IEC 62271-207

Edition 3.0 2023-11

INTERNATIONAL STANDARD

NORME INTERNATIONALE

colour inside

High-voltage switchgear and controlgear – Part 207: Seismic qualification for gas-insulated switchgear assemblies, metal enclosed and solid-insulation enclosed switchgear for rated voltages above 1 kV

Appareillage à haute tension – Partie 207: Qualification sismique des ensembles d'appareillages à isolation gazeuse et des appareillages sous enveloppe métallique et sous enveloppe isolante solide pour des tensions assignées supérieures à 1 kV

IEC 62271-207:2023-11(en-fr)

IEC Secretariat
3, rue de Varembé
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
info@iec.ch
www.iec.ch

About the IEC
The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

About IEC publications
The technical content of IEC publications is kept under constant review by the IEC. Please make sure that you have the latest edition, a corrigendum or an amendment might have been published.

IEC publications search - webstore.iec.ch/advsearchform
The advanced search enables to find IEC publications by a variety of criteria (reference number, text, technical committee, …). It also gives information on projects, replaced and withdrawn publications.

IEC Just Published - webstore.iec.ch/justpublished
Stay up to date on all new IEC publications. Just Published details all new publications released. Available online and once a month by email.

IEC Customer Service Centre - webstore.iec.ch/csc
If you wish to give us your feedback on this publication or need further assistance, please contact the Customer Service Centre: sales@iec.ch.

IEC Products & Services Portal - products.iec.ch
Discover our powerful search engine and read freely all the publications previews. With a subscription you will always have access to up to date content tailored to your needs.

Electropedia - www.electropedia.org
The world's leading online dictionary on electrotechnology, containing more than 22 300 terminological entries in English and French, with equivalent terms in 19 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.

A propos de l'IEC
La Commission Electrotechnique Internationale (IEC) est la première organisation mondiale qui élabore et publie des Normes internationales pour tout ce qui a trait à l'électricité, à l'électronique et aux technologies apparentées.

A propos des publications IEC
Le contenu technique des publications IEC est constamment revu. Veuillez vous assurer que vous possédez l'édition la plus récente, un corrigendum ou amendement peut avoir été publié.

Recherche de publications IEC - webstore.iec.ch/advsearchform
La recherche avancée permet de trouver des publications IEC en utilisant différents critères (numéro de référence, texte, comité d'études, …). Elle donne aussi des informations sur les projets et les publications remplacées ou retirées.

IEC Just Published - webstore.iec.ch/justpublished
Restez informé sur les nouvelles publications IEC. Just Published détaille les nouvelles publications parues. Disponible en ligne et une fois par mois par email.

Service Clients - webstore.iec.ch/csc
Si vous désirez nous donner des commentaires sur cette publication ou si vous avez des questions contactez-nous: sales@iec.ch.

IEC Products & Services Portal - products.iec.ch
Découvrez notre puissant moteur de recherche et consultez gratuitement tous les aperçus des publications. Avec un abonnement, vous aurez toujours accès à un contenu à jour adapté à vos besoins.

Electropedia - www.electropedia.org
Le premier dictionnaire d'électrotechnologie en ligne au monde, avec plus de 22 300 articles terminologiques en anglais et en français, ainsi que les termes équivalents dans 19 langues additionnelles. Egalement appelé Vocabulaire Electrotechnique International (IEV) en ligne.

