IEC 62271-207

Edition 2.0 2012-04

INTERNATIONAL STANDARD

NORME INTERNATIONALE

colour inside

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

Tel.: +41 22 919 02 11
Fax: +41 22 919 03 00
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 corrigenda or an amendment might have been published.

Useful links:

IEC publications search - www.iec.ch/searchpub

The advanced search enables you 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It also gives information on projects, replaced and withdrawn publications.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 on-line and also once a month by email.

Electropedia - www.electropedia.org

The world's leading online dictionary of electronic and electrical terms containing more than 30 000 terms and definitions in English and French, with equivalent terms in additional languages. Also known as the International Electrotechnical Vocabulary (IEV) on-line.

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: csc@iec.ch.

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.

Liens utiles:

Recherche de publications CEI - www.iec.ch/searchpub

La recherche avancée vous permet de trouver des publications CEI 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.

Just Published CEI - webstore.iec.ch/justpublished

Restez informé sur les nouvelles publications de la CEI. Just Published détaille les nouvelles publications parues. Disponible en ligne et aussi une fois par mois par email.

Electropedia - www.electropedia.org

Le premier dictionnaire en ligne au monde de termes électroniques et électriques. Il contient plus de 30 000 termes et définitions en anglais et en français, ainsi que les termes équivalents dans les langues additionnelles. Egalement appelé Vocabulaire Electrotechnique International (VEI) en ligne.

Service Clients - webstore.iec.ch/csc

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

IEC 62271-207

Edition 2.0 2012-04

INTERNATIONAL STANDARD

NORME INTERNATIONALE

colour inside

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

ICS 29.130.10 ISBN 978-2-88912-060-4

Warning! Make sure that you obtained this publication from an authorized distributor.
Attention! Veuillez vous assurer que vous avez obtenu cette publication via un distributeur agréé.

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 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) 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.

This second edition of IEC 62271-207 cancels and replaces the first edition published in 2007. It constitutes a technical revision.

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

– modification of the minimum voltage rating from 72,5 kV to above 52 kV;
– harmonisation of qualification procedures for GIS with IEEE 693:2005 Annex A and P by modifying the response spectra;
– modification of the test procedures;
– addition of criteria of allowed stresses;

– addition of dynamic analysis CQC.

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

FDIS	Report on voting
17C/542/FDIS	17C/549/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 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 stability 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.

The contents of the corrigendum of January 2013 have been included in this copy.

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

HIGH-VOLTAGE SWITCHGEAR AND CONTROLGEAR –

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

1 Scope

This part of IEC 62271 applies to gas-insulated switchgear assemblies for alternating current of rated voltages above 52 kV for indoor and outdoor installations, including their supporting structure.

For switchgear devices, e.g. live tank circuit breakers, IEC/TR 62271-300 is applicable.

Guidance on interactions between the supporting structure and the soil / foundations is provided in Annex B.

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

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

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. 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, *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 62271-1, *High-voltage switchgear and controlgear – Part 1: Common specifications*

IEC 62271-203, *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 terms and definitions given in IEC 60068-3-3, IEC 62271-203 and IEC 62271-1 apply.

4 Seismic qualification requirements

4.1 General

The seismic qualification shall demonstrate the ability of the switchgear assemblies to withstand seismic stress. It may be proofed by test or by a combination of test and analysis.

No failure on the enclosure and the main circuits as well as on the control and auxiliary circuit, including the relevant supporting structures, shall occur.

For ductile material, minor 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 7.2 and 7.3.

4.2 Qualification levels

The qualification has to be done on one of the recommended levels of Table 1. For vertical severities the direction factor is 0,5.

No qualification is required for low seismic level as far as construction practice and seismic construction practice comply with the state of the art.

Other qualification levels which consist in requirements from the customer that can be based on specific investigation at site or regulations in national standard, taking into account for example the type of soil, soil structure interaction, building response, and elevation may be used.

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

Qualification level	Required response spectrum (RRS)	Zero period acceleration (ZPA) m/s^2
High	Figure 2	5
Moderate	Figure 1	2,5
Low	---	1

5 Test procedures for qualification

5.1 General

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 a representative test-set.

NOTE 1 For GIS it is not possible to test a complete substation on a shake table, because of the size and weight. Numerical analysis is always needed to give information about the seismic qualification.

The seismic test needs to be carried out under the rated filling pressure of the GIS.

The rated filling pressure in the GIS is required to test under realistic situations. Nevertheless test laboratories for seismic testing need adequate safety measures. Test laboratories are available in USA, Europe and Japan.

During the seismic testing no operation of the circuit breaker is necessary.

NOTE 2 The circuit breaker operates much faster than any earthquake excitation and therefore a switching operation has no practical impact on the test result.

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 taken into account 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.

5.2 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 fixations or connections that are required only the convenience of testing must 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. IEC 60068-2-47 provides guidance.

5.3 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 of critical elements (e.g. bushings, flanges, enclosures and support structures).

