IEC 62271-207

Edition 1.0 2007-08

INTERNATIONAL STANDARD

NORME INTERNATIONALE

High-voltage switchgear and controlgear – Part 207: Seismic qualification for gas-insulated switchgear assemblies for rated voltages above 52 kV

Appareillage à haute tension – Partie 207: Qualification sismique pour ensembles d'appareillages à isolation gazeuse pour des niveaux de tension assignée supérieurs à 52 kV

IEC Central Office
3, rue de Varembé
CH-1211 Geneva 20
Switzerland
Email: inmail@iec.ch
Web: 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 corrigenda or an amendment might have been published.

- Catalogue of IEC publications: www.iec.ch/searchpub
The IEC on-line Catalogue enables you to search by a variety of criteria (reference number, text, technical committee,…). It also gives information on projects, withdrawn and replaced publications.
- IEC Just Published: www.iec.ch/online_news/justpub
Stay up to date on all new IEC publications. Just Published details twice a month all new publications released. Available on-line and also by email.
- Electropedia: www.electropedia.org
The world's leading online dictionary of electronic and electrical terms containing more than 20 000 terms and definitions in English and French, with equivalent terms in additional languages. Also known as the International Electrotechnical Vocabulary online.
- Customer Service Centre: www.iec.ch/webstore/custserv
If you wish to give us your feedback on this publication or need further assistance, please visit the Customer Service Centre FAQ or contact us:
Email: csc@iec.ch
Tel.: +41 22 919 02 11
Fax: +41 22 919 03 00

A propos de la CEI

La Commission Electrotechnique Internationale (CEI) 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 CEI

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

- Catalogue des publications de la CEI: www.iec.ch/searchpub/cur_fut-f.htm
Le Catalogue en-ligne de la CEI vous permet d'effectuer des recherches en utilisant différents critères (numéro de référence, texte, comité d'études,…). Il donne aussi des informations sur les projets et les publications retirées ou remplacées.
- Just Published CEI: www.iec.ch/online_news/justpub
Restez informé sur les nouvelles publications de la CEI. Just Published détaille deux fois par mois les nouvelles publications parues. Disponible en-ligne et aussi par email.
- Electropedia: www.electropedia.org
Le premier dictionnaire en ligne au monde de termes électroniques et électriques. Il contient plus de 20 000 termes et définitions en anglais et en français, ainsi que les termes équivalents dans les langues additionnelles. Egalement appelé Vocabulaire Electrotechnique International en ligne.
- Service Clients: www.iec.ch/webstore/custserv/custserv_entry-f.htm
Si vous désirez nous donner des commentaires sur cette publication ou si vous avez des questions, visitez le FAQ du Service clients ou contactez-nous:
Email: csc@iec.ch
Tél.: +41 22 919 02 11
Fax: +41 22 919 03 00

IEC 62271-207

Edition 1.0 2007-08

INTERNATIONAL STANDARD

NORME INTERNATIONALE

High-voltage switchgear and controlgear –
Part 207: Seismic qualification for gas-insulated switchgear assemblies for rated voltages above 52 kV

Appareillage à haute tension –
Partie 207: Qualification sismique pour ensembles d'appareillages à isolation gazeuse pour des niveaux de tension assignée supérieurs à 52 kV

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

COMMISSION
ELECTROTECHNIQUE
INTERNATIONALE

PRICE CODE
CODE PRIX T

ICS 29.130.10

ISBN 2-8318-9282-1

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

HIGH-VOLTAGE SWITCHGEAR AND CONTROLGEAR –

Part 207: Seismic qualification for gas-insulated switchgear assemblies for rated voltages above 52 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 provides no marking procedure to indicate its approval and cannot be rendered responsible for any equipment declared to be in conformity with an IEC Publication.
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) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

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

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

FDIS	Report on voting
17C/407/FDIS	17C/415/RVD

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

This first edition of IEC 62271-207 cancels and replaces the first edition of IEC 62271-2 and constitutes a technical revision.