IEC 62271-207

Edition 3.0 2023-11

INTERNATIONAL STANDARD

NORME INTERNATIONALE

colour inside

High-voltage switchgear and controlgear – Part 207: Seismic qualification for gas-insulated switchgear assemblies, metal enclosed and solid-insulation enclosed switchgear for rated voltages above 1 kV

Appareillage à haute tension – Partie 207: Qualification sismique des ensembles d'appareillages à isolation gazeuse et des appareillages sous enveloppe métallique et sous enveloppe isolante solide pour des tensions assignées supérieures à 1 kV

INTERNATIONAL ELECTROTECHNICAL COMMISSION

COMMISSION ELECTROTECHNIQUE INTERNATIONALE

ICS 29.130.10

ISBN 978-2-8322-7776-8

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

_____

HIGH-VOLTAGE SWITCHGEAR AND CONTROLGEAR –

Part 207: Seismic qualification for gas-insulated switchgear assemblies, metal-enclosed and solid-insulation enclosed switchgear for rated voltages above 1 kV

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.
2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
6) All users should ensure that they have the latest edition of this publication.
7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
9) IEC draws attention to the possibility that the implementation of this document may involve the use of (a) patent(s). IEC takes no position concerning the evidence, validity or applicability of any claimed patent rights in respect thereof. As of the date of publication of this document, IEC had not received notice of (a) patent(s), which may be required to implement this document. However, implementers are cautioned that this may not represent the latest information, which may be obtained from the patent database available at https://patents.iec.ch. IEC shall not be held responsible for identifying any or all such patent rights.

IEC 62271-207 has been prepared by subcommittee 17C: Assemblies, of IEC technical committee 17: High-voltage switchgear and controlgear. It is an International Standard.

This third edition cancels and replaces the second edition published in 2012. This edition constitutes a technical revision. It also cancels and replaces, through merging, the first edition of IEC TS 62271-210 published in 2013.

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

a) modification of the minimum voltage rating from 52 kV to above 1 kV in order to include medium voltage equipment previously being within IEC TS 62271-210 scope;

b) further harmonisation of qualification procedures with the revised IEEE Std 693-2018 [1][1], Annex A and Annex P, including

   1) matching this document's required response spectra with IEEE Std 693-2018 performance level spectra and IEC TS 62271-210 spectra,

   2) addition of a step-by-step procedure assisting the user of this document to select an appropriate seismic qualification level combining seismic integrity with cost-effective design,

   3) addition of analytical earthquake component combination techniques, and

   4) reference to publicly available accelerograms specially developed to match the IEEE Std 693-2018 spectra for testing and analysis purposes, since this document and IEC TS 62271-210 spectra are identical in shape with IEEE Std 693 spectra.

c) various enhancements of test procedures;

d) addition of minimum contents for seismic qualification reports;

e) scope extended to cover DC GIS including and above 100 kV.

The text of this International Standard is based on the following documents:

Draft	Report on voting
17C/902/FDIS	17C/916/RVD

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

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

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

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

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

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

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

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

HIGH-VOLTAGE SWITCHGEAR AND CONTROLGEAR –

Part 207: Seismic qualification for gas-insulated switchgear assemblies, metal-enclosed and solid-insulation enclosed switchgear for rated voltages above 1 kV

1 Scope

This part of IEC 62271 applies to

– gas-insulated switchgear (GIS) assemblies
  - for alternating current of rated voltages above 52 kV complying with IEC 62271-203, and
  - for direct current of rated voltages including and above 100 kV,
  - for indoor and outdoor installations, including their supporting structures,
– AC metal-enclosed switchgear and controlgear assemblies for rated voltages above 1 kV and up to and including 52 kV complying with IEC 62271-200, ground or floor mounted, intended to be used under seismic conditions, and
– AC solid-insulation enclosed switchgear and controlgear assemblies for rated voltages above 1 kV and up to and including 52 kV complying with IEC 62271-201, ground or floor mounted, intended to be used under seismic conditions.

The seismic qualification of the switchgear and controlgear assemblies takes into account testing of typical switchgear and controlgear assemblies combined with methods of analysis. Mutual interaction between directly mounted auxiliary and control equipment and switchgear assemblies is considered.

Seismic qualification philosophy includes selection of seismic qualification level (Clause 4), methodologies for qualification by testing (Clause 5) and by combined testing and analysis (Clause 6), acceptance criteria (Clause 7) and seismic qualification documentation (Clause 8).