5.4 Frequency range

Frequency range shall be 0,5 Hz to 33 Hz. The frequency range is applied to the resonant frequency search test and the generation of artificial earthquake wave.

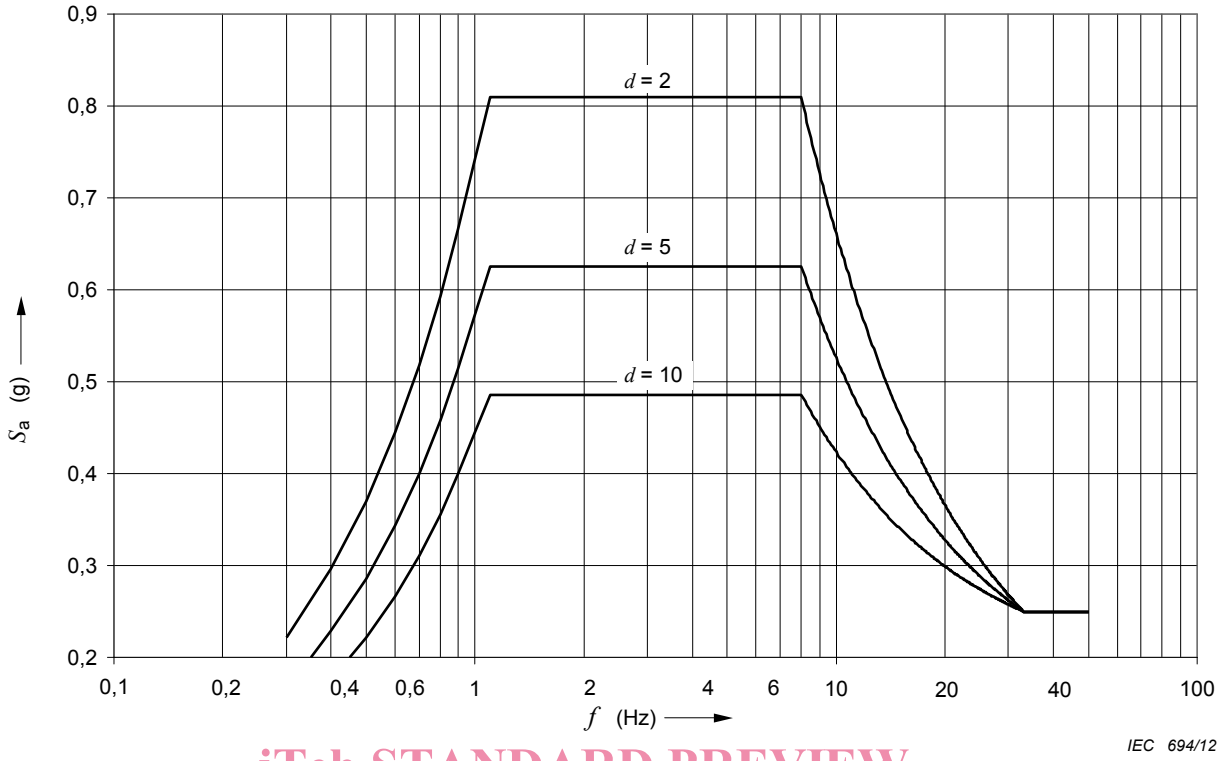
5.5 Test severity

5.5.1 General

The test severity shall be chosen in accordance with Clause 4.

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

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



Spectral Accelerations, S_a (g), for Frequencies, f (Hz):

