas-insulated metal-enclosed switchgear for rated voltages above 52 kV – Fluid-filled and extruded insulation cables – Fluid-filled and dry-type cable terminations

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This consolidated version of the official IEC Standard and its amendment has been prepared for user convenience.

IEC 62271-209 edition 2.1 contains the second edition (2019-02) [documents 17C/696/FDIS and 17C/701/RVD] and its amendment 1 (2022-03) [documents 17C/833/FDIS and 17C/841/RVD].

This Final version does not show where the technical content is modified by amendment 1. A separate Redline version with all changes highlighted is available in this publication.

International Standard IEC 62271-209 has been prepared by subcommittee 17C: Assemblies, of IEC technical committee 17: High-voltage switchgear and controlgear.

This second edition constitutes a technical revision.

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

a) New numbering in accordance with ISO/IEC directives, Part 2 (2016) and to IEC 62271-1:2017;
b) Clause 3: addition of a definition for plug-in cable termination, filling pressure and minimum function pressure for insulation;
c) Clause 7: An additional dielectric type test for plug-in cable termination was added; also a pressure type test as well as a leak rate test on the insulator of a cable termination was implemented;
d) Clause 12: New clause about safety practices;
e) Clause 13: New clause about influence of the product on the environment;
f) New informative Annex A: Mechanical forces applied on the flange of the cable connection enclosure.

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

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

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

The committee has decided that the contents of the base publication and its amendment will remain unchanged until the stability date indicated on the IEC web site under webstore.iec.ch in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

INTRODUCTION TO Amendment 1

This amendment includes the following modifications:

a) In accordance with the decision taken at IEC Plenary Meeting October 2019 in Shanghai (17C/Shanghai/Sec07) Subclause 6.103, Figure 1 and Figure 2 have been modified;

b) The CDV was modified in accordance with the above-mentioned documents and based on the decision taken at the virtual IEC Plenary Meeting in October 2021 (17C/823/RM).

NOTE CIGRE has published TB 784 “Standard design of a common, dry type plug-in interface for GIS and power cables up to 145 kV describing the basis for further standardisation of such a common interface. The matter will be dealt with during the next revision of IEC 62271-209.

HIGH-VOLTAGE SWITCHGEAR AND CONTROLGEAR –

Part 209: Cable connections for gas-insulated metal-enclosed switchgear for rated voltages above 52 kV – Fluid-filled and extruded insulation cables – Fluid-filled and dry-type cable terminations

1 Scope

This part of IEC 62271 covers the connection assembly of fluid-filled and extruded cables to gas-insulated metal enclosed switchgear (GIS), in single- or three-phase arrangements where the cable terminations are fluid-filled or dry-type and there is a separating insulating barrier between the cable insulation and the gas insulation of the switchgear.

The purpose of this document is to establish electrical and mechanical interchangeability between cable terminations and the gas-insulated metal-enclosed switchgear and to determine the limits of supply. It complements and amends, if applicable, the relevant IEC standards. For the purpose of this document the term "switchgear" is used for "gas-insulated metal enclosed switchgear".

It does not cover directly immersed cable terminations, as described in CIGRE brochure 89 [4][1].

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, *IEC standard voltages*

IEC 60068-2-17:1994, *Basic environmental testing procedures – Part 2-17:Tests – Test Q: Sealing*

IEC 60141 (all parts), *Tests on oil-filled and gas-pressure cables and their accessories*

IEC 60376, *Specification of technical grade sulphur hexafluoride (SF_6) and complementary gases to be used in its mixtures for use in electrical equipment*

IEC 60480, *Guidelines for the checking and treatment of sulphur hexafluoride (SF_6) taken from electrical equipment and specification for its re-use*

IEC 60840, *Power cables with extruded insulation and their accessories for rated voltages above 30 kV (U_m = 36 kV) up to 150 kV (U_m = 170 kV) – Test methods and requirements*

IEC 62067, *Power cables with extruded insulation and their accessories for rated voltages above 150 kV (U_m = 170 kV) up to 500 kV (U_m = 550 kV) – Test methods and requirements*

[1] Numbers in square brackets refer to the Bibliography.