Recommendations on increasing the seismic adequacy of switchgear and controlgear assemblies are provided in Annex B. A flowchart of the seismic qualification process is included in Annex C.

The seismic qualification of switchgear and controlgear assemblies by the manufacturer is performed usually if needed.

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 60068-2-47, *Environmental testing – Part 2-47: Tests – Mounting of specimens for vibration, impact and similar dynamic tests*

IEC 60068-2-57:2013, *Environmental testing – Part 2-57: Tests – Test Ff: Vibration – Time-history and sine-beat method*

IEC 60068-3-3:2019, *Environmental testing – Part 3-3: Supporting documentation and guidance – Seismic test methods for equipment*

IEC 60099-4:2014, *Surge arresters – Part 4: Metal-oxide surge arresters without gaps for a.c. systems*

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

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

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

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

ISO 2041, *Mechanical vibration, shock and condition monitoring – Vocabulary*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60068-3-3, IEC 62271-1, IEC 62271-200, IEC 62271-201, IEC 62271-203, ISO 2041 and the following apply.

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

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

3.1
switchgear and controlgear
switching devices and their combination with associated control, measuring, protective and regulating equipment, including assemblies of such devices and equipment with associated interconnections, accessories, enclosures and supporting structures

[SOURCE: IEC 60050-441:1984, 441-11-01]

3.2
metal-enclosed switchgear and controlgear
switchgear and controlgear assemblies with an external metal enclosure intended to be earthed, and complete except for external connections

[SOURCE: IEC 60050-441:1984, 441-12-04, modified – Note deleted.]

3.3
gas-insulated metal-enclosed switchgear
GIS
metal-enclosed switchgear in which the insulation is obtained, at least partly, by an insulating gas or gas mixture other than air at atmospheric pressure

[SOURCE: IEC 60050-441:1984, 441-12-05, modified – Abbreviated term "GIS" added. Words "or gas mixture" added to the definition, and note deleted.]

3.4
solid-insulation enclosed switchgear and controlgear
switchgear and controlgear assemblies with an external solid insulating enclosure and completely assembled, except for external connections

[SOURCE: IEC 62271-201:2014, 3.103 – Note deleted.]

3.5
high voltage switchgear
HV switchgear
gas-insulated switchgear (GIS) assemblies for alternating current of rated voltages above 52 kV complying with IEC 62271-203 and for direct current of rated voltages including and above 100 kV, for indoor and outdoor installations, including their supporting structure

Note 1 to entry: The upcoming IEC TS 62271-318 [9] is expected to regulate DC GIS of rated voltages including and above 100 kV.

3.6
medium voltage switchgear
MV switchgear
AC metal-enclosed switchgear and controlgear assemblies for rated voltages above 1 kV and up to and including 52 kV complying with IEC 62271-200 and AC solid-insulation enclosed switchgear and controlgear assemblies for rated voltages above 1 kV and up to and including 52 kV complying with IEC 62271-201, ground or floor mounted

3.7
user
utility, customer, final owner of the qualified equipment

3.8
brittle material
material that experiences limited or no plastic deformation before fracture

Note 1 to entry: Limited deformation shall be taken as less than 10 % in 5 cm at failure in tension.

[SOURCE: IEEE Std 693-2018. Adapted and reprinted with permission from IEEE. Copyright IEEE 2018. All rights reserved.]

3.9
ductile material
material that experiences considerable plastic deformation before fracture

Note 1 to entry: Considerable plastic deformation is defined as 10 % or greater in 5 cm at failure in tension.

[SOURCE: IEEE Std 693-2018. Adapted and reprinted with permission from IEEE. Copyright IEEE 2018. All rights reserved.]

3.10
flexible equipment
equipment, structures, and components whose lowest resonant frequency is less than 33 Hz

3.11
rigid equipment
equipment, structures, and components whose lowest resonant frequency is greater than 33 Hz

[SOURCE: IEEE Std 693-2018. Adapted and reprinted with permission from IEEE. Copyright IEEE 2018. All rights reserved.]

