IEC 60068-2-64

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INTERNATIONAL STANDARD

NORME INTERNATIONALE

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

Essais d'environnement –
Partie 2-64: Essais – Essai Fh: Vibrations aléatoires à large bande et guide

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Part 2-64: Tests – Test Fh: Vibration, broadband random and guidance

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.
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International Standard IEC 60068-2-64 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 1993, and constitutes a technical revision.

The major changes with regard to the previous edition concern the removal of Method 1 and Method 2, replaced by a single method, and replacement of Annex A with suggested test spectra and removal of Annex C.

Also included in this revision is the testing of soft packed specimens.

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

FDIS	Report on voting
104/456/FDIS	104/459/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.

It has the status of a basic safety publication in accordance with IEC Guide 104.

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 publication will remain unchanged until the maintenance result 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.

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 may be subjected to vibrations of a stochastic nature. The methods and techniques in this standard are based on digital control of random vibration. It permits the introduction of variations to suit individual cases if these are prescribed by the relevant specification.

Compared with most other 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 supplier and purchaser 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 used as a vibration testing system.

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

ENVIRONMENTAL TESTING –

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

1 Scope

This part of IEC 60068 demonstrates the adequacy of specimens to resist dynamic loads without unacceptable degradation of its functional and/or structural integrity when subjected to the specified random vibration test requirements.

Broadband random vibration may 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, may be used to assess the acceptability of specimens.

This standard is applicable to specimens which may 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 may 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 standard may 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, testing with pure random may not be 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 standard is not restricted to them and may be used in other fields where desired (see Annex A).

2 Normative references

The following referenced documents are indispensable for the application 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 60050-300: *International Electrotechnical Vocabulary – Electrical and electronic measurements and measuring instruments – Part 311: General terms relating to measurements – Part 312: General terms relating to electrical measurements – Part 313: Types of electrical measuring instruments – Part 314: Specific terms according to the type of instrument*

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

IEC 60068-3-8:2003, *Environmental testing – Part 3-8: Supporting documentation and guidance – Selecting amongst vibration tests*

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

IEC 60721-3 (all parts), *Classification of environmental conditions – Part 3: Classification of groups of environmental parameters and their severities*

IEC Guide 104, *The preparation of safety publications and the use of basic safety publications and group safety publications*

ISO 2041: *Vibration and shock – Vocabulary*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

NOTE The terms used are generally defined in IEC 60050-300, IEC 60068-1, IEC 60068-2-6, and IEC 60068-5-2 and ISO 2041. If a definition from one of those sources is included here, the derivation is indicated and departures from the definitions in those sources are also indicated.

3.1
cross-axis motion
motion not in the direction of the stimulus; generally specified in the two axes orthogonal to the direction of the stimulus

NOTE 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 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.

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 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 For the purposes of this standard, the value of g_n is rounded up to the nearest whole number, that is 10 m/s^2.

3.6
measuring points
specific points at which data are gathered for conducting the test

NOTE These 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 A number of checkpoints are used as a means of ensuring that the test requirements are satisfied.

NOTE 2 If four or fewer fixing points exist, each is used as a checkpoint. For packaged products, where a fixing point may be interpreted as the packaging surface in contact with the vibration table, one checkpoint may be used, provided that there are no effects due to resonances of the vibration table or the mounting structure in the frequency range specified for the test. If this is the case, multipoint control may be necessary, but see also NOTE 3. If more than four fixing points exist, four representative fixing points will be defined in the relevant specification to be used as checkpoints.

NOTE 3 In special cases, for example for large or complex specimens, the checkpoints will be prescribed by the relevant specification if not close to the fixing points.

NOTE 4 Where a large number of small specimens are mounted on one fixture, or in the case of a small specimen with a number of fixing points, a single checkpoint (that is the reference point) may be selected for the derivation of the control signal. This signal is then related to the fixture rather than to the fixing points of the specimen(s). This procedure is only valid when the lowest resonance frequency of the loaded fixture is well above the upper frequency of the test.

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 standard 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 standard 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 These points are not the same as checkpoints or reference points.

3.11
preferred testing axes
three orthogonal axes that correspond to the most vulnerable axes of the specimen

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 strategies
method for calculating the reference control signal when using multipoint control

NOTE 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 (maximum or minimum)
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 r.m.s. value of the time history

[ISO 2041]

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

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 system loop
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.)