The change from IEC 62271-2 is as follows:

– the minimum voltage rating was changed from 72,5 kV to above 52 kV;

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

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 publication will remain unchanged until the maintenance result date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

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

HIGH-VOLTAGE SWITCHGEAR AND CONTROLGEAR –

Part 207: Seismic qualification for gas-insulated switchgear assemblies for rated voltages above 52 kV

1 Scope and object

This International Standard applies to switchgear assemblies for alternating current of rated voltages above 52 kV for indoor and outdoor installations, including their supporting structure rigidly connected to the ground, and does not cover the seismic qualification of live tank circuit breakers. Switchgear assemblies do have typically low centers of gravity, e.g. gas-insulated switchgear (GIS).

For switchgear with higher gravity levels, e.g. live tank circuit breakers, the IEC 62271-300 is applicable.

Where switchgear assemblies are not ground-mounted, e.g. in a building, conditions for applications are subject to agreement between users and manufacturers.

The seismic qualification of the switchgear assemblies takes into account any auxiliary and control equipment either directly mounted or as a separate structure.

This standard provides procedures to seismically qualify ground-mounted switchgear assemblies for rated voltages above 52 kV.

The seismic qualification of the switchgear assemblies is only performed upon request.

This standard specifies seismic severity levels and gives a choice of methods that may be applied to demonstrate the performance of high-voltage switchgear assemblies for which seismic qualification is required.

The final seismic analysis shall be performed by assuming that the switchgear is installed on firm ground.

2 Normative references

The following referenced documents are indispensable for the application 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: Test – Mounting of specimens for vibration, impact and similar dynamic tests*

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

IEC 60068-3-3:1991, *Environmental testing – Part 3: Guidance – Seismic test methods for equipments*

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

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

3 Terms and definitions

For the purposes of this document, the terms and definitions in IEC 60068-3-3, IEC 62271-203 and IEC 60694 apply.

4 Seismic qualification requirements

4.1 General

The seismic qualification shall demonstrate the ability of the switchgear assemblies to withstand seismic stress.

No failure on the main circuits, the control and auxiliary circuit, including the relevant mounting structures, shall occur.

Permanent deformations are acceptable provided that they do not impair the functionality of the equipment. The equipment shall properly operate after the seismic event as defined in 8.2 and 8.3.

NOTE In the USA the evaluation of the seismic qualifications is conducted according to IEEE 693.

4.2 Preliminary analysis

4.2.1 Selection of the representative test-set

Due to practical reasons concerned with the available experimental facilities, the seismic qualification of switchgear assemblies can require the definition and the choice of different sub-sets which still meaningfully represent the whole system for the purpose of structural and functional checks.

Such test-sets shall include the switching devices with their relevant operating mechanism and control equipment, and their electrical and mechanical interfaces.

It is recommended

– to test generic components; to test the worst case components, such as those with the highest load and center of gravity.
– to identify the dynamic behaviour of the plant (natural frequencies and damping ratios) through the experimental activities of Annex A.

4.2.2 Mathematical model of the test-set

On the basis of technical information concerning the design characteristics of the substation, a three-dimensional model of the test-set shall be created. Such a model shall take into consideration the presence of actual compartments and of their supporting structures, and shall have sufficient sensitivity to describe the dynamic behaviour of the test-set in the frequency range being studied.

5 Severities

The severity levels shall be chosen from Table 1.

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

Qualification level	Required response spectrum (RRS)	Zero period acceleration (ZPA) m/s^2
AF5	Figure 1	5
AF3	Figure 2	3
AF2	Figure 3	2

For vertical severities the direction factor is 0,5 (see IEC 60068-3-3).

NOTE 1 The required response spectrum of qualification level AF5 covers partly, in the range of predominant seismic frequency of 1 Hz to 35 Hz, the following response spectra: Endesa, Edelca, USA/NRC RG 1.60, Newmark Design Response Spectra (scaled to 5 m/s^2), Nema (5 m/s^2 maximum foundation acceleration), Dept. of Water & Power Los Angeles, San Diego SDG & E Imperial Substation.

NOTE 2 Information on the correlation between seismic qualification levels and different seismic scales is given in IEC 60068-3-3.

6 Qualification by test

6.1 Introduction

The test procedure for qualification of a test-set shall be in accordance with IEC 60068-3-3.