3.12
acceleration of gravity
g
acceleration due to gravity that is 9,81 m/s^2

Note 1 to entry: For the purposes of this document, the value of g is rounded up to the nearest integer, that is 10 m/s^2.

3.13
ground acceleration
acceleration of the ground resulting from the motion of a given earthquake

3.14
peak ground acceleration
PGA
maximum ground acceleration of any component of the time history

3.15
zero period acceleration
ZPA
zero period acceleration is the spectral acceleration for frequencies above 33 Hz

3.16
floor acceleration
acceleration of a particular building floor (or an equipment mounting) resulting from its response to the ground motion of a given earthquake

3.17
response spectrum
plot of the maximum response of an array of single-degree-of-freedom (SDOF) identically damped oscillators with different frequencies, all subjected to the same base excitation

[SOURCE: IEEE Std 693-2018. Adapted and reprinted with permission from IEEE. Copyright IEEE 2018. All rights reserved.]

3.18
required response spectrum
RRS
response spectrum that defines the required level of input motion for a given level of qualification

[SOURCE: IEEE Std 693-2018. Adapted and reprinted with permission from IEEE. Copyright IEEE 2018. All rights reserved.]

3.19
floor response spectrum
response spectrum of the floor acceleration history of a building floor (or an equipment mounting)

Note 1 to entry: Response acceleration spectra can be calculated for each one of the three components of excitation.

3.20
superelevation factor
amplification factor accounting for the amplification of seismic loading with respect to ground level due to the response of buildings and structures

Note 1 to entry: A superelevation factor is used in lieu of a more accurate estimation of the contribution of the building (or other equipment mounting) response to the response of the qualified equipment.

3.21
resonant frequency
frequency coinciding with the natural frequency of a system (at which the response amplitude is a relative maximum)

Note 1 to entry: At a resonant frequency, even small periodic driving forces can produce large amplitude oscillations

[SOURCE: IEEE Std 693-2018. Adapted and reprinted with permission from IEEE. Copyright IEEE 2018. All rights reserved.]

3.22
complete quadratic combination method
CQC method
modal combination method, especially useful for systems with closely spaced frequencies

[SOURCE: IEEE Std 693-2018. Adapted and reprinted with permission from IEEE. Copyright IEEE 2018. All rights reserved.]

3.23
damping
energy dissipation mechanisms in a system

Note 1 to entry: In practice, damping depends on many parameters, such as the structural system, mode of vibration, strain, applied forces, velocity, materials, joint slippage.

[SOURCE: IEC 60068-3-3:2019, 3.8, modified – Second note to entry deleted.]

3.23.1
critical damping
minimum viscous damping that will allow a displaced system to return to its initial position without oscillation

[SOURCE: IEC 60068-3-3:2019, 3.8.1]

3.23.2
damping ratio
ratio of actual damping to critical damping in a system with viscous damping

[SOURCE: IEC 60068-3-3:2019, 3.8.2]

3.24
direction factor
factor taking account of the difference in magnitude at ground level that normally exists between the horizontal and vertical accelerations resulting from an earthquake

[SOURCE: IEC 60068-3-3:2019, 3.9]

3.25
normal operating load
force, stress, or load resulting from equipment operation that can reasonably be expected to occur during an earthquake

3.26
seismic qualification level
level of seismic excitation to which equipment shall maintain the seismic qualification objective

Note 1 to entry: The seismic qualification level is dependent upon the seismicity of the region where the equipment will be in service.

Note 2 to entry: Information on comparison between seismic levels for different standards is given in Table 2.

3.27
time history
recording, as a function of time, of acceleration or velocity or displacement

Note 1 to entry: This definition is not identical to that given in ISO 2041.

