

INTERNATIONAL STANDARD

BASIC SAFETY PUBLICATION

HORIZONTAL PUBLICATION

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



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CONTENTS

FOREWORD	4
INTRODUCTION	6
1 Scope	7
2 Normative references	7
3 Terms and definitions	8
4 Requirements for test apparatus	13
4.1 General	13
4.2 Basic motion	14
4.3 Cross-axis motion	14
4.4 Mounting	15
4.5 Measuring systems	15
4.6 Vibration tolerances	16
4.6.1 ASD and RMS value	16
4.6.2 Distribution	16
4.6.3 Statistical accuracy	17
4.6.4 Frequency resolution	18
4.7 Control strategy	19
4.7.1 Single/multipoint control	19
4.7.2 Multireference control	20
4.8 Vibration response investigation	20
4.9 Exceptions and deviations	20
5 Severities	21
5.1 General	21
5.2 Test frequency range	21
5.3 RMS value of acceleration	21
5.4 Shape of acceleration spectral density curve	21
5.5 Test duration	21
6 Preconditioning	22
7 Initial measurements and functional performance test	22
8 Testing	22
8.1 General	22
8.2 Initial vibration response investigation	23
8.3 Low-level excitation for equalization prior to testing	23
8.4 Random testing	24
8.4.1 General	24
8.4.2 Intermediate measurements and functional performance	25
8.5 Final vibration response investigation	25
9 Recovery	26
10 Final measurements and functional performance	26
11 Information to be given in the relevant specification	27
12 Information to be given in the test report	28
Annex A (informative) Guidance on test severities	29
A.1 Transportation	29
A.2 Stationary installations	30
A.3 Storage, handling and portable use	31

A.4	Equipment installed in wheeled vehicles	32
A.5	Equipment installed in ships	32
A.6	Equipment installed in aircraft including helicopters	33
Annex B (informative)	Guidance on good test quality and reproducibility	34
B.1	General	34
B.2	Requirements for testing	35
B.2.1	Single-point and multipoint control	35
B.2.2	Distribution	36
B.2.3	Initial and final slope	37
B.3	Testing procedures	38
B.4	Equipment normally used with vibration isolators	38
B.4.1	Transmissibility factors for isolators	38
B.4.2	Temperature effect	38
B.5	Test severities	39
B.6	Equipment performance	39
B.7	Initial and final measurements	39
Annex C (informative)	Guidance on non-Gaussian distribution and high kurtosis tests	40
C.1	Non-Gaussian random vibration	40
C.2	Methods to generate non-Gaussian random vibration	40
C.2.1	General	40
C.2.2	Amplitude modulation technique	41
C.2.3	Phase modification technique	41
C.2.4	Non-uniform phase technique	42
C.3	Additional analysis	42
C.4	Frequency range	43
C.5	Beta distribution	43
Annex D (informative)	Verification against the environmental test specification and test purpose	44
D.1	Scope of test verification	44
D.2	Purpose of test verification	44
D.3	Information required for test verification	45
D.4	Verification of test procedures and severities	45
D.5	Verification of sequential test programme	45
D.6	Technical verification of vibration tests	46
Bibliography		48
Figure 1	– Tolerance bands for acceleration spectral density – Initial and final slope	16
Figure 2	– Time history of stochastically excitation – Probability density function with Gaussian (normal) distribution	17
Figure 3	– Statistical accuracy of acceleration spectral density versus degrees of freedom for different confidence levels	18
Figure 4	– Time history of non-Gaussian excitation – Probability density function compared with Gaussian (normal) distribution	25
Figure B.1	– Tolerance band for distribution of instantaneous acceleration values for conventional broad band Gaussian vibration test	37
Figure C.1	– Examples of the beta distribution with different α and β values	43
Table 1	– Information to be given in the relevant specification	27

Table 2 – Information to be given in the test report	28
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Environmental testing - Part 2-64: Tests - Test Fh: Vibration, broadband random and guidance

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IEC 60068-2-64 has been prepared by IEC technical committee 104: Environmental conditions, classification and methods of test. It is an International Standard.

This document has been given the status of a horizontal basic safety document in accordance with the ISO/IEC Directives, Part 1.

This third edition cancels and replaces the second edition, published in 2008, and Amendment 1:2019. This edition constitutes a technical revision.

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

- a) update of Annex A with references to examples;
- b) introduction of an organizational deviation treatment;
- c) clarification on requirements.