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

IEC 62271-203:2011, *High-voltage switchgear and controlgear – Part 203:Gas-insulated metal-enclosed switchgear for rated voltages above 52 kV*

3 Terms and definitions

For the purposes of this document, the following terms and definitions 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

3.1
cable termination
equipment fitted to the end of a cable to ensure electrical connection with other parts of the system and to maintain the insulation up to the point of connection

3.1.1
fluid-filled cable termination
cable termination which comprises a separating insulating barrier between the cable insulation and the gas insulation of switchgear, including a fluid

3.1.2
dry-type cable termination
cable termination which comprises an elastomeric electrical stress control component in direct contact with a separating insulating barrier (insulator) between the cable insulation and the gas insulation of the switchgear, not requiring any fluid

3.2
main circuit end terminal
part of the main circuit of a gas-insulated metal enclosed switchgear forming part of the connection interface

3.3
cable connection enclosure
part of the gas-insulated metal-enclosed switchgear which houses the cable termination and the main circuit end terminal

3.4
cable connection assembly
combination of a cable termination, a cable connection enclosure and a main circuit end terminal, which mechanically and electrically connects the cable to the gas-insulated metal enclosed switchgear

3.5
plug-in cable termination
cable termination where cable/stress cone assembly can be engaged into the insulator assembly that is already installed into switchgear enclosure

3.6
design pressure
pressure used to determine the design of the enclosure and the components of the cable termination subjected to that pressure

Note 1 to entry: It is at least equal to the maximum pressure in the enclosure at the highest temperature that the gas used for insulation can reach under specified maximum service conditions.

3.7
fluid
liquid or gas for insulation purposes

3.8
cable system
cable with installed accessories

3.9
filling pressure p_{re} for insulation
filling density ρ_{re} for insulation
pressure (in Pa), for insulation, referred to the standard atmospheric air conditions of 20 °C and 101,3 kPa, which may be expressed in relative or absolute terms (or density), to which the assembly is filled before being put into service

3.10
minimum functional pressure p_{me} for insulation
minimum functional density ρ_{me} for insulation
pressure (in Pa), for insulation, referred to the standard atmospheric air conditions of 20 °C and 101,3 kPa, which may be expressed in relative or absolute terms (or density), at which and above which the characteristics of the switchgear-cable connection are maintained and at which replenishment becomes necessary

4 Normal and special service conditions

4.1 General

Clause 2 of IEC 62271-203:2011 is applicable.

4.2 Normal service conditions

Subclause 2.1 of IEC 62271-203:2011 is applicable.

4.3 Special service conditions

Subclause 2.2 of IEC 62271-203:2011 is applicable.

5 Ratings

5.1 General

When dimensioning the cable connection assembly, the following rated values shall apply:

a) rated voltage of the equipment of the cable connection (U_{rm});
b) rated insulation level (U_p, U_d and U_s where applicable);
c) rated frequency (f_r)
d) rated continuous current (I_r);
e) rated short-time withstand current (I_k);
f) rated peak withstand current (I_p);
g) rated duration of short circuit (t_k).

5.2 Rated voltage of the equipment of the cable connection (U_{rm})

The rated voltage for the equipment of the cable connection (U_{rm}) is equal to the lower of the values U_m for the cable system and U_r for the gas-insulated metal-enclosed switchgear and shall be selected from the following standard values:

72,5 kV – 100 kV – 123 kV – 145 kV – 170 kV – 245 kV – 300 kV – 362 kV – 420 kV – 550 kV

NOTE 1 Values above U_r = 550 kV are not considered.

NOTE 2 U_m = 100 kV is not defined in IEC 60840.

5.3 Rated insulation level (U_d, U_p, U_s)

The rated insulation level for the cable connection assembly shall be selected from the values given in IEC 60038 as well as IEC 62271-203.

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)

The connection interface of the main circuit shown in Figures 2 and 3 for fluid-filled cable terminations and Figures 4 and 5 for dry-type cable terminations is applicable at rated continuous currents up to 3 150 A.

The connection interface shall be designed so that at a current equal to the cable rated current corresponding to a maximum temperature of 90 °C, no heat transfer from the switchgear main circuit end terminal to the cable termination will occur.

NOTE As the maximum conductor temperature for cables is limited by the maximum operating temperature for the insulation, there are certain cable dielectrics which cannot withstand the maximum temperature specified for gas-insulated metal-enclosed switchgear if there is heat transfer across the connection interface to the cable terminations.

For cases when the above design requirement of 90 °C at rated continuous current of the cable system cannot be allowed because of cable design limitations, the manufacturer of the switchgear should provide the necessary data on temperature rise of the main circuit end terminal and of the insulating gas as a function of current.

5.6 Rated short-time withstand current (I_k)

Short-time currents of short circuit shall refer to the levels provided by the cable system, not exceeding the values defined for the switchgear in line with IEC 62271-1.

