IEC 62271-209

Edition 2.0 2019-02
REDLINE VERSION

INTERNATIONAL STANDARD

colour inside

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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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 cancels and replaces the first edition published in 2007. This 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.

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

FDIS	Report on voting
17C/696/FDIS	17C/701/RVD

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

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 this document will remain unchanged until the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific document. At this date, the document will be

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- withdrawn,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

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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

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 ~~necessary~~ 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~~:1983~~, *IEC standard voltages* ~~[2]~~
~~Amendment 1 (1994)~~
~~Amendment 2 (1997)~~

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 60141-1:1993, *Tests on oil-filled and gas-pressure cables and their accessories – Part 1: Oil-filled, paper-insulated, metal-sheathed cables and accessories for alternating voltages up to and including 400 kV*~~

~~IEC 60141-2:1963, *Tests on oil-filled and gas-pressure cables and their accessories – Part 2: Internal gas-pressure cables and accessories for alternating voltages up to 275 kV*~~

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

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1 Numbers in square brackets refer to the Bibliography.

~~2 There exists a consolidated version (2002) including Amendment 1 and 2.~~

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

~~IEC 60694:1996, *Common specifications for high-voltage switchgear and controlgear standards*~~

IEC 60840~~:2004~~, *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~~:2001~~, *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*
~~Amendment 1 (2006)~~

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

IEC 62271-203:~~2003~~ 2011, *High-voltage switchgear and controlgear – Part 203: Gas-insulated metal-enclosed switchgear for rated voltages above 52 kV*

~~Report of CIGRE WG 23-10, ELECTRA 151, December 1993, *Earthing of GIS – An Application Guide*~~

~~CIGRE brochure 89: *Accessories for HV Extruded Cables, CIGRE WG 21.06, 1995, Chapter 2.1.5 Directly Immersed Metal Enclosed GIS Termination*~~

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. ~~Two types are described in this standard.~~

3.1.1
fluid-filled cable termination
cable termination which comprises ~~of~~ a separating insulating barrier between the cable insulation and the gas insulation of switchgear, including a fluid. ~~The cable-termination includes an insulating fluid as part of the cable connection assembly.~~

3.1.2
dry-type cable termination
cable termination which comprises an elastomeric electrical stress control component in ~~intimate~~ direct contact with a separating insulating barrier (insulator) between the cable insulation and the gas insulation of the switchgear, not requiring any fluid. ~~The cable-termination does not require any insulating 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 ~~thickness~~ design of the enclosure and the components of the cable termination subjected to that pressure ~~(according to IEC 62271-203:2003)~~

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~~/insulating fluid~~
~~the term "fluid" means a~~ liquid or ~~a~~ 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) number of phases in one enclosure;~~

b) rated insulation level (U_p, U_d and U_s where applicable);

c) rated frequency (f_r)

~~d) rated normal current and temperature rise;~~

~~e) rated short-time and peak withstand currents;~~

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 ~~(U_r)~~ of the cable connection (U_{rm}) is equal to the ~~lowest~~ 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

~~For cables, the rated voltage U_r corresponds to the highest voltage for equipment U_m.~~

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~~:2003~~.

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 ~~normal~~ continuous current (I_r) ~~and temperature rise~~

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 ~~normal~~ continuous currents up to 3 150 A. ~~The normal current-carrying contact surfaces of the connection interface shall be silver- or copper-coated or solid copper.~~

For full interchangeability of the cable-termination, 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 GIS 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.

NOTE For cases when the above design value requirement of 90 °C at rated normal continuous current of the cable system cannot be achieved 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 (SF_6) as a function of current.

5.5 Rated short-time and peak withstand currents and rated duration of short circuit

Short-time and peak withstand currents as well as the duration of short circuit shall refer to the levels provided by the cable system, not exceeding the values given in IEC 60694.

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 requirements

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

~~If a metallic earth connection between parts 6 or 11 and part 13 of Figure 2 for fluid-filled cable terminations and Figure 4 for dry-type cable-terminations is not feasible, non-linear resistors (part 15) may be connected across the insulated junction to limit the voltage under transient conditions. The number and characteristics of the non-linear resistors shall be determined and supplied by the cable termination manufacturer, taking into consideration the requirements of the user and the switchgear manufacturer. For further details refer to report of CIGRE WG 23-10: ELECTRA 151, 1993.~~

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.

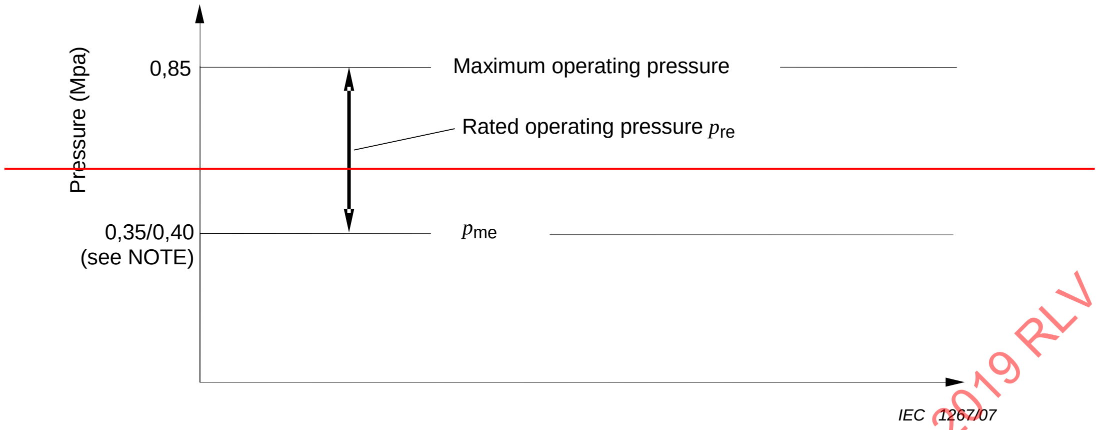
The overvoltage protection elements, i.e. connections between part 6 and part 13 of Figure 2 for fluid-filled cable terminations and Figure 4 for dry-type cable terminations as described above, are not meant to serve as the cable system grounding connection.