3.21
drive signal clipping (see also Figure 1)
limitation of the maximum crest factor of the drive signal effective frequency range

3.22
effective frequency range (see also Figure 1)
frequency range between 0,5 times f_1 and 2,0 times f_2

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

3.24
equalization
minimization of the error acceleration spectral density

3.25
final slope (see also Figure 1)
part of the specified acceleration spectral density above f_2

3.26
frequency resolution
B_e
width of the frequency intervals in the acceleration spectral density in Hertz

NOTE It 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 (see also Figure 1)
part of the specified acceleration spectral density below f_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 changing from one estimate to another of the acceleration spectral density because of the limitation of averaging time and filter bandwidth in practice

3.31
record
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,
– by different observers,
– in different laboratories,
– after intervals of time which are long compared with the duration of a single measurement,
– under different customary conditions of use of the instruments employed

NOTE The term “reproducible” also applies to the case where only certain of the preceding conditions are taken into account.

[IEC 60050-300, modified]

3.33
root-mean-square value (see also Figure 2)
root-mean-square value (r.m.s. value) of a single-valued function over an interval between two frequencies is the square root of the average of the squared values of all functions over the total frequency interval f_1 and f_2

3.34
standard deviation, σ (see also Figure 2)
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 r.m.s. value

3.35
statistical accuracy
ratio of true acceleration spectral density to indicated acceleration spectral density

3.36
statistical degrees of freedom (see also Figure 3)
DOF
for estimation of acceleration spectral density of random data with a time-averaging technique, the effective number of statistical degrees of freedom is derived from the frequency resolution and the effective averaging time

3.37
test frequency range
frequency range between f_1 and f_2 (see Figure 1) in which the ASD is constant or shaped as given in the relevant specification

3.38
true acceleration spectral density
acceleration spectral density of the random signal acting on the specimen

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:

1) An initial vibration response investigation, with low level sinusoidal excitation, or low level random excitation, (see 8.2).
2) The random excitation as the mechanical load or stress test.
3) 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).

Where the dynamic behaviour is known, and it is not considered relevant, or sufficient data can be gathered during the test at full level, the relevant specification may not require pre and post test vibration response investigations.

4.2 Basic motion

The basic motion of the fixing points of the specimen shall be prescribed by the relevant specification. The fixing points shall have substantially identical motions in phase and amplitude and shall be rectilinear relative to the direction of excitation. If substantially identical motions are difficult to achieve, then multipoint control shall be used.

NOTE For large structures and a high frequency range, for example 20 Hz – 2 000 Hz, the dynamics of the test specimen is likely to require multipoint control.

4.3 Cross-axis motion

Cross-axis motion should be checked, if required by the relevant specification, either before the test is applied by conducting a sine or random investigation at a level prescribed by the relevant specification, or during testing by utilising additional monitoring channels in the two perpendicular axes.

The ASD value of each frequency at the checkpoints in both axes perpendicular to the specified axis shall not exceed the specified ASD values above 500 Hz and below 500 Hz shall not exceed –3 dB of the specified ASD values. The total r.m.s. value of acceleration in both axes perpendicular to the specified axis shall not exceed 50 % of the r.m.s. value for the specified axis. For example for a small specimen, the ASD value of the permissible cross axis motion may be limited such that it does not exceed –3 dB of the basic motion, if so prescribed by the relevant specification.

At some frequencies or with large-size or high-mass specimens, it may be difficult to achieve these values. Also, in those cases where the relevant specification requires severities with a large dynamic range, it may also be difficult to achieve these. In such cases, the relevant specification shall state which of the following requirements applies:

a) any cross-axis motion in excess of that given above shall be stated in the test report;

b) cross-axis motion which is known to offer no hazard to the specimen need not be monitored.

4.4 Mounting

The specimen shall be mounted in accordance with IEC 60068-2-47. In any case, the transmissibility curve chosen from IEC 60068-2-47 must be squared before multiplication with the ASD spectrum.

4.5 Measuring systems

The characteristics of the measuring system shall be such that it can be determined whether the true value of the vibration as measured in the intended axis at the reference point is within the tolerance required for the test.

The frequency response of the overall measuring system, which includes the transducer, the signal conditioner and the data acquisition and processing device, has a significant effect on the accuracy of the measurements. The frequency range of the measuring system shall extend from at least 0,5 times the lowest frequency (f_1) to 2,0 times the highest frequency (f_2) of the test frequency range (see Figure 1). The frequency response of the measuring system shall be flat within ±5 % of the test frequency range. Outside of this range any further deviation shall be stated in the test report.