SVENSK STANDARD SS-EN 60068-2-64

Fastställd	Utgåva	Sida	Ansvarig kommitté
2009-02-23	2	1 (1+34)	SEK TK 104

Miljötålighetsprovning – Del 2-64: Provningsmetoder – Fh: Bredbandig brusvibration, med vägledning

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

Som svensk standard gäller europastandarden EN 60068-2-64:2008. Den svenska standarden innehåller den officiella engelska språkversionen av EN 60068-2-64:2008.

Nationellt förord

Europastandarden EN 60068-2-64:2008

består av:

– **europastandardens ikraftsättningsdokument,** utarbetat inom CENELEC
– **IEC 60068-2-64, Second edition, 2008 - Environmental testing - Part 2-64: Tests - Test Fh: Vibration, broadband random and guidance**

utarbetad inom International Electrotechnical Commission, IEC.

Tidigare fastställd svensk standard SS-EN 60068-2-64, utgåva 1, 2001, gäller ej fr o m 2011-07-01.

ICS 19.040

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Telefon: 08 - 444 14 00. *Telefax*: 08 - 444 14 30
E-post: sek@elstandard.se. *Internet*: www.elstandard.se

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SEK Svensk Elstandard
Box 1284
164 29 Kista
Tel 08-444 14 00
www.elstandard.se

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN 60068-2-64

September 2008

ICS 19.040

Supersedes EN 60068-2-64:1994

English version

Environmental testing - Part 2-64: Tests - Test Fh: Vibration, broadband random and guidance (IEC 60068-2-64:2008)

Essais d'environnement -
Partie 2-64: Essais -
Essai Fh: Vibrations aléatoires à large bande et guide
(CEI 60068-2-64:2008)

Umgebungseinflüsse -
Teil 2-64: Prüfverfahren -
Prüfung Fh: Schwingen, Breitbandrauschen (digital geregelt) und Leitfaden
(IEC 60068-2-64:2008)

This European Standard was approved by CENELEC on 2008-07-01. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CENELEC member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CENELEC member into its own language and notified to the Central Secretariat has the same status as the official versions.

CENELEC members are the national electrotechnical committees of Austria, Belgium, Bulgaria, Cyprus, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and the United Kingdom.

CENELEC

European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

Central Secretariat: rue de Stassart 35, B - 1050 Brussels

Ref. No. EN 60068-2-64:2008 E

Foreword

The text of document 104/456/FDIS, future edition 2 of IEC 60068-2-64, prepared by IEC TC 104, Environmental conditions, classification and methods of test, was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as EN 60068-2-64 on 2008-07-01.

This European Standard supersedes EN 60068-2-64:1994.

The major changes with regard to EN 60068-2-64:1994 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 following dates were fixed:

– latest date by which the EN has to be implemented at national level by publication of an identical national standard or by endorsement	(dop)	2009-04-01
– latest date by which the national standards conflicting with the EN have to be withdrawn	(dow)	2011-07-01

Annex ZA has been added by CENELEC.

Endorsement notice

The text of the International Standard IEC 60068-2-64:2008 was approved by CENELEC as a European Standard without any modification.

In the official version, for Bibliography, the following notes have to be added for the standards indicated:

IEC 61373	NOTE Harmonized as EN 61373:1999 (not modified).
ISO/IEC 17025	NOTE Harmonized as EN ISO/IEC 17025:2005 (not modified).

Annex ZA
(normative)

Normative references to international publications with their corresponding European publications

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.

NOTE When an international publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

Publication	Year	Title	EN/HD	Year
IEC 60050-300	- [1]	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	- [1]	Environmental testing - Part 1: General and guidance	EN 60068-1	1994 [2]
IEC 60068-2-6	- [1]	Environmental testing - Part 2-6: Tests - Test Fc: Vibration (sinusoidal)	EN 60068-2-6	2008 [2]
IEC 60068-2-47	2005	Environmental testing - Part 2-47: Tests - Mounting of specimens for vibration, impact and similar dynamic tests	EN 60068-2-47	2005
IEC 60068-3-8	2003	Environmental testing - Part 3-8: Supporting documentation and guidance - Selecting amongst vibration tests	EN 60068-3-8	2003
IEC 60068-5-2	- [1]	Environmental testing - Part 5: Guide to drafting of test methods - Terms and definitions	EN 60068-5-2	1999 [2]
IEC 60721-3	Series	Classification of environmental conditions - Part 3: Classification of groups of environmental parameters and their severities	EN 60721-3	Series
IEC Guide 104	- [1]	The preparation of safety publications and the use of basic safety publications and group safety publications	-	-
ISO 2041	- [1]	Vibration and shock - Vocabulary	-	-

[1] Undated reference.

[2] Valid edition at date of issue.

CONTENTS

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.