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

6.102 ~~Rated~~ 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 ~~rated~~ 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.

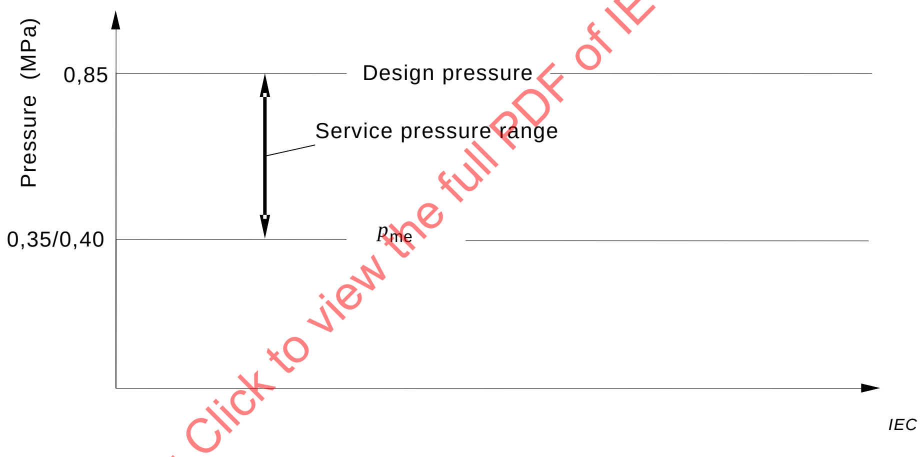


p_{re} rated filling pressure of gas for insulating (not lower than p_{me})

p_{me} minimal functional pressure for insulation

NOTE 0,35 MPa for voltages up to 300 kV

0,40 MPa for voltages exceeding 300 kV



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 give the same dielectric strength while being lower than the maximum recommended operating pressure as per 6.1. 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 (absolute) for the outside of the cable termination is 0,85 MPa (absolute) at 20 °C independent from the GIS design pressure applied. The cable termination shall be capable of withstanding the vacuum conditions when the cable connection enclosure is evacuated as part of the gas filling process.

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, taking into account lack of symmetry, it is considered that this additional force is small. However, a total mechanical force of 2 kN applied to the connection interface transversely, should be assumed. 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

The testing of the cable termination and the gas-insulated metal-enclosed switchgear is to be performed for cable terminations in accordance with IEC 60141-1:1993 for oil-filled cables, IEC 60141-2:1963 for gas-filled cables, IEC 60840:2004 or IEC 62067:2001 (and its amendment 1:2006) for cables with extruded insulation, IEC 62271-203:2003 for switchgear. In addition, this standard gives recommended arrangements for dielectric tests and for the tests after cable installation.

In case the insulator for cable termination is pre-installed during GIS manufacturing, this insulator is subject to the GIS routine tests specified in IEC 62271-203:2003.

As such the insulator shall be designed to withstand these routine tests. The GIS manufacturer shall follow the handling and/or assembling instructions for test preparation provided by the cable termination manufacturer.

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 ~~Dielectric~~ Electrical type tests of cable terminations

7.2.1 General

~~The dielectric type tests of the cable-termination fitted with a representative cable shall be performed in an enclosure as per 8.2.2, filled with insulating gas at the pressure not exceeding p_{me}+0,02 MPa as specified in 5.6. If a shield is an integral part of the cable-termination design, it shall be mounted in its service position during the test.~~

~~An additional test shield may be used to screen the exposed connection interface, if required by the cable-termination manufacturer, provided it does not overlap the connection interface by more than the distance l_2 in Figure 3 for fluid-filled cable-terminations and Figure 5 for dry-type cable-terminations.~~

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 ~~Dielectric~~ 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~~s~~ (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 ~~Dielectric~~ Electrical type test of cable termination in a three-phase enclosure

The single-phase test arrangement using the single-phase cable ~~termination~~ connection enclosure from the ~~GIS~~ switchgear covers the test requirements of the cable termination in a three-phase enclosure as it imposes ~~the most~~ 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.

7.3 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. ~~With the given~~ Four standard sizes cover the voltage range (U_r) from 72,5 kV to 550 kV ~~is covered~~.

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. ~~The given~~ 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. ~~For~~ Type B incorporates the insulating barrier inside the elastomeric electrical stress control component ~~is located externally~~.

~~NOTE 1 In case the dry-type termination dimensions for 245 kV to 300 kV are in excess of those specified in Figure 5, the termination may be fitted into the housing for fluid filled terminations of this voltage class. In this case it is the cable termination manufacturer's responsibility to meet the dimensions of the cable termination enclosure for 245 kV to 300 kV as per Figure 3. It falls further within the responsibility of the cable termination manufacturer to clearly notify all involved party about his intent to rely on the stipulations of this note.~~

~~NOTE 2 For a full interchangeability of both fluid-filled and dry-type cable-terminations, a suitable connection interface extension, if required, should be supplied by the cable-termination manufacturer.~~

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~~-termination~~ connection enclosure

The minimum dimensions of the three-phase cable~~-termination~~ 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~~:2004~~ or IEC 62067~~:2001 (and its amendment 1:2006),~~ or IEC 60141~~-1:1993~~ (all parts), and IEC 62271-203~~:2003~~. 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,~~ operation~~ service and maintenance

11.1 General

Refer to ~~IEC 60694:1996, Clause 10~~ 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 ~~5.2 of IEC 60694:1996~~ 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. ~~For cases where~~ If necessary to achieve adequate electrical clearances ~~are inadequate~~, the ~~term~~ 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 It should be noted that 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. The AC test voltages of extruded cables after installation according to IEC 60840 and IEC 62067 are normally not critical for GIS insulators if the level is below the site test voltages of GIS according to IEC 62271-203 Subclause 10.2.101.1.4.~~

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.

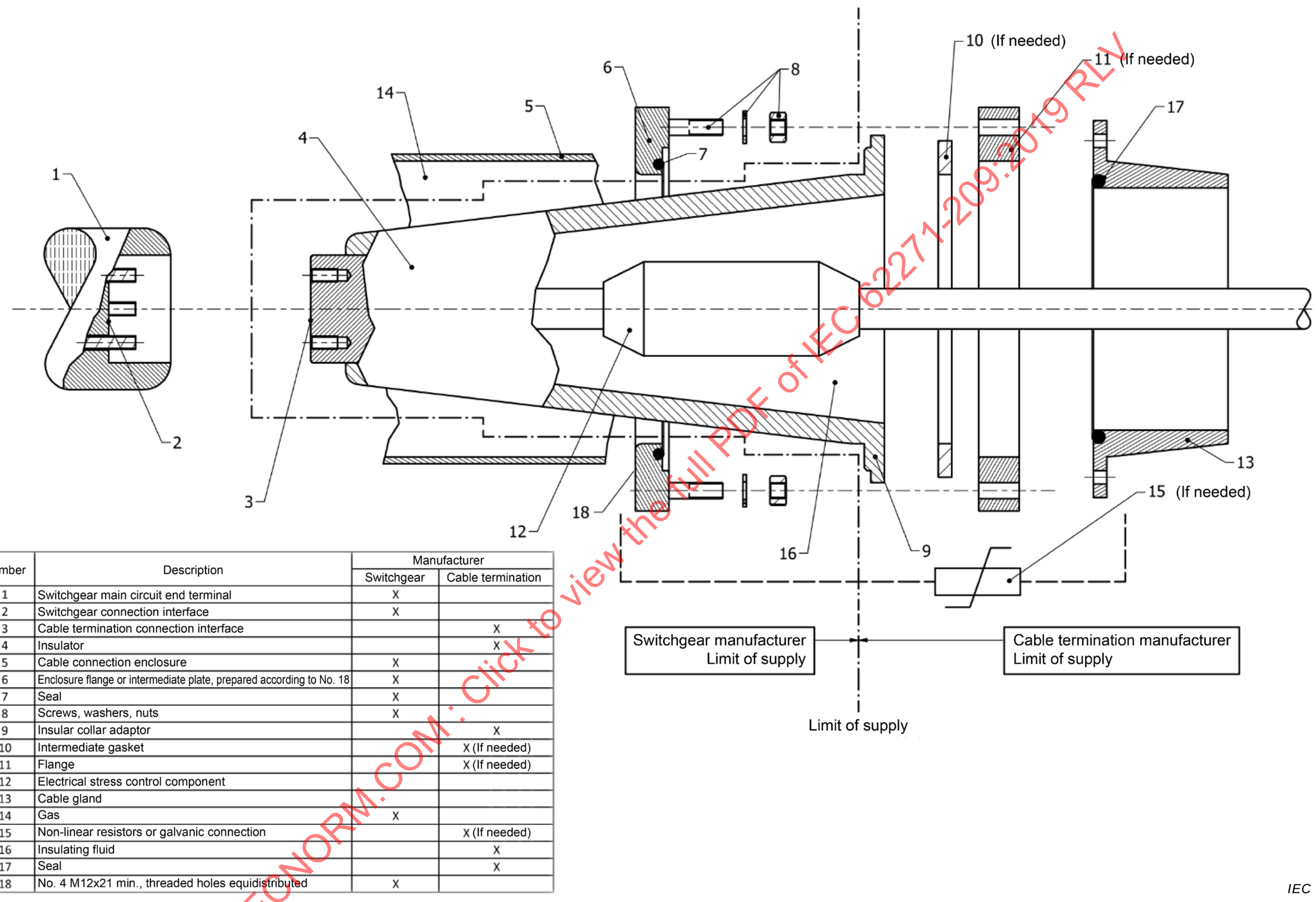
12 Safety practices and constraints during installation of cable connection to switchgear

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.

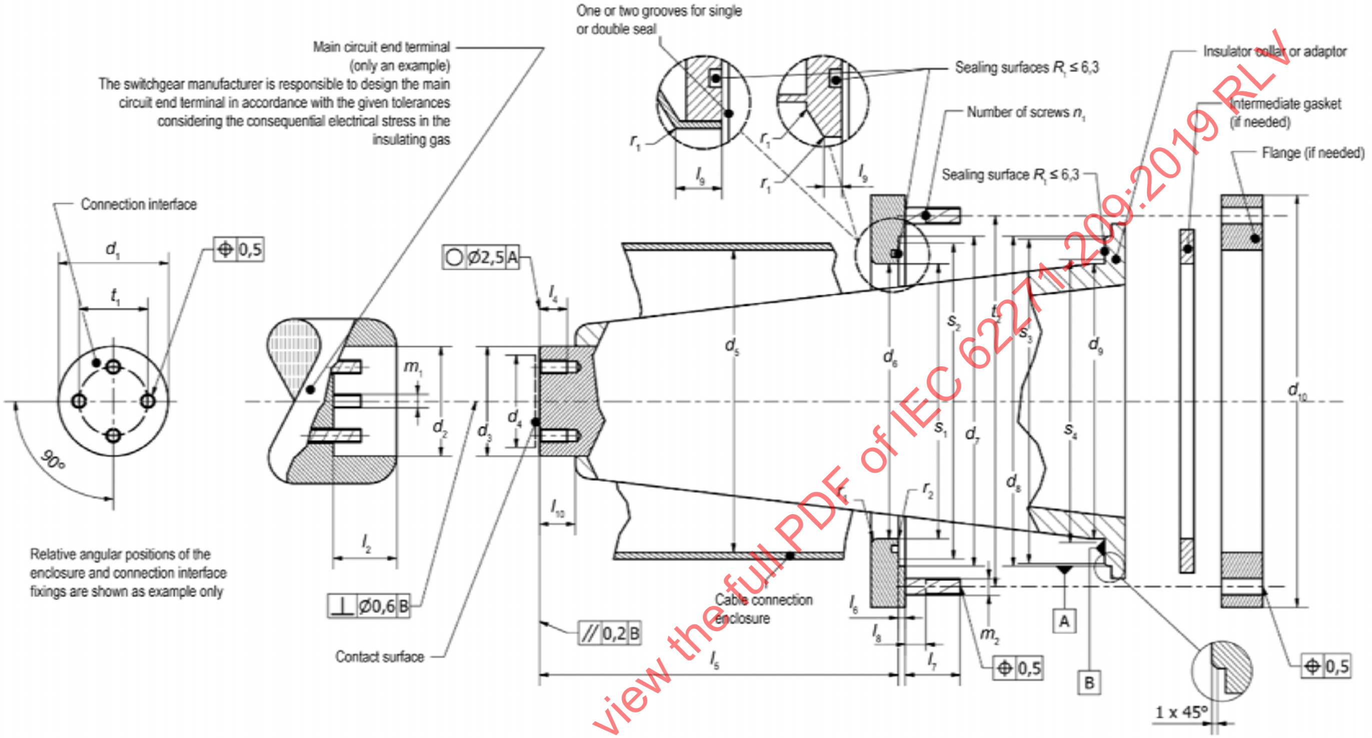
13 Influence of the product on the environment