5.7 Rated peak withstand current (I_p)

Peak withstand currents of short circuit shall refer to the levels provided by the cable system, not exceeding the values defined for the switchgear in line with IEC 62271-1.

5.8 Rated duration of short circuit (t_k)

The duration of short circuit shall refer to the levels provided by the cable system, not exceeding the values given in IEC 62271-1.

6 Design and construction

6.1 Gas and vacuum tightness

Subclause 6.16 of IEC 62271-1:2017 is applicable with the following addition:

For conditions up to the maximum occurring gas operating pressure, the cable termination shall prevent insulating gas from the switchgear diffusing into the interior of the cable termination and into the cable. The cable termination shall prevent insulating fluid from the cable termination entering the switchgear. The insulator (part 4 in Figures 2 and 4) shall be capable of withstanding the vacuum conditions when the cable connection enclosure is evacuated, as part of the gas filling process.

In the case of a gas insulated cable or a gas insulated termination, the gas compartment of the cable or of the gas insulated termination shall be treated independently from the switchgear with respect to tightness.

6.101 Limits of supply

6.101.1 General

The limits of supply of gas-insulated metal-enclosed switchgear and the cable termination shall be in accordance with Figure 2 for fluid-filled cable terminations and Figure 4 for dry-type cable terminations.

6.101.2 Over-voltage protection and earthing

It is necessary to have either a direct low resistance connection or an insulated section bridged by non-linear resistors between part 6 and part 13 of Figure 2 for fluid-filled cable terminations and Figure 4 for dry-type cable terminations. To enable suitable connections to be made to the switchgear, for the purposes of this direct connection or installation of any sheath voltage limiting device, the switchgear manufacturer shall provide four connection points per phase (evenly spaced around each phase) each comprising an M12 threaded hole of minimum 21 mm length (for all voltage levels). The position of these 4 connection points is different from the mechanical connection points used for fixing the cable termination insulator. The number of connection points used shall be determined by the cable system designer.

Where applicable, the number and characteristics of the non-linear resistors shall be determined by the cable system designer, and they shall be supplied by the cable termination manufacturer, taking into consideration the requirements of the user and the switchgear manufacturer. Reference is made to CIGRE TB 44, 1993 [5], as well as to IEEE 1300-2011, Clause 11 [3].

In addition, the installation design of the area around the cable termination shall take into account the space required to install any non-linear resistors, including adequate clearances to earth.

For three phases in one enclosure arrangements special clarification between the GIS manufacturer, the cable termination manufacturer and the cable system designer may be necessary because of limited space between the three phases.

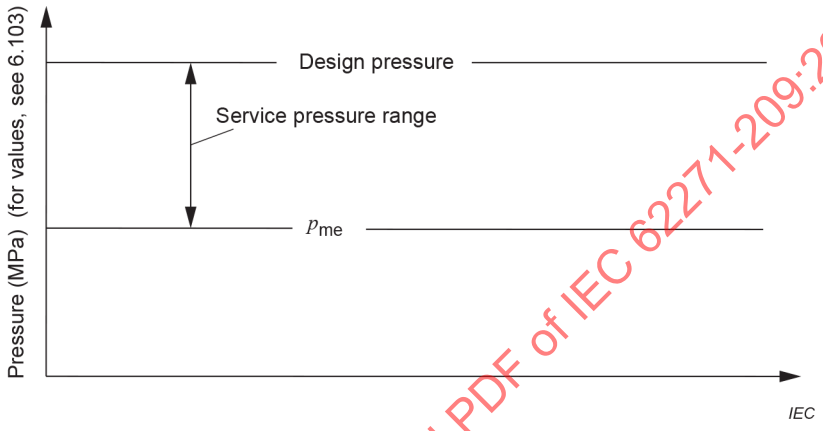
The overvoltage protection elements, i.e. connections between part 6 and part 13 of Figure 2 for fluid-filled cable terminations and Figure 4 for dry-type cable terminations as described above, are not meant to serve as the cable system grounding connection.

Earthing of enclosures shall be in accordance with the relevant subclause of IEC 62271-203:2011.

6.102 Filling pressure of insulating gas in the cable connection enclosure

If SF_6 is used as the insulating gas, the minimum functional pressure for insulation p_{me} used to determine the design of the cable termination insulation shall not exceed p_{me} = 0,35 MPa (absolute) at 20 °C for maximum rated voltages up to 300 kV. For maximum rated voltages exceeding 300 kV the minimum functional pressure for insulation p_{me} used to determine the design of the cable termination insulation shall not exceed p_{me} = 0,4 MPa (absolute) at 20°C (see Figure 1).

