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Edition 2.0 2019-08

INTERNATIONAL STANDARD

NORME INTERNATIONALE

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

**Essais d'environnement –
Partie 3-3: Documentation d'accompagnement et recommandations – Méthodes d'essais sismiques applicables aux matériels**

IEC 60068-3-3:2019-08(en-fr)

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

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

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ENVIRONMENTAL TESTING –

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FOREWORD

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International Standard IEC 60068-3-3 has been prepared by IEC technical committee 104: Environmental conditions, classification and methods of test.

This second edition cancels and replaces the first edition published in 1991. This edition constitutes a technical revision.

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

a) the main aim of this revision is to connect the testing level to the seismic activity level of the zone where the equipment could be installed;
b) a standard shape for the required response spectrum is also given for the general seismic class for which the seismic environment is either not known or is imprecisely known;

c) Clauses 11 to 15 were renumbered and some adjustments were made as their content is very general and the requirements can be applied both to the general seismic class and to the specific seismic class;

d) the word “envelope” is replaced with “dominance” and “to envelop” with “to dominate” in order to provide a more precise meaning from a mathematical point of view.

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

FDIS	Report on voting
104/835/FDIS	104/841/RVD

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

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

This International Standard is to be used in conjunction with IEC 60068-1.

A list of all parts in the IEC 60068 series, published under the general title *Environmental testing*, can be found on the IEC website.

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

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

INTRODUCTION

Guidance is included in each of the two test methods referred to in this document but it is specific to the test method. The guidance in this document is directed towards choosing the appropriate test method and applying it to seismic testing.

ENVIRONMENTAL TESTING –

Part 3-3: Supporting documentation and guidance – Seismic test methods for equipment

1 Scope

This part of IEC 60068 applies primarily to electro-technical equipment but its application can be extended to other equipment and to components.

In addition, if some type of analysis is always performed when making a seismic qualification, for example for the choice of the representative sample to be tested or for the extension of the seismic qualification from the tested specimen to similar specimens, the verification of the performance of an equipment by analysis or by a combination of testing and analysis can be acceptable but is outside the scope of this document, which is restricted to verification based entirely upon data from dynamic testing.

This document deals solely with the seismic testing of a full-size equipment which can be tested on a vibration table. The seismic testing of an equipment is intended to demonstrate its ability to perform its required function during and/or after the time it is subjected to the stresses and displacements resulting from an earthquake.

The object of this document is to present a range of methods of testing which, when specified by the relevant specification, can be applied to demonstrate the performance of equipment for which seismic testing is required with the main aim of achieving qualification.

NOTE Qualification by so-called “fragility-testing” is not considered to be within the scope of this document which has been prepared to give generally applicable guidance on seismic testing and specifically on the use of IEC 60068-2 test methods.

The choice of the method of testing can be made according to the criteria described in this document. The methods themselves are closely based on published IEC test methods.

This document is intended for use by manufacturers to substantiate, or by users to evaluate and verify, the performance of an equipment.

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 60068-1, *Environmental testing – Part 1: General and guidance*

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

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 and sine-beat method*

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

IEC 60068-2-81, *Environmental testing – Part 2-81: Tests – Test Ei: Shock – Shock response spectrum synthesis*

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 60068-1, IEC 60068-2-6, IEC 60068-2-57 and ISO 2041 and the following apply.

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

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

3.1
assembly
two or more devices sharing a common mounting or supporting structure

3.2
bandpass at –3 dB
frequency intervals defined by the points possessing an ordinate larger than or equal to $\sqrt{2}/2$ times the maximum value of the plot

SEE: Figure 2.

3.3
basic response spectrum
unmodified response spectrum defined by the characteristics of the building, its floor level, damping ratio, etc. and obtained from a specific ground motion

SEE: Figure 2.

Note 1 to entry: The basic response spectrum is generally of the narrow band type at floor level. The basic response spectrum is calculated by the architect engineer of the plant and it is generally not known by the equipment manufacturer and by the test engineer.

3.4
broadband response spectrum
response spectrum that describes the motion indicating that a number of interacting frequencies exist which should be treated as a whole

SEE: Figure 3c).

Note 1 to entry: The bandwidth is normally greater than one octave.

3.5
critical frequency
frequency at which:

– malfunctioning and/or deterioration of performance of the specimen which are dependent on vibration are exhibited, and/or
– mechanical resonances and/or other response effects occur, for example chatter

[SOURCE: IEC 60068-2-6:2007, 3.9]

3.6
crossover frequency
frequency at which the characteristic of a vibration changes from one relationship to another

Note 1 to entry: For example, a crossover frequency may be that frequency at which the control of the test vibration amplitude changes from a constant displacement value versus frequency to a constant acceleration value versus frequency.

[SOURCE: ISO 2041:2009, 2.118, modified – Example omitted and note added.]

3.7
cut-off frequency
frequency in the response spectrum where the zero period acceleration (ZPA) asymptote begins

Note 1 to entry: The cut-off frequency is the frequency beyond which the single-degree-of-freedom (SDOF) oscillators exhibit no amplification of motion and indicate the upper limit of the frequency content of the waveform being analysed.

3.8
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.

Note 2 to entry: This definition is not identical to that given in ISO 2041.

