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TECHNICAL SPECIFICATION

SPÉCIFICATION TECHNIQUE

High-voltage switchgear and controlgear –
Part 210: Seismic qualification for metal enclosed and solid-insulation enclosed switchgear and controlgear assemblies for rated voltages above 1 kV and up to and including 52 kV

Appareillage à haute tension –
Partie 210: Qualification sismique pour ensembles d'appareillage sous enveloppe métallique pour tensions assignées supérieures à 1 kV et inférieures ou égales à 52 kV

IEC/TS 62271-210:2013

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HIGH-VOLTAGE SWITCHGEAR AND CONTROLGEAR –

Part 210: Seismic qualification for metal enclosed and solid-insulation enclosed switchgear and controlgear assemblies for rated voltages above 1 kV and up to and including 52 kV

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Technical specifications are subject to review within three years of publication to decide whether they can be transformed into International Standards.

IEC 62271-210, which is a technical specification, has been prepared by subcommittee 17C: High-voltage switchgear and controlgear assemblies, of IEC technical committee 17: Switchgear and controlgear.

The text of this technical specification is based on the following documents:

Enquiry draft	Report on voting
17C/515/DTS	17C/548/RVC

Full information on the voting for the approval of this technical specification 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

- transformed into an International standard,
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- withdrawn,
- replaced by a revised edition, or
- amended.

HIGH-VOLTAGE SWITCHGEAR AND CONTROLGEAR –

Part 210: Seismic qualification for metal enclosed and solid-insulation enclosed switchgear and controlgear assemblies for rated voltages above 1 kV and up to and including 52 kV

1 General

1.1 Scope

This part of IEC 62271 applies to metal enclosed switchgear and controlgear assemblies complying with IEC 62271-200 for metal enclosed and IEC 62271-201 for solid-insulation enclosed, ground or floor mounted, intended to be used under seismic conditions.

The seismic qualification of the switchgear and controlgear assemblies takes into account any auxiliary and the control equipment mounted directly on the assembly.

It will specify seismic severity levels, acceptance levels, and give a choice of methods that may be applied to demonstrate the performance of high-voltage switchgear and controlgear assemblies for which seismic qualification is required.

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

1.2 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 60068-2-6, *Environmental testing – Part 2-6: Tests – Test Fc: Vibration (sinusoidal)*

IEC 60068-2-57:1999, *Environmental testing – Part 2-57: Tests – Test Ff: Vibration – Time-history method*

IEC 60068-2-64, *Environmental testing – Part 2-64: Tests – Test Fh: Vibration, broadband random and guidance*

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

IEC 62271-1:2007, *High-voltage switchgear and controlgear – Part 1: Common specifications*

IEC 62271-200, *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, *High-voltage switchgear and controlgear – Part 201: AC insulation-enclosed switchgear and controlgear for rated voltages above 1 kV and up to and including 52 kV*

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

2 Normal and special service conditions

(void)

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 and ISO 2041 apply.

4 Seismic qualification requirements

4.1 General

The seismic qualification shall demonstrate the ability of the switchgear and controlgear assemblies to withstand seismic stresses.

Basis of seismic qualification is the test, because only that allows a verification of functionality of the equipment during and after the seismic events. The test is also a necessary input for setup of numerical model used for analysis.

A combination of test and analysis is needed because not each type of switchgear arrangement can be tested.

4.2 Preliminary analysis

4.2.1 Selection of the representative test sample

Due to practical reasons concerned with the available experimental facilities, the seismic qualification of switchgear and controlgear assemblies requires the choice of proper test samples which reasonably represent the whole system for the purpose of structural and functional checks.

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

These test samples shall demonstrate the worst cases, such as those with heaviest mass and highest centre of gravity. In case of functional units with different masses, the heaviest panel shall be placed at one end of the test arrangement. Simulation can be used to determine the test sample, which satisfies the above criteria.