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	
9	Insular collar adaptor		X
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	

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.	Former dimension l_1 was deleted	l_2 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	+1,0 583 -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	+1,0 757 -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	480	+5 480 -0	+0,5 560 -0	+0,3 559 -0,3	440	620		100		21	+2,0 960 -2,0	6	110	30	70	105	M12	M16	16	10 [a]	2,5	490	554	555	491	+0,3 110 -0,3	+0,5 582 -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 1 400 -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_6 and r_2.

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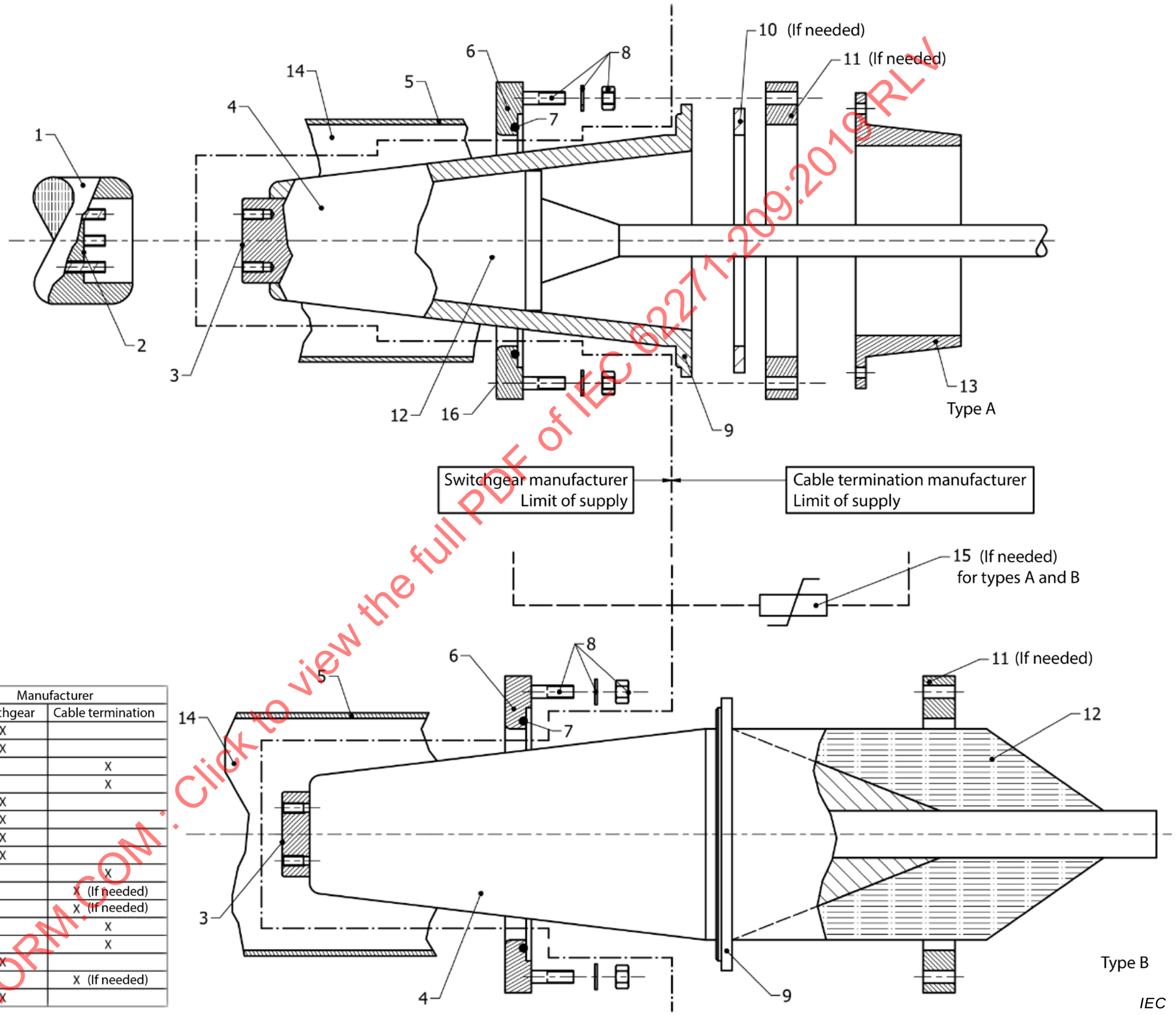
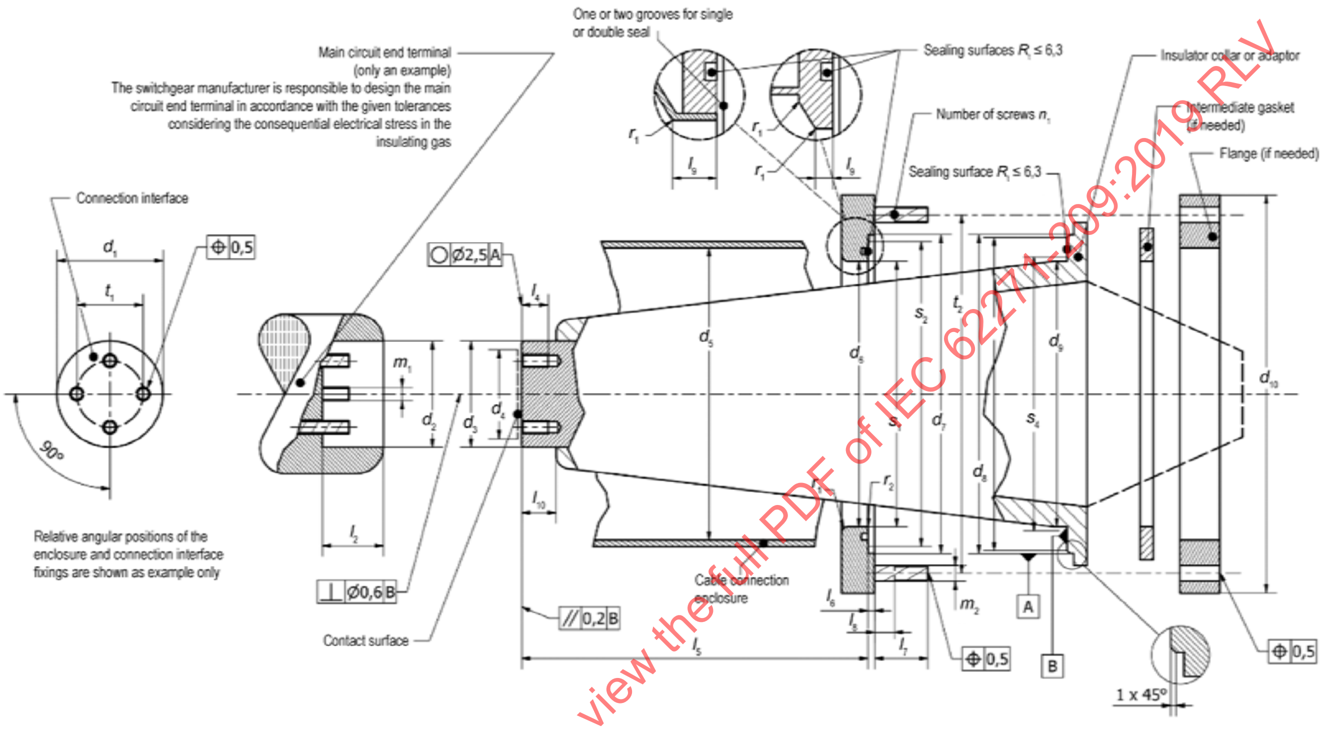
Figure 3 – Fluid-filled cable connection – Assembly dimensions