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

Draft	Report on voting
104/1190/FDIS	104/1214/RVD

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

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/publications.

A list of all the parts in the IEC 60068 series, 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 webstore.iec.ch in the data related to the specific document. At this date, the document will be

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INTRODUCTION

This part of IEC 60068 deals with broadband random vibration testing intended for general application to components, equipment and other products, hereinafter referred to as "specimens", that can be subjected to vibrations of a stochastic nature. The methods and techniques in this document are based on digital control of random vibration. It permits the introduction of variations to suit individual cases if these are required by the relevant specification.

Compared with most other vibration tests, test Fh is not based on deterministic but on statistical techniques. Broad-band random vibration testing is therefore described in terms of probability and statistical averages.

It is emphasized that random testing always demands a certain degree of engineering judgement, and both equipment supplier and purchaser as well as the test house should be fully aware of this fact. The writer of the relevant specification is expected to select the testing procedure and the values of severity appropriate to the specimen and its use.

The test method is based primarily on the use of an electrodynamic or a servo-hydraulic vibration generator with an associated computer-based control system relying on measurement sensors used as a vibration testing system.

The traditional general-purpose broad-band random vibration test utilizes waveforms with a Gaussian distribution of amplitudes. However, when so specified, this test procedure can also be utilized with random vibration tests with a non-Gaussian distribution of amplitudes. Such tests are sometimes alternatively known as "high kurtosis tests".

Annex A and Annex B are informative annexes giving reference to examples of test spectra for different environmental conditions and a list of details to be considered for inclusion in specifications and guidance.

Annex C is an informative annex giving information on non-Gaussian distribution/high kurtosis tests.

Annex D is an informative annex giving guidance on technical measures of verification that the intended test purpose is achieved by the test.

1 Scope

This part of IEC 60068 demonstrates the adequacy of a specimen to resist dynamic loads without unacceptable degradation of its functional and structural integrity (or either of them) when subjected to the specified random vibration test requirements.

Broadband random vibration can be used to identify accumulated stress effects and the resulting mechanical weakness and degradation in the specified performance. This information, in conjunction with the relevant specification, can be used to assess the acceptability of specimens.

This document is applicable to specimens which can be subjected to vibration of a stochastic nature resulting from transportation or operational environments, for example, in aircraft, space vehicles and land vehicles. It is primarily intended for unpackaged specimens, and for items in their transportation container when the latter can be considered as part of the specimen itself. However, if the item is packaged, then the item itself is referred to as a product, and the item and its packaging together are referred to as a test specimen. This document can be used in conjunction with IEC 60068-2-47:2005, for testing packaged products.

If the specimens are subjected to vibration of a combination of random and deterministic nature resulting from transportation or real-life environments, for example, in aircraft, space vehicles and for items in their transportation container, it is possible that testing with pure random is not sufficient. See IEC 60068-3-8:2003 for estimating the dynamic vibration environment of the specimen and based on that, selecting the appropriate test method.

Although primarily intended for electrotechnical specimens, this document is not restricted to them and can be used in other fields where desired (see Annex A).

This document has the status of a horizontal basic safety publication in accordance with IEC Guide 108.

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 60068-2-6:2007, *Environmental testing - Part 2-6: Tests - Test Fc: Vibration (sinusoidal)*

IEC 60068-2-47:2005, *Environmental testing - Part 2-47: Test - Mounting of specimens for vibration, impact and similar dynamic tests*

IEC 60068-5-2, *Environmental testing - Part 5-2: Guide to drafting of test methods - Terms and definitions*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60068-1, IEC 60068-2-6, IEC 60068-5-2 and the following apply.

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

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

3.1

cross-axis motion

motion not in the direction of the stimulus and which is generally specified in the two axes orthogonal to the direction of the stimulus

Note 1 to entry: The cross-axis motion should be measured close to the fixing points.

3.2

actual motion

motion represented by the wideband signal returned from the reference point transducer

3.3

fixing point

part of the specimen in contact with the fixture or vibration table at a point where the specimen is normally fastened in service

Note 1 to entry: If a part of the real mounting structure is used as the fixture, the fixing points are taken as those of the mounting structure and not of the specimen.

Note 2 to entry: Where the specimen consists of a packaged product, the fixing point can be interpreted as the surface of the specimen which is in contact with the vibration table.