$S_a = 0{,}572\ \beta\ f$ for $0{,}0 \leq f \leq 1{,}1$

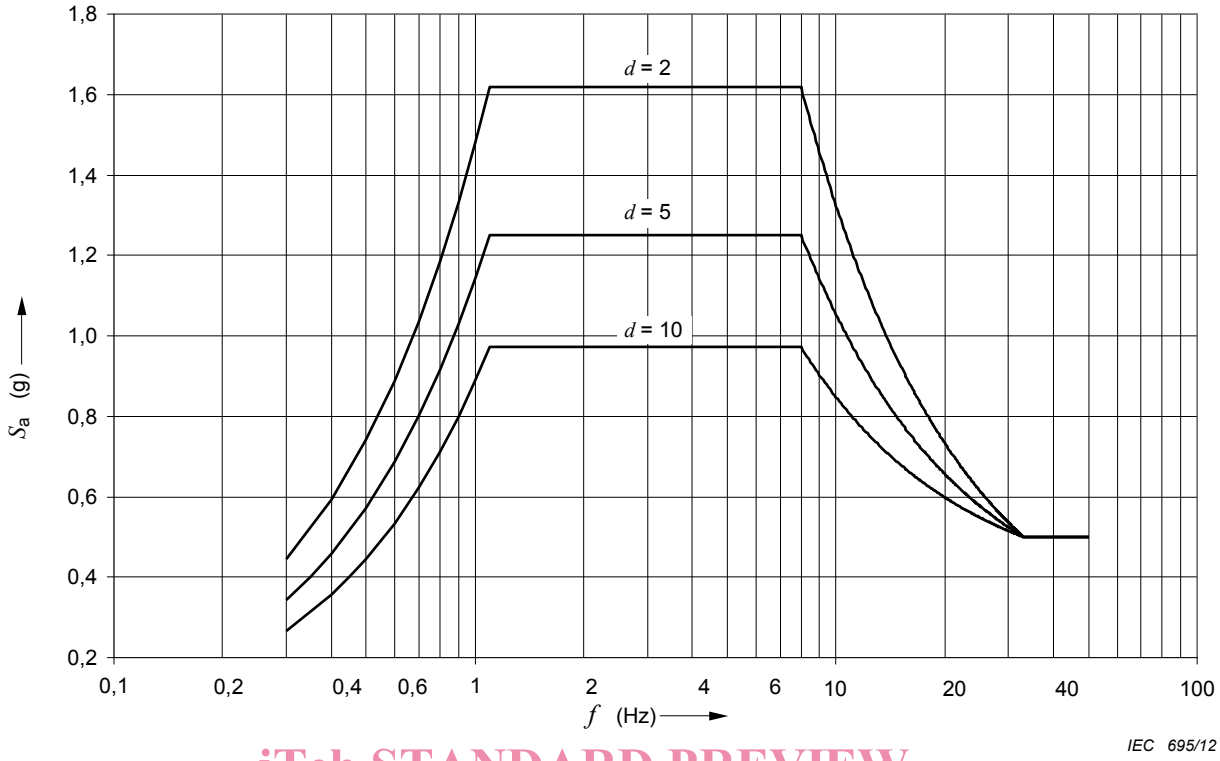
$S_a = 0{,}625\ \beta$ for $1{,}1 \leq f \leq 8{,}0$

$S_a = (6{,}6\ \beta - 2{,}64) / f - 0{,}2\ \beta + 0{,}33$ for $8{,}0 \leq f \leq 33$

$S_a = 0{,}25$ for $f > 33$

$\beta = (3{,}21 - 0{,}68 \ln(d)) / 2{,}115\ 6$, where d is the percent damping (2, 5, 10, etc.) and $d \leq 20$ %

Figure 1 – Required response spectrum (RRS) for qualification level moderate



Spectral Accelerations, S_a (g), for Frequencies, f (Hz):

S_a = 1,144 β f for 0,0 ≤ f ≤ 1,1

S_a = 1,25 β for 1,1 ≤ f ≤ 8,0

S_a = (13,2 β – 5,28) / f – 0,4 β + 0,66 for 8,0 ≤ f ≤ 33

S_a = 0,5 for f > 33

β = (3,21 – 0,68 ln(d)) / 2,1156, where d is the percent damping (2, 5, 10, etc.) and d ≤ 20%

Figure 2 – Required response spectrum (RRS) for qualification level high

5.5.2 Parameters for time-history excitation

The total duration of the time-history shall be about 30 s, of which the strong part shall not be less than 20 s. The duration of strong part shall start when the time-history excitation first reaches 25 % of its maximum acceleration. It shall end when the time-history excitation drops below 25 % of its maximum acceleration for the last time.

5.5.3 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.

5.5.4 Test sequence

5.5.4.1 General

The test sequence shall be as follows:

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

5.5.4.2 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 at rated filling pressure for operation p_{rm}:

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.

5.5.4.3 Vibration response investigation

The resonant frequency search test and the damping measurement test shall be carried out according to IEC 60068-3-3 over the frequency range stated in 5.4.

5.5.4.4 Seismic qualification test

The test shall be performed by applying one of the procedures stated in the flow charts of Annex A of IEC 60068-3-3:1991, depending on the test facilities.

The test shall be performed once at the level chosen in 4.2.

During the seismic test the following parameters shall be recorded:

– strains of 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.

6 Qualification by combined test and numerical analysis

6.1 General

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 or extension of the arrangement or in the mass of components);
– to qualify switchgear assemblies if their dynamic and functional data are known;
– to qualify switchgear assemblies which cannot be qualified by testing (e.g. because of their size, their weight or their complexity).

6.2 Dynamic and functional data

Dynamic data (damping ratios, natural 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 natural 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.

6.3 Numerical analysis

6.3.1 General

The general procedure is as follows:

a) Mathematical model:

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.

b) Calibration of the model:

Using experimental data stated in 6.2, the mathematical model shall be calibrated in order to assess its dynamic characteristics. Considering the modularity of switchgear assemblies, the mathematical model implemented and calibrated for the test-set may be extented to a complete substation, provided that the right adaptations, related to the structural differences existing for the different modules, are considered;

c) Response of the analysis:

The response, in the frequency range stated in 5.4, using either of the methods described in the following subclauses has to be determined. Other methods may be used if they are properly justified.

6.3.2 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.

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

When the dynamic analysis is carried out by the response spectrum method, the following shall apply: