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Environmental testing – iTeh Standards
Part 3-3: Supporting documentation and guidance – Seismic test methods for
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IEC Central Office
3, rue de Varembe
CH-1211 Geneva 20
Switzerland

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

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IEC 60068-3-3

Edition 2.0 2019-08
REDLINE VERSION

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INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 19.040

ISBN 978-2-8322-7315-9

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

ENVIRONMENTAL TESTING –

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

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.

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.

The contents of the corrigendum of September 2021 have been included in this copy.

INTRODUCTION

Guidance is included in each of the ~~three~~ 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.

~~This standard is to be used in conjunction with IEC 60068-1.~~

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ENVIRONMENTAL TESTING –

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

1 Object 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 ~~may~~ 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 ~~prescribed~~ 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

~~The terms used in this standard are generally defined in ISO 2041 or in IEC 60068-1, IEC 60068-2-6, IEC 60068-2-57 and IEC 60068-2-59. Where, for the convenience of the reader, a definition from one of these sources is included here, the derivation is indicated and departures from the definitions in those sources are also indicated.~~

~~The additional terms and definitions that follow are also applicable for the purpose of this standard.~~

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 ~~must~~ 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 ~~(definition technically equivalent to that in 8.1 of IEC 60068-2-6):~~
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 ~~(definition technically equivalent to that of ISO 2041)~~
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 ~~(not identical with ISO 2041 definitions)~~
~~generic term ascribed to the numerous~~ 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/s².

3.13**ground acceleration**

acceleration ~~of the ground~~ 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 ~~structure~~ 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 ~~given mode~~ damped linear system, the values of resonance frequency for displacement, velocity and acceleration (respectively dynamic compliance, mobility and acceleration; 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 ~~(not identical with ISO 2041 definition)~~

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.