3.4

control methods

3.4.1

single point control

control method using the signal from the transducer at the reference point in order to maintain this point at the specified vibration level

3.4.2

multipoint control

control method using the signals from each of the transducers at the checkpoints

Note 1 to entry: The signals are either continuously averaged arithmetically or processed by using comparison techniques, depending upon the relevant specification. See also 3.13.

3.5

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.

3.6

measuring points

specific points at which data are gathered for conducting the test

Note 1 to entry: The measuring points are of three types, as defined in 3.7 to 3.9.

3.7

checkpoint

point located on the fixture, on the vibration table or on the specimen as close as possible to one of its fixing points, and in any case, rigidly connected to it

Note 1 to entry: A number of checkpoints are used as a means of ensuring that the test requirements are satisfied.

3.8

reference point

<single-point control> point, chosen from amongst the checkpoints, whose signal is used to control the test, such that the requirements of this document are satisfied

3.9

fictitious reference point

<multipoint control> point, derived from multiple checkpoints either manually or automatically, the result of which is used to control the test so that the requirements of this document are satisfied

3.10

response points

specific points on the specimen from which data is gathered for the purpose of the vibration response investigation

Note 1 to entry: The response points are not the same as checkpoints or reference points.

3.11

preferred testing axes

three (usually) orthogonal axes that correspond to the most vulnerable axes of the specimen

Note 1 to entry: The selection of the preferred testing axes can depend on the specimen's design and the sub-components inside; the preferred testing axes are not always orthogonal. The in-service mounting orientation of the specimen can also play a role in the selection of the preferred testing axes. See also IEC 60068-2-86 for more information on multi-axis testing.

3.12

sampling frequency

number of discrete magnitude values taken per second to record or represent a time-history in a digital form

3.13

multipoint control strategy

method for calculating the reference control signal when using multipoint control

Note 1 to entry: Different frequency domain control strategies are discussed to in 4.7.1.

3.14

averaging

process of determining the control acceleration spectral density formed from the arithmetic average of the acceleration spectral densities at each frequency line of more than one checkpoint

3.15

extremal

process of determining the control acceleration spectral density formed from the maximum or minimum acceleration spectral density at each frequency line of more than one checkpoint

3.16

crest factor

ratio of the peak value to the RMS value of the time history

3.17**–3 dB bandwidth**

frequency bandwidth between two points in a frequency response function which are at 0,707 of the maximum response when associated with a single resonance peak

Note 1 to entry: The –3 dB bandwidth can be applied to power or field dimensions, but the chosen dimension is to be given.

3.18**acceleration spectral density**

ASD

mean-square value of that part of an acceleration signal passed by a narrow-band filter of a centre frequency, per unit bandwidth, in the limit as the bandwidth approaches zero and the averaging time approaches infinity

3.19**control acceleration spectral density**

acceleration spectral density measured at the reference point or the fictitious reference point

3.20**control loop****control system**

sum of the following actions:

- digitizing the analogue waveform of the signal derived from the reference point or fictitious reference point;
- performing the necessary processing;
- producing an updated analogue drive waveform to the vibration system power amplifier (see Clause B.1)

Note 1 to entry: Subsystems in the control system loop and steps in the signal processing chain can be

- a transducer (measurement instrument transferring the physical quantity to be measured – usually kinetic like acceleration – to an electric signal), feeding to
- a signal conditioning, which can be included in the controller (power supply, AC-coupling) or the transducer (charge amplifier), feeding to
- a controller (producing a defined output signal to achieve a certain wanted vibration environment), feeding drive signal to
- a power amplifier (including further control loops and signal processing), feeding to
- a shaker (transfer from electric actuation power to mechanical movement and force), movement measurement by transducer.

3.21**drive signal clipping**

limitation of the maximum crest factor imposed on the drive signal within the effective frequency range

Note 1 to entry: The drive signal clipping is processed to apply the required crest factor (3.16) to the drive signal(s) produced by the digital control system.

3.22**effective frequency range**

frequency range of measurement and control between 0,5 times f_1 and 2,0 times f_2 of the test frequency range

SEE Figure 1.

Note 1 to entry: Due to initial and final slope, the effective frequency range is higher than the test frequency range between f_1 and f_2 .

3.23**error in acceleration spectral density**

difference between the specified acceleration spectral density and the control acceleration spectral density

3.24**equalization**

<spectral densities> minimization of the error in acceleration spectral density

3.25**final slope**

part of the specified acceleration spectral density above f_2

SEE Figure 1.