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_1 was deleted	l_2 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	200 +3 -0	246 +0,5 -0	245 +0,3 -0,3	196	300		50		18	310 +1,0 -1,0	5,5	90	30	50	55	M10	M10	8	10	1	205	241	242	206	80 +0,3 -0,3	270 +0,5 -0,5
123 to 170	550 to 750	100	112	110	100	300	255 +0,5 -0	299 +0,5 -0	298 +0,3 -0,3	250	350		50		18	470 +1,0 -1,0	5,5	90	30	50	55	M10	M12	12	10	1,5	258	294	295	266	80 +0,3 -0,3	320 +0,5 -0,5
245 to 300	850 to 1 050	139	202	200	140	400	385 +5 -0	455 +0,5 -0	454 +0,3 -0,3	375	500		100		21	620 +2,0 -2,0	6	110	30	70	105	M12	M12	16	10	2,5	390	450	451	391	110 +0,3 -0,3	475 +0,5 -0,5
362 to 550	1 175 to 1 550	139	252	250	140	540	540 +5,0 -0	618 +0,5 -0	617 +0,3 -0,3	500	690		100		21	960 +2,0 -2,0	6	110	30	70	105	M12	M16	20	10 [a]	2,5	550	612	613	551	110 +0,3 -0,3	640 +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.

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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*

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IEC 62271-209

Edition 2.0 2019-02

INTERNATIONAL STANDARD

NORME INTERNATIONALE

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

IEC 62271-209:2019-02(en-fr)

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

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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

FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
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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 cancels and replaces the first edition published in 2007. This 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.

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

FDIS	Report on voting
17C/696/FDIS	17C/701/RVD

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

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 this document will remain unchanged until the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific document. At this date, the document will be

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

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.

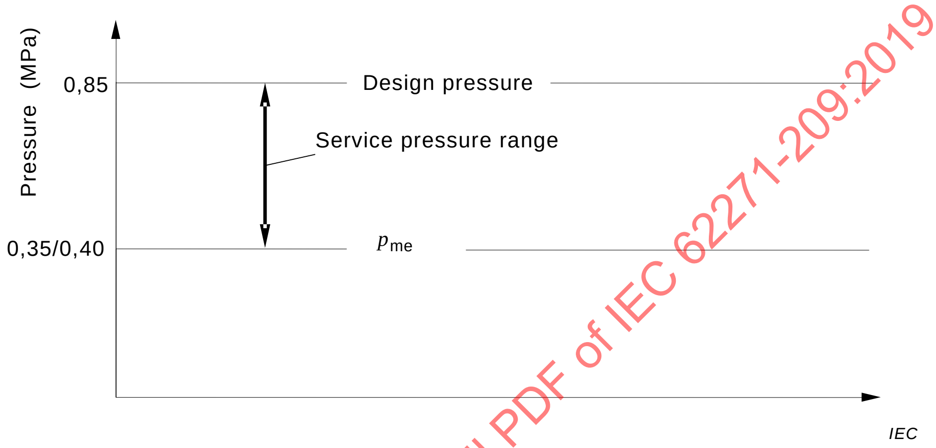
The overvoltage protection elements, i.e. connections between part 6 and part 13 of Figure 2 for fluid-filled cable terminations and Figure 4 for dry-type cable terminations as described above, are not meant to serve as the cable system grounding connection.

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.

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 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.

7.3 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.