[SOURCE: IEC 60068-3-3:2019, 3.34]

3.28
strong part of time history
part of time history from the time when the plot first reaches 25 % of the maximum value to the time when it falls for the last time to the 25 % level

[SOURCE: IEC 60068-3-3:2019, 3.27]

4 Seismic qualification requirements

4.1 Seismic qualification objective

The seismic qualification shall demonstrate the ability of the switchgear and controlgear assemblies to withstand seismic stress without impairing the functionality of the equipment during and after seismic events. It may be proved by testing or by a combination of testing and analysis.

4.2 Qualification levels

A seismic qualification level is defined as the magnitude of seismic excitation to which equipment shall maintain the seismic qualification objective. The qualification shall be done on one of the four seismic qualification levels of Table 1: low, AG2.5, AG5 and AG10.

Qualification levels are associated with ZPA of the required response spectrum. For the low qualification level, the horizontal ZPA is 0,10 g or less. For the AG2.5 qualification level, the ZPA is 0,25 g. For the AG5 qualification level, the ZPA is 0,50 g. For the AG10 qualification level, the ZPA is 1,00 g.

NOTE Seismic qualification level AG10 is a very severe requirement which can need the consideration of special measures such as reinforcement of the gantry/enclosure and application of high-strength insulators, so caution is advised when applying.

Table 1 – Seismic qualification levels for switchgear and controlgear assemblies – Horizontal severities

Qualification level	Required response spectrum (RRS)	Zero period acceleration (ZPA)
Low	---	≤ 1,0m/s^2 (0,10 g)
AG2.5	Figure 1	2,5 m/s^2 (0,25 g)
AG5	Figure 2	5,0 m/s^2 (0,50 g)
AG10	Figure 3	10 m/s^2 (1,00 g)

A comparison between the qualification levels of this document and the qualification levels of IEC 62271-207:2012, IEC TS 62271-210:2013 and IEEE Std 693-2018 is presented on Table 2. ZPA is used as basis for the comparison.

Table 2 – Comparison of qualification levels between various standards

ZPA	This document	IEC 62271-207:2012 [2]	IEC TS 62271-210:2013 [3]	IEEE Std 693-2018
≤ 1,0 m/s^2 (0,10 g)	Low	Low	-	Low
2,5 m/s^2 (0,25 g)	AG2.5	Moderate	-	-
5,0 m/s^2 (0,50 g)	AG5	High	Severity level 1	Moderate performance level
10,0 m/s^2 (1,00 g)	AG10	-	Severity level 2	High performance level

The fixed seismic qualification levels of Table 1 are practical for standardization purposes and testing. Typical examples are medium voltage metal-enclosed and solid-insulation enclosed switchgear and controlgear assemblies.

In the case of custom layout applications such as high voltage GIS substations comprising constellations of standardized GIS modules combined with gas-insulated busducts (GIB) that can span up to several hundred meters and are supported by custom-made steel structures, consideration of local seismic hazard level could enable a cost-effective and seismically safe design. In that sense, other qualification levels which consist in requirements from the user that can be based on specific investigation at site or regulations in national standards, taking into account for example the type of soil, soil structure interaction, building response, and elevation may be used as described in 4.3.

The selection of the seismic qualification level is the responsibility of the user and is normally based on an assessment of site geophysical parameters, seismic hazard, risk assessments, and economics.

No qualification is required for low seismic level as far as construction practice and seismic construction practice comply with the state of the art. The recommended required response spectra related to the horizontal components of the seismic excitation are given in Figure 1, Figure 2 and Figure 3 for the different seismic qualification levels. The curves relate to 2 % and 5 % damping ratio of the switchgear and controlgear assemblies. If damping ratio is unknown, 2 % damping is applied for high voltage switchgear or 5 % damping for medium voltage switchgear. The corresponding response spectra related to the vertical component of excitation are defined as 80 % of the horizontal ones.

Response spectra for different damping values may be calculated by applying the formulae provided in Figure 1 through Figure 3.