3.8.1
critical damping
minimum viscous damping that will allow a displaced system to return to its initial position without oscillation

3.8.2
damping ratio
ratio of actual damping to critical damping in a system with viscous damping

3.9
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

3.10
floor acceleration
acceleration of a particular building floor (or an equipment mounting) resulting from the ground motion of a given earthquake

Note 1 to entry: In practice the floor acceleration may be resolved into its horizontal and vertical components.

3.11
geometric factor
factor required in single axis testing to take into account the interaction along the different axes of the equipment of simultaneous multi-directional input vibrations

3.12
g_n
standard acceleration due to the earth's gravity, which itself varies with altitude and geographical latitude

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

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

Note 1 to entry: In practice the ground acceleration may be resolved into its horizontal and vertical components.

3.14
lateral frequencies
two frequencies determined according to the –3 dB response around the overall resonance frequency

SEE: Figure 2.

3.15
malfunction
loss of capability of the equipment to initiate or sustain a required function, or the initiation of undesired spurious action which may result in adverse consequences for safety

Note 1 to entry: Malfunction will be defined by the relevant specification.

3.16
narrowband response spectrum
response spectrum in which single-frequency excitation predominates

SEE: Figure 3a).

Note 1 to entry: The bandwidth is normally 1/3 oct (one third octave) or less.

Note 2 to entry: When several widely spaced well-defined frequencies exist, if justified, each of their responses may be treated separately as a narrow-band response spectrum (see Figure 3b)).

3.17
damped natural frequency
frequency of free vibration of a damped linear system depending only on its own physical characteristics (mass, stiffness, and damping)

3.18
overall resonance
resonance frequency at which a complete structure amplifies the exciting motion

Note 1 to entry: Within the frequency range between 1 Hz and 35 Hz, overall resonance generally corresponds to the first mode of vibration. It is important to take into account the overall resonance frequencies when they are enclosed in the strong part of the required response spectrum (see 3.27).

3.19
pause
interval between consecutive test waves (for example sine beats)

Note 1 to entry: A pause should be such that it results in no significant superposition of the response motions of an equipment.

3.20
preferred testing axes
three orthogonal axes which correspond to the most vulnerable axes of the equipment

3.21
required response spectrum
RRS
response spectrum specified by the user

SEE: Figures 1, 2 and 3.

3.22
resonance frequency
frequency at which, in forced oscillation, a change in the frequency of excitation causes a decrease in the response of the system

Note 1 to entry: The value of resonance frequency depends upon the measured variable. For a damped linear system, the values of resonance frequency for displacement, velocity and acceleration (respectively dynamic compliance, mobility and accelerance; see ISO 2041) are in increasing order of frequency. The differences between these resonance frequency values are small for the usual damping ratios.

Note 2 to entry: In seismic testing, it is often assumed that a resonance frequency is significant when the transmissibility of the response is greater than 2.

Note 3 to entry: For a damped linear system the resonance frequency is coincident with the damped natural frequency.

Note 4 to entry: This definition is not identical to that given in ISO 2041.

3.23
response spectrum
plot of the maximum response to a defined input motion of a family of single-degree-of-freedom bodies at a specified damping ratio

SEE: Figures 1, 2 and 3.

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

3.24
S1-earthquake
earthquake which would be expected to occur during the operating life of the equipment and for which safety related equipment is to be designed to continue to operate without malfunction

Note 1 to entry: An S1-earthquake corresponds in nuclear applications to the operating base earthquake (OBE).

3.25
S2-earthquake
earthquake which produces the maximum vibratory ground motion for which certain structures, systems and components are designed to remain functional

Note 1 to entry: The structures, systems and components are those essential to ensure proper function, integrity and safety of the total system.

Note 2 to entry: An S2-earthquake corresponds in nuclear applications to the safe shutdown earthquake (SSE).

3.26
sine beat
continuous sinusoidal wave of one frequency which is modulated by a sinusoidal wave of a lower frequency

SEE: Figure 5.

Note 1 to entry: The duration of one sine beat is half the period of the modulating frequency.

Note 2 to entry: In this document, the sine beat is considered as a single-frequency wave.

3.27
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

SEE: Figure 6.

3.28
strong part of the response spectrum
part of the spectrum for which the response acceleration is higher than for the –3 dB bandpass of the required response spectrum

SEE: Figure 2.

Note 1 to entry: Generally, the strong part of the response spectrum is located in the first third of the frequency band.

3.29
superelevation factor
factor accounting for the change in the acceleration with respect to the earth due to the transmissibility of buildings and structures

3.30
synthesized time history
artificially generated time history such that its response spectrum dominates the required response spectrum

3.31
test level
largest peak value within a test wave

Note 1 to entry: In seismic testing, acceleration is the parameter normally used.

3.32
test frequency
frequency at which the specimen is to be excited during a test

Note 1 to entry: A test frequency is one of two types as defined in 3.32.1 and 3.32.2.

3.32.1
predetermined test frequency
frequency specified by the relevant specification

3.32.2
investigated test frequency
frequency obtained by a vibration response investigation

3.33
test response spectrum
response spectrum derived from the real motion of the vibration table either analytically or by using spectrum analysis equipment

SEE: Figures 2, 3c) and 3d).

3.34
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.

3.35
zero period acceleration
ZPA
high-frequency asymptotic value of acceleration of a response spectrum

Note 1 to entry: An example of ZPA is given in Figure 2.