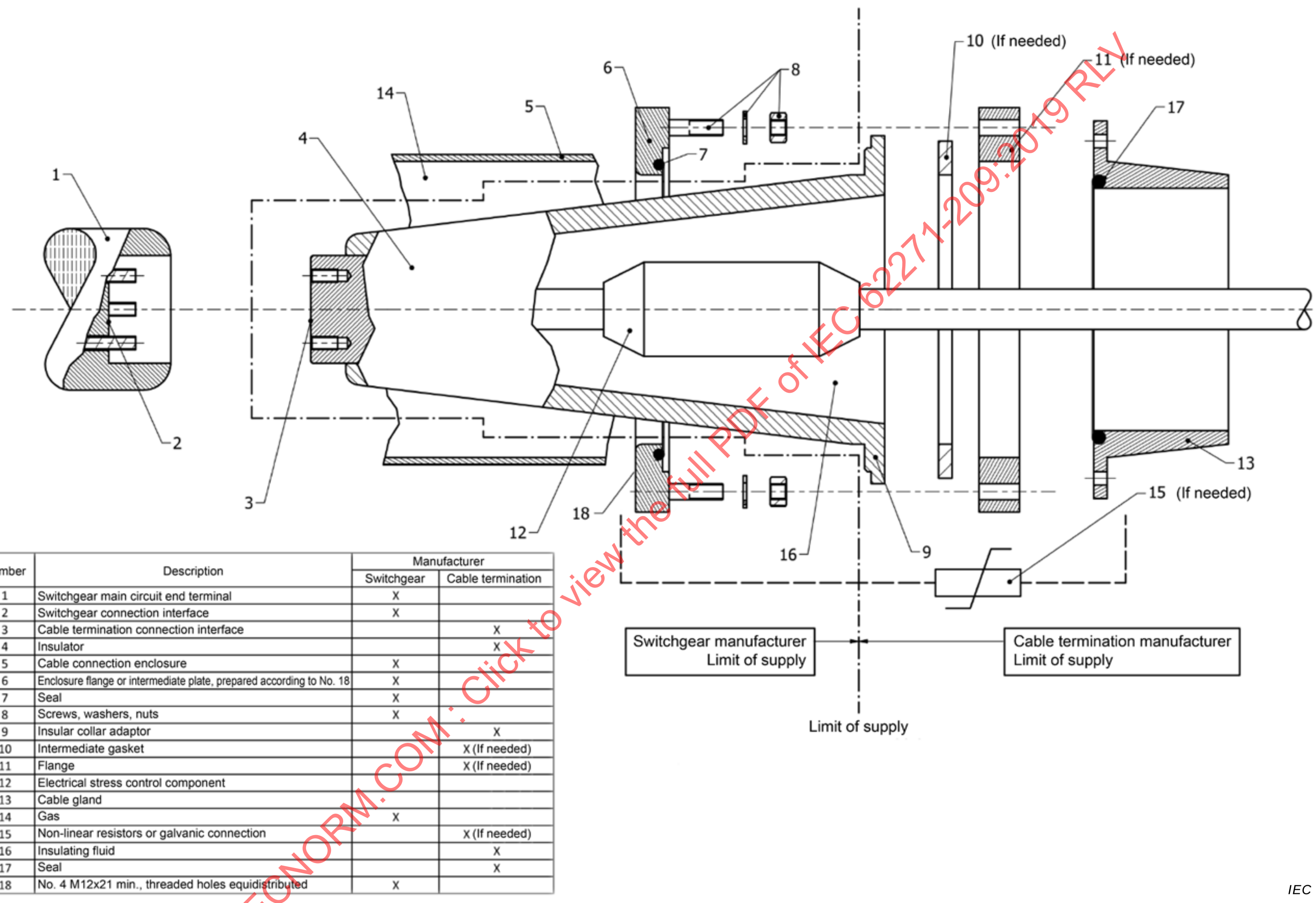
12 Safety practices and constraints during installation of cable connection to switchgear

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.

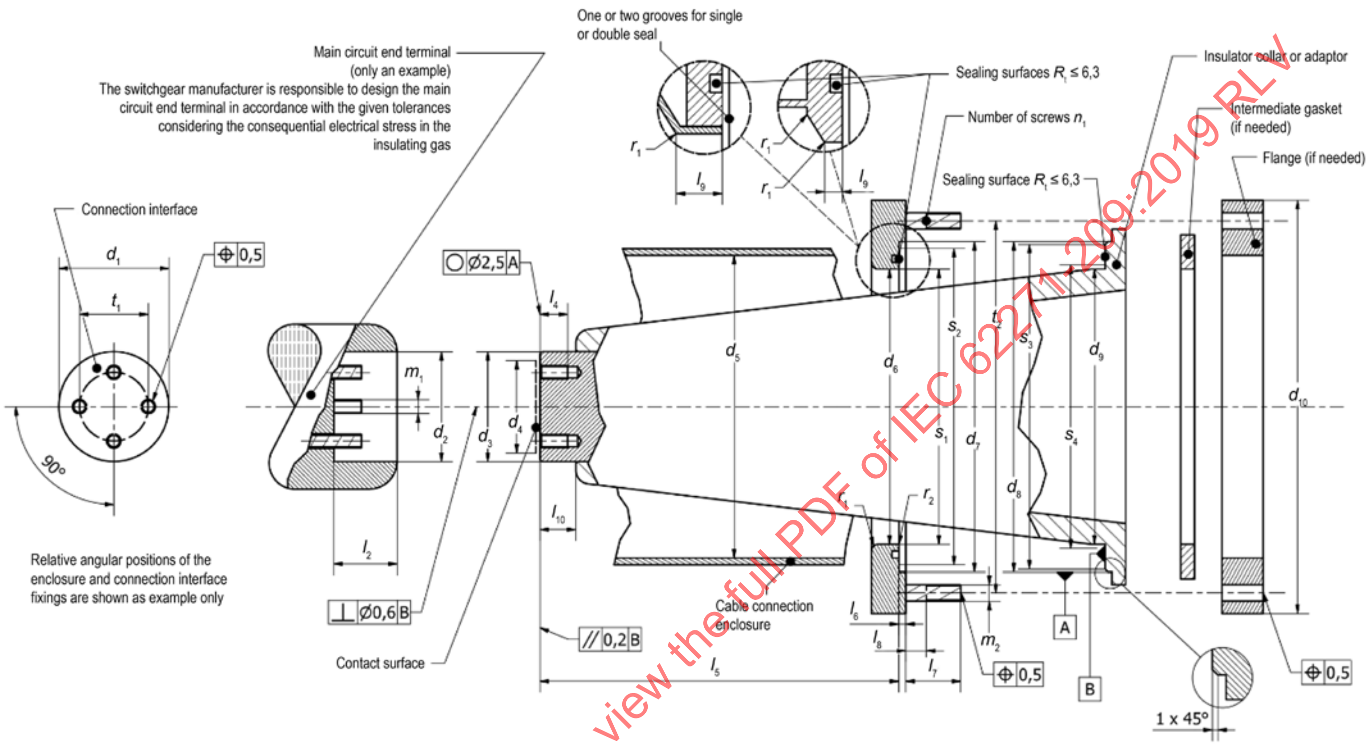
13 Influence of the product on the environment