4.2.2 Mathematical model of the test sample

If qualification by combined test and numerical analysis, according to Clause 6, is foreseen, a three-dimensional mathematical model of the test sample shall be created on the basis of technical information concerning the design characteristics.

Such a model shall take into consideration the presence of switching and control devices, compartments and of their supporting structures, and shall have sufficient sensitivity to describe the dynamic behaviour of the test sample in the frequency range being studied.

The validity of the model shall be established by comparison between simulation results and actual tests results, as stated in 7.3.

4.3 Severities

4.3.1 General

In earthquake zone 4 (risk of very strong earthquakes) the measured peak ground acceleration in many cases is approximately 0,5 g. In a few cases the measured peak ground acceleration is around 1 g (see also Annex D).

Due to the wide range of ground motions, site conditions, switchgear installations in buildings, two severity levels are defined for seismic qualification in order to avoid designing or testing always to the highest levels.

The shape of the Required Response Spectra (RRS) (severity levels 1 and 2) is a broadband response spectrum to cover many site conditions (magnitude, depth and distance to epicentre, rock or soft soil) and super elevation due to the floor level installation.

For qualification, one of the following severity levels shall be chosen:

The severity level 1 is recommended for peak ground / floor accelerations up to 0,5 g.

The severity level 2 is recommended for peak ground / floor accelerations up to 1,0 g.

The Required Response Spectra are given in Figures 1 and 2 for the different seismic qualification levels. The curves relate to 2 %, 5 % and 10 % damping ratio of the switchgear and controlgear assemblies. For testing and if the exact damping behaviour is unknown 5 % damping ratio is recommended.

Severity Level 1 is recommended for equipments mounted at the ground level for zones 0 to 4 or at upper floor levels combined with earthquake zones 0 to 3 (see Annex D). For Zone 0, it is not necessary to perform any seismic qualification.

Severity Level 2 is only recommended for equipments mounted at upper floor levels combined with earthquake zone 4 (see Annex D).

If site-specific conditions are known the user may develop a site-specific response spectrum which envelops the shape of the severity level 1 and/or severity level 2.

NOTE The severity level 1 is equivalent to the moderate performance level according to IEEE 693:2005.

The severity level 2 is equivalent to the high performance level according to IEEE 693:2005.

4.3.2 Severity level 1

The RRS is described by the following equations:

Horizontal spectral accelerations S_a (m/s²) for frequencies f (Hz):

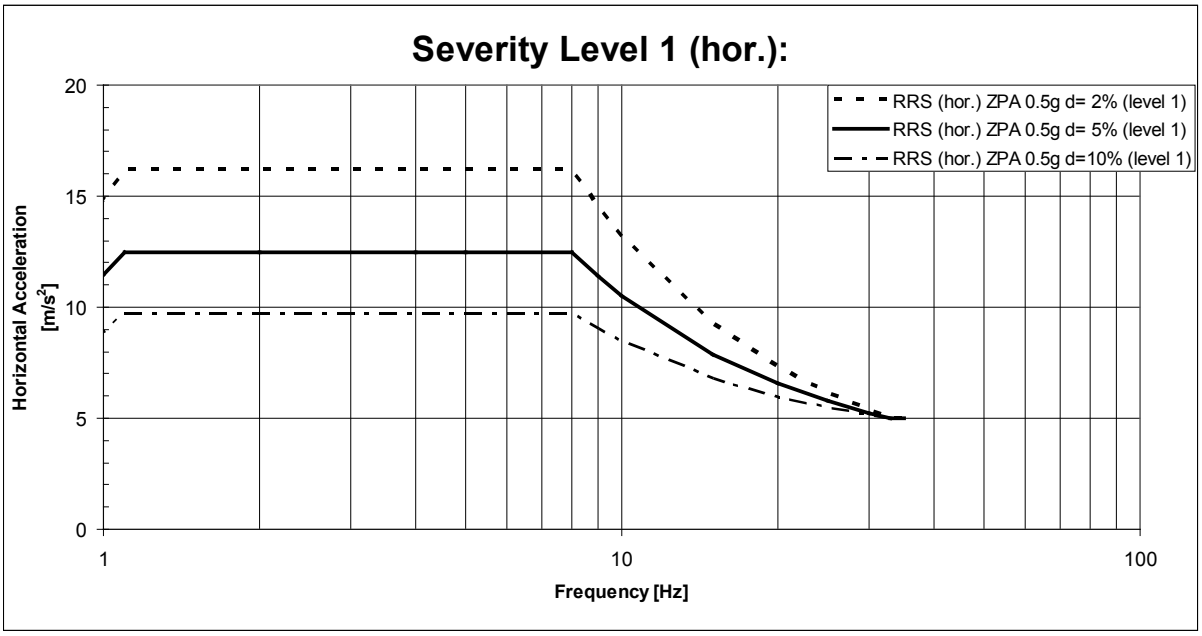
- $S_a = 1{,}144 \times \beta \times f \times g$ for $0{,}0 \le f \le 1{,}1$
- $S_a = 1{,}250 \times \beta \times g$ for $1{,}1 \le f \le 8{,}0$
- $S_a = 2 \times ((6{,}62 \times \beta - 2{,}64) / f - 0{,}2 \times \beta + 0{,}33)) \times g$ for $8{,}0 \le f \le 33$
- $S_a = 0{,}5 \times g$ for $f \ge 33$