The qualification shall be carried out on representative test sets, as described in 4.2.1.

If the auxiliary and control equipment or other parts of the equipment are dynamically uncoupled, they may be qualified independently.

If a test-set cannot be tested with its supporting structure (e.g., due to its size), the dynamic contribution of the structure shall be determined by analysis and accounted for in the test.

The time-history test method is to be preferred, since it more closely simulates actual conditions, particularly if the behaviour of the test-set is not linear. The test method shall be in accordance with IEC 60068-2-57.

6.2 Mounting

The test-set shall be mounted as in service including dampers (if any).

The horizontal orientation of the test-set shall be in the direction of excitation acting along its two main orthogonal axes.

Any fixtures or connections required only for testing shall not affect the dynamic behaviour of the test-set.

The method of mounting of the test-set shall be documented and shall include a description of any interposing fixtures and connections (see IEC 60068-2-47).

6.3 Measurements

Measurements shall be performed in accordance with IEC 60068-3-3 and shall include

– vibration motion of components where maximum deflections and significant relative displacements are expected;
– strains on critical elements (e.g. bushings, flanges, enclosures and support structures).

6.4 Frequency range

The frequency range shall be 0,5 Hz to 35 Hz. The frequency range is applied to the resonant frequency search test and the generation of artificial earthquake wave.

6.5 Test severity

6.5.1 General

The test severity shall be chosen in accordance with Clause 5.

The recommended required response spectra are given in Figures 1 to 3 for the different seismic qualification levels. The curves relate to 2 %, 5 %, 10 % and 20 % or more damping ratio of the switchgear assemblies. If damping factor is unknown, 2 % damping is applied.

Spectra for different damping values may be obtained by linear interpolation.

6.5.2 Parameters for time-history excitation

The total duration of the time-history shall be about 30 s, of which the strong part shall be not less than 6 s. The strong part is the section of the time history with the highest accelerations.

6.6 Testing

6.6.1 Test directions

The test directions shall be chosen according to IEC 60068-3-3.

In some cases, the effect of the vertical acceleration results in negligible stresses and the vertical excitation may be omitted. In such cases justification for the omission of the vertical component shall be provided.

6.6.2 Test sequence

6.6.2.1 General

The test sequence shall be as follows:

– functional checks before testing;
– vibration response investigation (required to determine critical frequencies and damping ratios and/or for analysis);
– seismic qualification test;

– functional checks after testing.

6.6.2.2 Functional checks

Before and after the tests, the following operating characteristics or settings shall be recorded or evaluated (when applicable) at the rated supply voltage and operating pressure:

a) closing time;
b) opening time;
c) time spread between units of one pole;
d) time spread between poles (if multipole tested);
e) gas and/or liquid tightness;
f) resistance measurement of the main current path.

6.6.2.3 Vibration response investigation

The resonant frequency search test, damping measurement test shall be carried out according to IEC 60068-3-3 over the frequency range stated in 6.5.

6.6.2.4 Seismic qualification test

The test shall be performed by applying one of the procedures stated in the flow charts of Appendix A of IEC 60068-3-3, depending on the test facilities.

The test shall be performed once at the level chosen in Clause 5.

During the seismic test the following parameters shall be recorded:

– strains on critical elements (e.g. bushings, flanges, enclosures and support structures);
– deflection of components where significant displacements are expected;
– electrical continuity of the main circuit (if applicable);
– electrical continuity of the auxiliary and control circuit at the rated voltage;
– acceleration.

7 Qualification by combined test and numerical analysis

7.1 Introduction

The method may be used

– to qualify switchgear assemblies already tested under different seismic conditions;
– to qualify switchgear assemblies similar to assemblies already tested but which include modifications influencing the dynamic behaviour (e.g. change in the arrangement of the assemblies, or in the mass of components);
– to qualify switchgear assemblies if their vibrational and functional data are known;
– to qualify switchgear assemblies which cannot be qualified by testing alone (e.g. because of their size and/or complexity).