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	
9	Insular collar adaptor		X
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	

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.	Former dimension l_1 was deleted	l_2 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	+1,0 583 -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	+1,0 757 -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	480	+5 480 -0	+0,5 560 -0	+0,3 559 -0,3	440	620		100		21	+2,0 960 -2,0	6	110	30	70	105	M12	M16	16	10 [a]	2,5	490	554	555	491	+0,3 110 -0,3	+0,5 582 -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 1 400 -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_6 and r_2.

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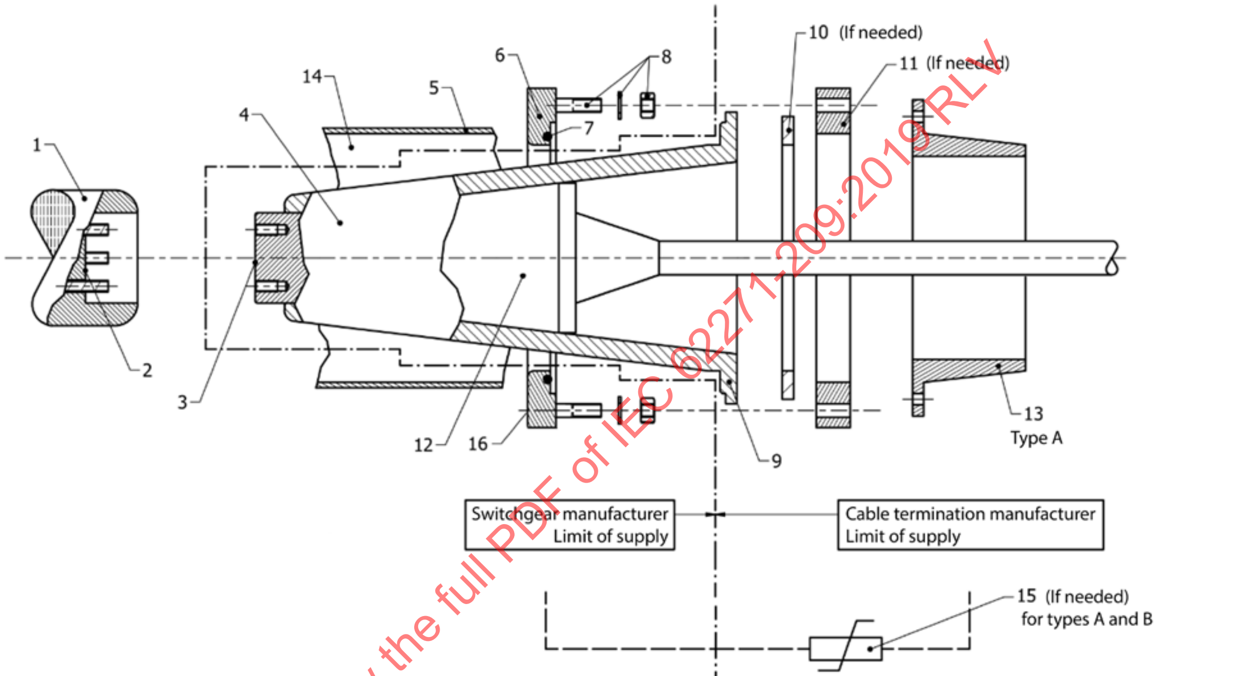
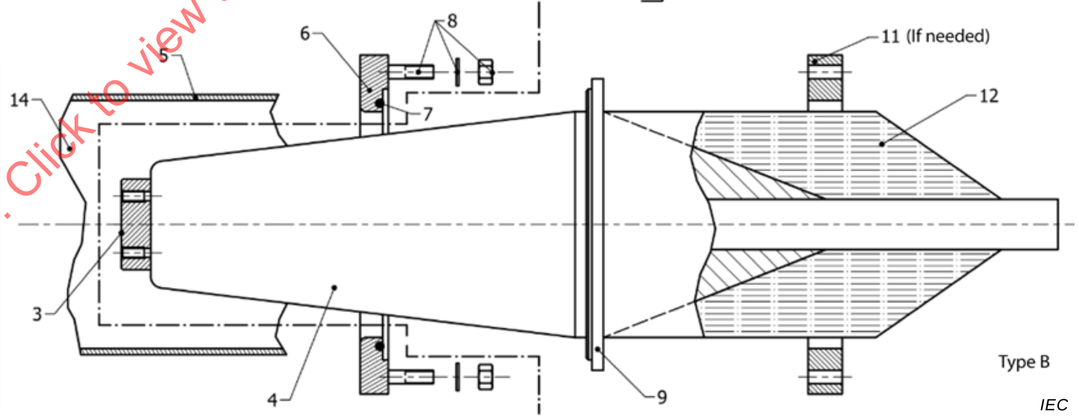
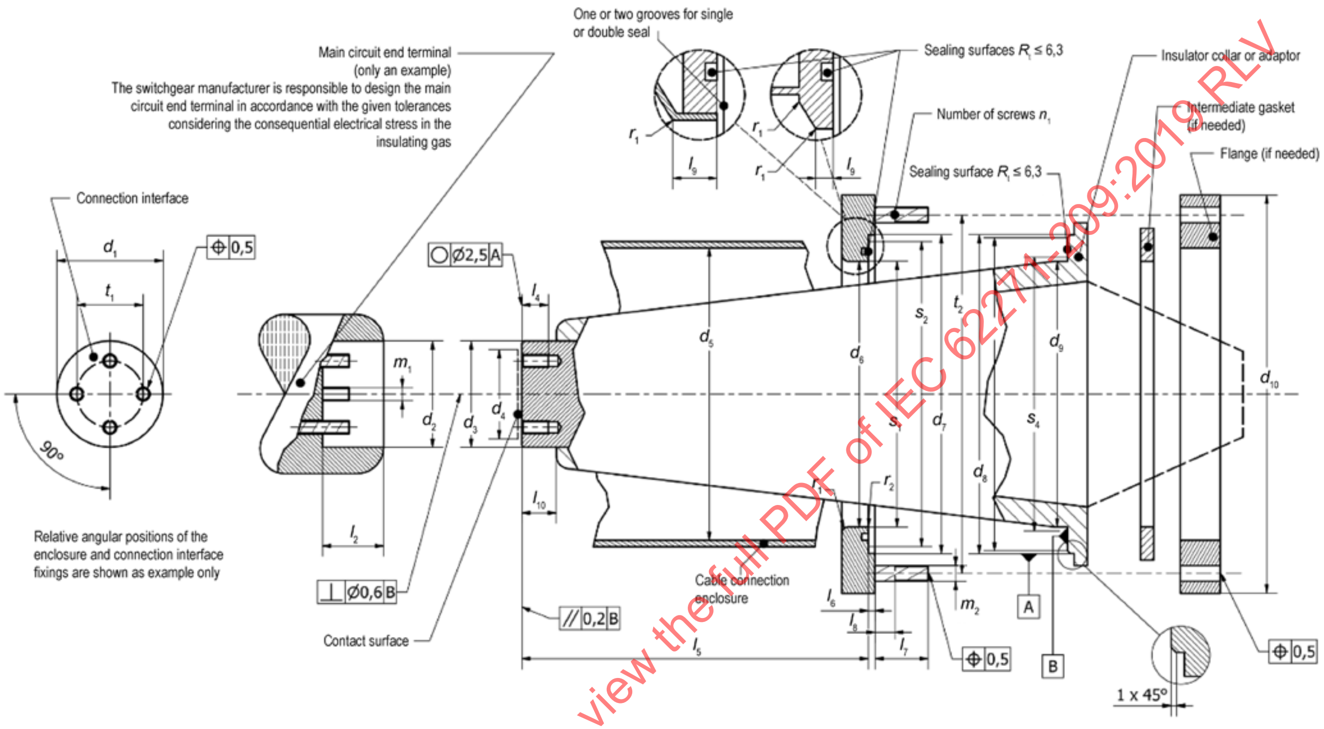
Figure 3 – Fluid-filled cable connection – Assembly dimensions