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

For qualification the RRS is limited to a frequency range starting at 1,0 Hz (see 5.3.2).

For vertical spectral accelerations the conversion factor is 0,8.

NOTE The conversion factor is 0,8 in order to harmonize the values settle by IEEE and IEC standards.



SOURCE: Reproduced from IEEE Std 693:2005, *IEEE Recommended Practice For Seismic Design of Substations* with the permission of IEEE.

Figure 1 – Severity level 1 (horizontal) – Zero period acceleration (ZPA) = 0,5 g

4.3.3 Severity level 2

The RRS is described by the following equations:

Horizontal spectral accelerations S_a (m/s²) for frequencies f (Hz):

- $S_a = 2{,}288 \times \beta \times f \times g$ for $0{,}0 \leq f \leq 1{,}1$
- $S_a = 2{,}5 \times \beta \times g$ for $1{,}1 \leq f \leq 8{,}0$
- $S_a = 2 \times ((13{,}2 \times \beta - 5{,}28)/ f - 0{,}4 \times \beta + 0{,}66)) \times g$ for $8{,}0 \leq f \leq 33$
- $S_a = 1 \times g$ for $f \geq 33$

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

For qualification the RRS is limited to a frequency range starting at 1,0 Hz (see 5.3.2).

For vertical spectral accelerations the conversion factor is 0,8.

NOTE The conversion factor is 0,8 in order to harmonize the values settle by IEEE and IEC standards.