The filling pressure p_{re} of insulating gas is assigned by the switchgear manufacturer but shall in no case be lower than p_{me}. The service pressure is in no case higher than the design pressure as per 6.103.



p_{me} minimal functional pressure for insulation depending on rated voltage

Figure 1 – Operating pressure of the gas insulation in the cable connection enclosure

If a gas other than SF_6 or a gas mixture is used, the minimum functional pressure shall be chosen to provide the same dielectric performance as in case of SF_6. The minimum functional pressure shall be below the maximum service pressure and design pressure of the enclosure as per 6.103.

6.103 Pressure withstand requirements

The design pressure for the outside of the cable termination is determined by the particular GIS design around the GIS/cable interface. Typical maximum gas pressures in service are up to 1,1 MPa (absolute) for SF_6 and up to 1,5 MPa (absolute) for other gases and gas mixtures.

The particular pressure withstand requirements coming from the specific gas and GIS design shall be thoroughly coordinated between GIS and cable termination manufacturer as well as the user.

NOTE Due to the lower service current of a HV-cable connection than the rated current of a GIS, the related temperature and pressure rise within the cable compartment can be lower. The design pressure of the GIS could be higher than the design pressure of the cable termination.

6.104 Mechanical forces on cable terminations

The manufacturer of the cable termination in a three-phase connection shall take into account the total dynamic forces generated during short circuit conditions. These forces consist of those generated within the cable termination and those coming from the main circuit of the switchgear. The maximum additional force applied from the switchgear to the connection interface (Figures 2 or 4) transversely and then being transferred from the main circuit end terminal shall not exceed 5 kN for a three phase arrangement. For single-phase connections,

the maximum additional force applied from the switchgear to the connection interface (Figures 2 or 4) transversely and then being transferred from the main circuit end terminal shall not exceed 2 kN. It is the responsibility of the manufacturer of the switchgear to ensure that the specified forces are not exceeded or to agree with the cable termination manufacturer that the cable termination shall withstand the higher forces.

For both single-phase and three-phase connections, additional forces and movements from the switchgear can be experienced due to temperature variations and vibrations in service. These forces can act on both switchgear and cable termination and depend largely on the switchgear layout, termination installation, cable design and the methods of mechanical support. The design of any support structure shall take into account these forces and movements. It is particularly important that the support for the switchgear shall not be affixed to the insulator collar and/or clamping flange, parts 9 and 11 of Figures 2 or 4. Further information regarding mechanical forces on the flanges of the cable connection enclosure are given in Annex A.

For seismic requirements, the switchgear manufacturer carries out a seismic calculation in order to identify the location of mechanical reinforcements; reference is made to IEC 62271-207 [2].

6.105 Switchgear connection interface and cable termination connection interface

The normal current-carrying contact surfaces of the switchgear and cable termination connection interface (refer to parts 2 and 3 of Figures 2 and 4) shall be silver coated or copper coated or non-coated solid copper.

7 Type tests

7.1 General

For type tests as per IEC 62271-1:2017, 7.1 applies. If SF_6 is used, technical grade SF_6 in accordance with IEC 60376 or used SF_6 in accordance with IEC 60480 shall be used.

7.2 Electrical type tests of cable terminations

7.2.1 General

The electric type tests of the cable termination shall be carried out according to the electrical type tests defined in IEC 60141 (all parts) or IEC 60840 or IEC 62067 as relevant for the cable design. Where applicable the insulator shall be tested to 7.2.4.

The cable termination shall be installed in an enclosure as per 7.2.2, filled with insulating gas at the pressure not exceeding p_{me}+0,02 MPa with filling pressure specified in 6.102.

The design of the main circuit end terminal (part 1 in Figures 2 or 4 respectively) used in the test as connection to part 3 of the cable connection assembly shall comply with Figures 2 and 4 respectively of this document.

7.2.2 Electrical type test of cable terminations in a single-phase enclosure

The cable termination is surrounded by a metal cylinder connected to earth, the maximum internal diameter is equal to d_5 for the four standard sizes of cable connection enclosure (d_5 in Figure 3 for fluid-filled cable terminations and Figure 5 for dry-type cable terminations). The minimum length of the metal cylinder shall be in accordance with the dimension l_5 given in Figures 3 and 5.