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_1 was deleted	l_2 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	200 +3 -0	246 +0,5 -0	245 +0,3 -0,3	196	300		50		18	310 +1,0 -1,0	5,5	90	30	50	55	M10	M10	8	10	1	205	241	242	206	80 +0,3 -0,3	270 +0,5 -0,5
123 to 170	550 to 750	100	112	110	100	300	255 +0,5 -0	299 +0,5 -0	298 +0,3 -0,3	250	350		50		18	470 +1,0 -1,0	5,5	90	30	50	55	M10	M12	12	10	1,5	258	294	295	266	80 +0,3 -0,3	320 +0,5 -0,5
245 to 300	850 to 1 050	139	202	200	140	400	385 +5 -0	455 +0,5 -0	454 +0,3 -0,3	375	500		100		21	620 +2,0 -2,0	6	110	30	70	105	M12	M12	16	10	2,5	390	450	451	391	110 +0,3 -0,3	475 +0,5 -0,5
362 to 550	1 175 to 1 550	139	252	250	140	540	540 +5,0 -0	618 +0,5 -0	617 +0,3 -0,3	500	690		100		21	960 +2,0 -2,0	6	110	30	70	105	M12	M16	20	10 [a]	2,5	550	612	613	551	110 +0,3 -0,3	640 +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.

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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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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 annule et remplace la première édition parue en 2007. Cette 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.

Le texte de cette norme est issu des documents suivants:

FDIS	Rapport de vote
17C/696/FDIS	17C/701/RVD

Le rapport de vote indiqué dans le tableau ci-dessus donne toute information sur le vote ayant abouti à l'approbation de la présente Norme internationale.

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 ce document ne sera pas modifié avant la date de stabilité indiquée sur le site web de l'IEC sous «http://webstore.iec.ch» dans les données relatives au document recherché. À cette date, le document sera

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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

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.

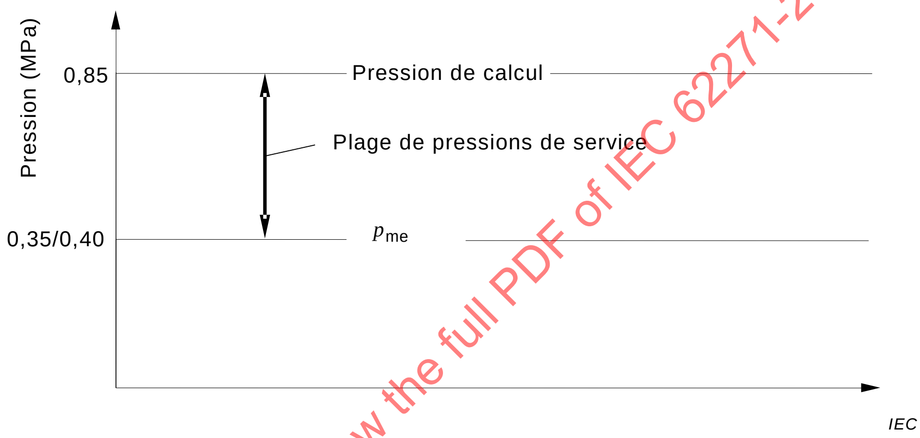
Les éléments de protection contre les surtensions, c'est-à-dire les raccordements entre l'élément 6 et l'élément 13 de la Figure 2 pour les extrémités de câble remplies d'un fluide et de la Figure 4 pour les extrémités de câble de type sec tel que décrit ci-dessus, ne sont pas faits pour raccorder le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

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.