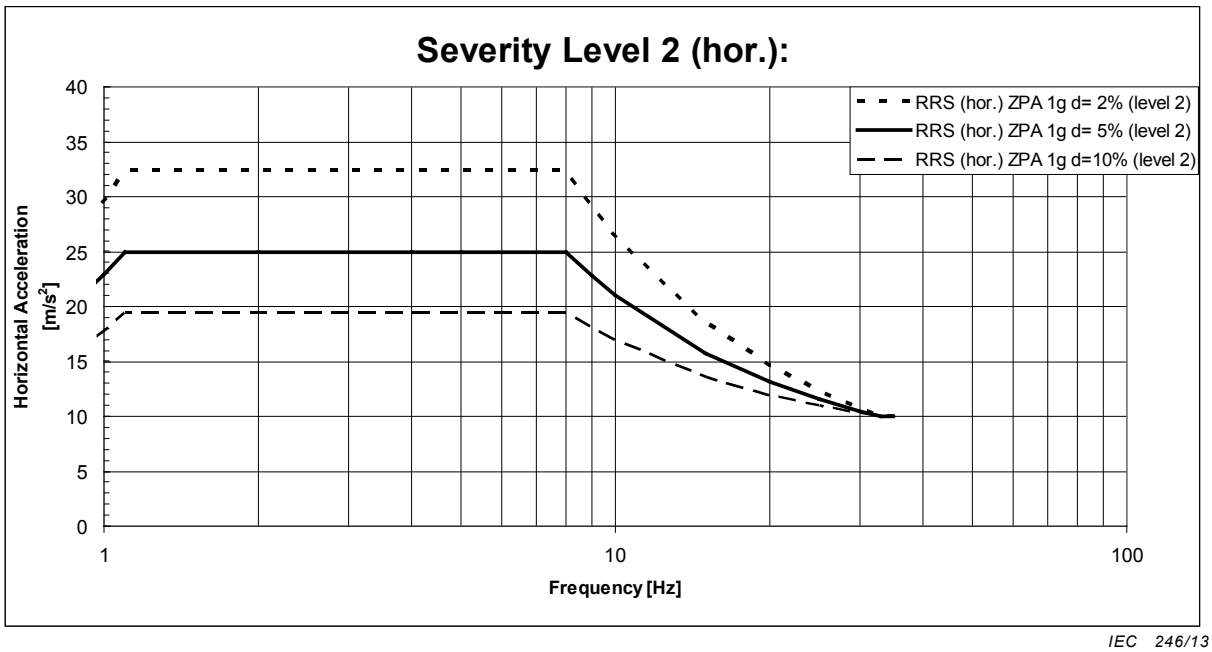


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Figure 2 – Severity level 2 (horizontal) – Zero period acceleration (ZPA) = 1 g

4.4 Acceptance classes

Two acceptance classes for equipment are defined:

For class 1, the equipment has to maintain its functionality during and after the earthquake. After the seismic event maintenance and partial replacement might be necessary to ensure long term operation.

For class 2, the equipment has to maintain its functionality during and after the earthquake. After the seismic event no maintenance is required.

5 Qualification by test

5.1 General

The test procedure shall be in accordance with IEC 60068-3-3 with the modification that the time history test method in accordance with IEC 60068-2-57 shall be applied. The time history test method more closely simulates actual conditions, because the behaviour of the test sample is always not linear.

The seismic test should demonstrate the ability of the switchgear and controlgear assemblies to perform its required functions during and after seismic loads in form of Test Response Spectrum (TRS) that envelopes the RRS. The demonstration shall be performed as it is settled in 5.4.1 and 5.4.3.

If a test sample 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.

5.2 Mounting

The test sample shall be mounted as in service condition including dampers (if any).

If exact service conditions are unknown, a rigid base frame shall be used between the equipment and the shaking table.

The horizontal orientation of the test sample 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 sample.

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

5.3 Test parameters

5.3.1 Measurements

The measurements should be in accordance with 5.2 of IEC 60068-3-3:1991.

At least the following signals shall be recorded:

- acceleration at the shake-table;
- acceleration at significant places within the test object:
  - at least one measurement point, directly connected to the main structure (usually on top of switchgear),
  - near to the centre of gravity (if accessible),
  - at critical components (e.g. heavy masses).

5.3.2 Frequency range

The frequency range shall be from 1 Hz to at least 35 Hz in accordance with the Annex B of IEC 60068-2-57:1999 because in earthquakes the predominant frequencies are in between this range. The frequency range is applied to the resonant frequency search test and the generation of artificial earthquake wave.

The first resonant frequency for a typical test setup in horizontal directions is in the range of 5 Hz to 10 Hz, therefore test frequencies below 1 Hz are not relevant.

Due to the limitation of some shake-tables it is not required to envelop the RRS below frequencies of 70 % of the lowest resonant frequency of the equipment.

5.3.3 Parameters for resonant frequency search

The resonant frequency search test shall be carried out according to 10.1 of IEC 60068-3-3:1991.

The recommended acceleration during the resonant frequency search is 0,1 g. The search shall be conducted successively by sine sweeps in the three main axes at a maximum rate of 1 octave/min.