7.2 Vibrational and functional data

Vibrational data (damping ratios, critical frequencies, stresses of critical elements as a function of input acceleration) for analysis shall be obtained by one of the following:

a) a dynamic test of a similar test-set;

b) a dynamic test at reduced test levels;

c) determination of critical frequencies and damping ratios by other tests such as free oscillation tests or low level excitation (see Annex A).

Functional data may be obtained from a previous test performed on a similar test-set.

7.3 Numerical analysis

7.3.1 General

The general procedure is as follows:

a) to establish, using experimental data stated in 7.2, a mathematical model of switchgear assemblies in order to assess their dynamic characteristics. Considering the modularity of switchgear assemblies, the mathematical model implemented and calibrated for the test-set may be extended to a complete substation, provided that the right adaptations, related to the structural differences existing for the different modules, are considered;

b) to calibrate the mathematical model by taking into account the non-linearities of the dynamic response of the test-set assessed during the experimental activity described in Annex A;

c) to determine the response, in the frequency range stated in 6.5, using either of the methods described in the following subclauses, but other methods may be used if they are properly justified.

7.3.2 Numerical analysis by the acceleration time-history method

When the seismic analysis is carried out by the time-history method, the ground motion acceleration time-histories shall comply with the RRS (see Table 1). Two types of superimposition may generally be applied depending on the complexity of the analysis:

a) separate calculation of the maximum responses due to each of the three components (x and y in the horizontal, and z in the vertical direction) of the earthquake motion. The effects of each single horizontal direction and the vertical direction shall be combined by taking the square root of the sum of the squares, i.e. $(x^2 + z^2)^{1/2}$ and $(y^2+z^2)^{1/2}$. The greater of these two values is used for dimensioning the switchgear assemblies;

b) simultaneous calculation of the maximum responses assuming one of the seismic horizontal directions and the vertical direction (x with z) and thereafter calculation with the other horizontal direction and the vertical direction (y with z). This means that after each time step of the calculation all values (forces, stresses) are superimposed algebraically. The greater of these two values is used for dimensioning the switchgear assemblies.

7.3.3 Modal and spectrum analysis using the required response spectrum (RRS)

When the response spectra method is used for seismic analysis, the procedure of combining the stresses shall be hereinafter described for an orthogonal system of coordinates in the main axes of the switchgear assemblies and with x and y in the horizontal and z in the vertical direction. The maximum values of stresses in the switchgear assemblies for each of the three directions x, y and z are obtained by superimposing the stresses calculated for the various modal frequencies in each of these directions by taking the square root of the sum of the squares. The maximum values in the x and z direction, and in the y and z direction, are combined by taking the square root of the sum of the squares. The greater value of these two cases (x, z) or (y, z) is the dimensioning factor for the switchgear assemblies.

7.3.4 Static coefficient analysis

For rigid equipment static analysis shall be applied (the lowest resonant frequency of equipment is greater than 35 Hz.) It may also be used for flexible equipment, as an alternative method of analysis; this allows a simpler technique in return for added conservatism. No determination of natural frequencies is made but, rather, the response spectrum of the switchgear assemblies is assumed to be the peak of the required response spectrum at a conservative and justifiable value of damping. The coefficient 1.5 shall only be applied to static coefficient analysis.

The seismic forces on each part of the switchgear assemblies are obtained by multiplying the values of the mass, concentrated at its centre of gravity, and the acceleration.

The resulting force shall be distributed proportionally to the mass distribution.

The stress analysis may then be completed as stated in 8.1.

8 Evaluation of the seismic qualification

8.1 Combination of stresses

The seismic stresses determined by test or analysis shall be combined algebraically with other service loads to determine the total withstand capability of the switchgear assemblies.

The probability of an earthquake of the recommended seismic qualification level occurring during the life-time of the switchgear assemblies is low, whilst the maximum seismic load in a natural earthquake would only occur if the switchgear assemblies were excited at their critical frequencies with maximum acceleration. As this will last only a few seconds, a combination of the utmost electrical and environmental service loads leads to unrealistic conservatism.

The following loads may be considered to occur additionally, if not otherwise specified:

– rated internal pressure;

– permanent loads (dead loads);

– thermal effects.

The combination of loads shall be effected by static analysis, applying the forces in the direction they occur.