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

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

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INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 29.130.10

ISBN 978-2-8322-6551-2

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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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.

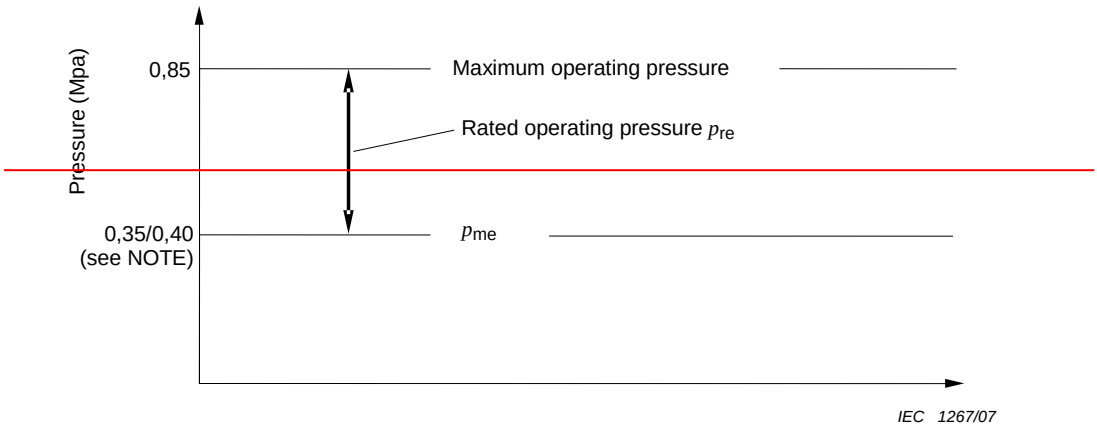
The overvoltage protection elements, i.e. connections between part 6 and part 13 of Figure 2 for fluid-filled cable terminations and Figure 4 for dry-type cable terminations as described above, are not meant to serve as the cable system grounding connection.

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.

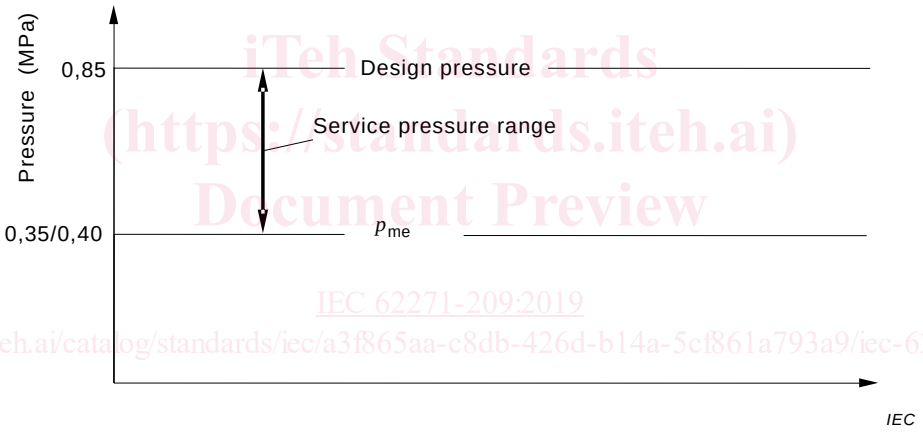


~~p_{re} rated filling pressure of gas for insulating (not lower than p_{me})~~

~~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