5.3.4 Parameters for time history test (seismic load test)

The test directions shall be chosen according to IEC 60068-3-3:1991, Clause 15.

Tri-axial testing is recommended.

The severity level shall be chosen according to 4.3.

The total duration of the time-history shall be 30 s at least and the strong part duration shall be not less than 20 s.

5.4 Testing procedure

5.4.1 General

The test sequence shall be as follows:

- functional checks before testing;
- resonant frequency search (required to determine critical frequencies and damping ratios and/or for analysis);
- time-history test (seismic load test);
- resonant-frequency search;
- functional checks after testing.

5.4.2 Inspection and 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) visual inspection;
b) operation of any switching device;
c) closing time of any fast-closing switching device;
d) opening time of any fast-opening switching device;
e) operation of any withdrawable or removable part;
f) gas and/or liquid tightness where relevant;
g) resistance measurement of the main circuit;
h) power-frequency withstand voltage test as condition check of the main circuit (all switching devices in closed position) phase to phase and phase to earth, according 6.2.11 of IEC 62271-1:2007;
i) power-frequency withstand voltage test as condition check of the switching devices in opened position, according 6.2.11 of IEC 62271-1:2007.

These functional tests can be performed at the laboratory of the manufacturer.

5.4.3 Resonant frequency search

The resonant frequency search test shall be carried out according to 10.1 of IEC 60068-3-3:1991.

5.4.4 Time history test (seismic load test)

The time history test shall be performed once according to IEC 60068-2-57 with the parameters as defined in 5.3.4.

During the seismic test the following parameters shall be recorded in addition to 5.3.1:

- electrical continuity of the main circuit (if applicable);
- electrical continuity of the auxiliary and control circuit (representative NO/NC contacts).

During the test the control circuits shall be energized at the rated voltage.

One test run is required, at the beginning all switching devices shall be in closed position; the test condition depends on the switching devices and their ability to perform operations during the strong motion part of the time history:

- during this operational test each circuit-breaker shall perform at least one operating sequence (recommendation: O-5s-C-5s-O within the middle of total test duration and therefore within the strong part of motion);
- other switching devices shall operate as specified (e.g. open operation for load break switches);
- switching devices unable to operate during seismic loads shall perform the test in closed position without operation.

NOTE 1 Circuit-breakers ensure the switching capability even during seismic events. Other switching devices give evidence only for the functionality specified by the manufacturer.

NOTE 2 A further test run can be performed optionally, with all switching devices in closed position without operation. This leads to a qualification valid for this standard and for the IEEE 693.

Criteria for assessing the test validity and the test results are provided in 7.1 and 7.2.

If the test is intended to be used as a basis for numerical analysis, then further recordings shall be performed in order to provide relevant data. Further test parameters are:

- deflection of components where significant displacements are expected;
- strains on critical elements (e.g. bushings, flanges, enclosures and support structures);
- acceleration on relevant locations on the test sample.

6 Qualification by combination of test and analysis

6.1 General

Analysis alone cannot be applied because metal-enclosed switchgear and controlgear assemblies are complex devices and functional operability can not be verified by analysis techniques alone.

Analysis may be used:

- in validating switchgear and controlgear assemblies already tested in the same configuration under different seismic conditions;
- in validating switchgear and controlgear assemblies similar to the ones already tested under the same seismic conditions but which include modifications influencing the dynamic behaviour (e.g. change in the arrangement of the switchgear and controlgear assemblies, or in the mass of components);
- in validating switchgear and controlgear assemblies which cannot be qualified by testing alone (e.g. because of their size and/or complexity).

The methodology comprises the analysis of the structural part and the testing of the functionality separately.

The structural part consists principally of the structure including braces, frames, struts and attachments that transmit all seismic loads between the equipment and the floor. The dynamic behaviour of the equipment or assembly depends on the structural part.

Two or more assemblies can be considered structurally similar when they have the same structural scheme and the same connections types; they can be different by the mass distribution and/or the dimensions.