3.26**frequency resolution**

B_e

width of the frequency intervals in the acceleration spectral density

Note 1 to entry: The frequency resolution is expressed in Hertz.

Note 2 to entry: The frequency resolution is equal to the reciprocal of the record block length (T) in digital analysis; the number of frequency lines is equal to the number of intervals in a given frequency range.

3.27**indicated acceleration spectral density**

estimate of the true acceleration spectral density read from the analyser presentation distorted by the instrument error and the random error

3.28**initial slope**

part of the specified acceleration spectral density below f_1

SEE Figure 1.

3.29**instrument error**

error associated with each analogue item of the input to the control system and control system analogue items

3.30**random error**

error in acceleration spectral density changing from one estimate to another because of the limitation of averaging time and filter bandwidth in practice

Note 1 to entry: With an infinite averaging time, the error would converge towards zero.

3.31**record**

<measurement data> collection of equally spaced data points in the time domain that are used in the calculation of the fast Fourier transform

3.32**reproducibility**

closeness of the agreement between the results of measurements of the same value of the same quantity, where the individual measurements are made

- by different methods,
- with different measuring instruments,
- with different signal generation,
- by different observers,
- in different laboratories,
- after intervals of time which are long compared with the duration of a single measurement, and
- under different customary conditions of use of the instruments employed

Note 1 to entry: The term "reproducible" also applies to the case where only certain of the preceding conditions are taken into account.

3.33**root-mean-square value****RMS value**

<single-valued function over an interval between two frequencies> square root of the average of the squared values of all functions over the total frequency interval f_1 and f_2

SEE Figure 2.

3.34**standard deviation**

σ

RMS value of the deviation of a random time history from a mean value

SEE Figure 2.

Note 1 to entry: In vibration theory, the mean value of vibration is equal to zero; therefore, for a random time history, the standard deviation is equal to the RMS value. For non-gaussian distribution, see Annex C.

3.35**statistical accuracy**

ratio of true acceleration spectral density to indicated acceleration spectral density

3.36**statistical degrees of freedom**

DOF

effective number derived from the frequency resolution and the effective averaging time for estimation of acceleration spectral density of random data with a time-averaging technique

SEE Figure 3.

3.37**test frequency range**

frequency range between f_1 and f_2 in which the ASD is constant or shaped as given in the relevant specification

SEE Figure 1.

3.38**true acceleration spectral density**

acceleration spectral density of the random signal acting on the specimen

3.39**kurtosis** $\tilde{\mu}_4$

4th statistical moment, which provides a measure of the shape of an amplitude distribution

Note 1 to entry: Typically, a waveform with Gaussian distribution will have a kurtosis of 3, if considered over an infinite period.

Note 2 to entry: Kurtosis is given by:

$$\tilde{\mu}_4 = \frac{1}{N} \sum_{i=1}^N (x_i - \bar{x})^4 \cdot \frac{1}{\sigma^4}$$

where

σ is the standard deviation of the N values which describe the waveform;

x_i are individual values representing the waveform described by N such values;

$\bar{x}$ is the mean value of the N values which describe the waveform.

3.40**skewness** $\tilde{\mu}_3$

3rd statistical moment, which provides a measure of non-symmetry of an amplitude distribution

Note 1 to entry: Typically, a waveform with Gaussian distribution will have a skewness of 0, if considered over an infinite period.

Note 2 to entry: Skewness is given by:

$$\tilde{\mu}_3 = \frac{1}{N} \sum_{i=1}^N (x_i - \bar{x})^3 \cdot \frac{1}{\sigma^3}$$

where

σ is the standard deviation of the N values which describe the waveform;

x_i are individual values representing the waveform described by N such values;

$\bar{x}$ is the mean value of the N values which describe the waveform.

4 Requirements for test apparatus**4.1 General**

The required characteristics apply to the complete vibration system, which includes the power amplifier, vibrator, test fixture, specimen and control system when loaded for testing.

The standardized test method consists of the following test sequence normally applied in each of the mutually perpendicular axes of the test specimen:

- a) an initial vibration response investigation, with low level sinusoidal excitation, or low-level random excitation (see 8.2);
- b) the random excitation as the mechanical load or stress test;
- c) a final vibration response investigation to compare the results with the initial one and to detect possible mechanical failures due to a change of the dynamic behaviour (see 8.2 and 8.5).