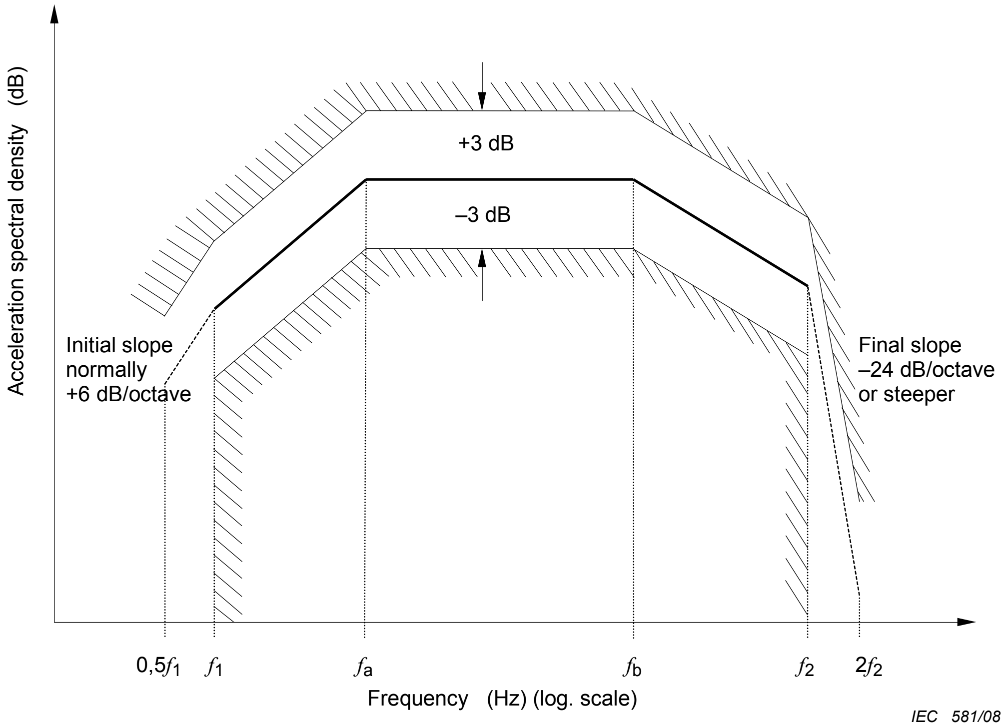

Figure 1 – Tolerance bands for acceleration spectral density; initial and final slope (see B.2.3)

4.6 Vibration tolerances

4.6.1 ASD and r.m.s. value

The indicated acceleration spectral density in the required axis at the reference point between f_1 and f_2 in Figure 1 shall be within ±3 dB, allowing for the instrument and random error, referred to the specified acceleration spectral density.

The r.m.s. value of acceleration, computed or measured between f_1 and f_2, shall not deviate more than 10 % from the r.m.s. value associated with the specified acceleration spectral density. These values are valid for both the reference point and fictitious reference point.

At some frequencies, or with large-size or high-mass specimens, it may be difficult to achieve these values. In such cases, the relevant specification shall prescribe a wider tolerance.

The initial slope shall not be less than +6 dB/octave and the final slope shall be –24 dB/octave or steeper (see also B.2.3).

4.6.2 Distribution

The instantaneous acceleration values at the reference point shall have an approximately normal (Gaussian) distribution as given in Figure 2. If explicitly desired, a validation shall be performed during normal system calibration (see B.2.2).

The drive signal clipping shall have a value of at least 2,5 (see 3.16). The crest factor of the acceleration signal at the reference point shall be examined to ensure that the signal contains peaks of at least 3 times the specified r.m.s. value, unless otherwise prescribed by the relevant specification.

If a fictitious reference point is used for control, the requirement for the crest factor applies to each individual checkpoint used to form the control acceleration spectral density.

The probability density function shall be computed for the reference point for a duration of 2 min during testing. The admissible deviation from the normal distribution, Figure 2, shall be prescribed in the relevant specification.

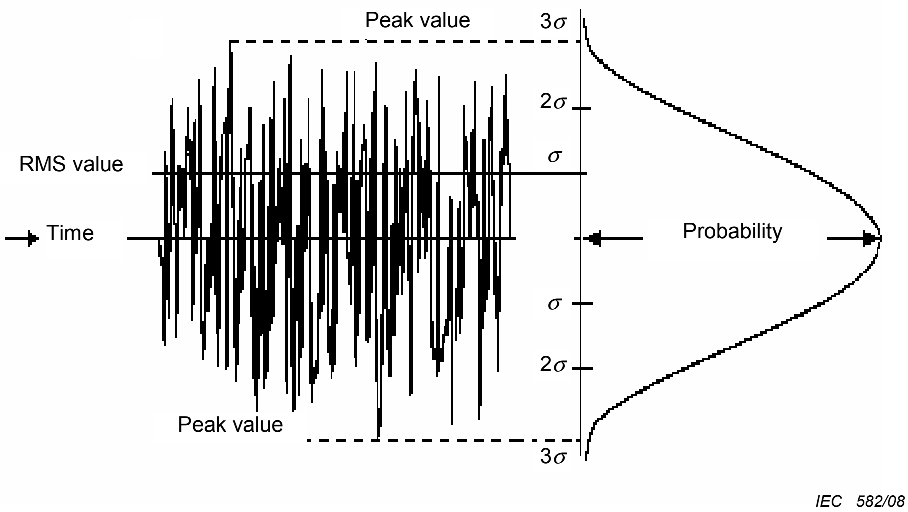

Figure 2 – Time history of stochastically excitation; probability density function with Gaussian (normal) distribution (example with crest factor = 3, see also 3.14 and 4.6.2)

4.6.3 Statistical accuracy

The statistical accuracy is determined from the statistical degrees of freedom N_d and the confidence level (see also Figure 3). The statistical degrees of freedom are given by:

$$N_d = 2B_e \times T_a \quad (1)$$

where

B_e is the frequency resolution;

T_a is the effective averaging time.

N_d shall not be less than 120 DOF, unless otherwise specified by the relevant specification. If the relevant specification states confidence levels to be met during the test, Figure 3 should be used to calculate statistical accuracy.

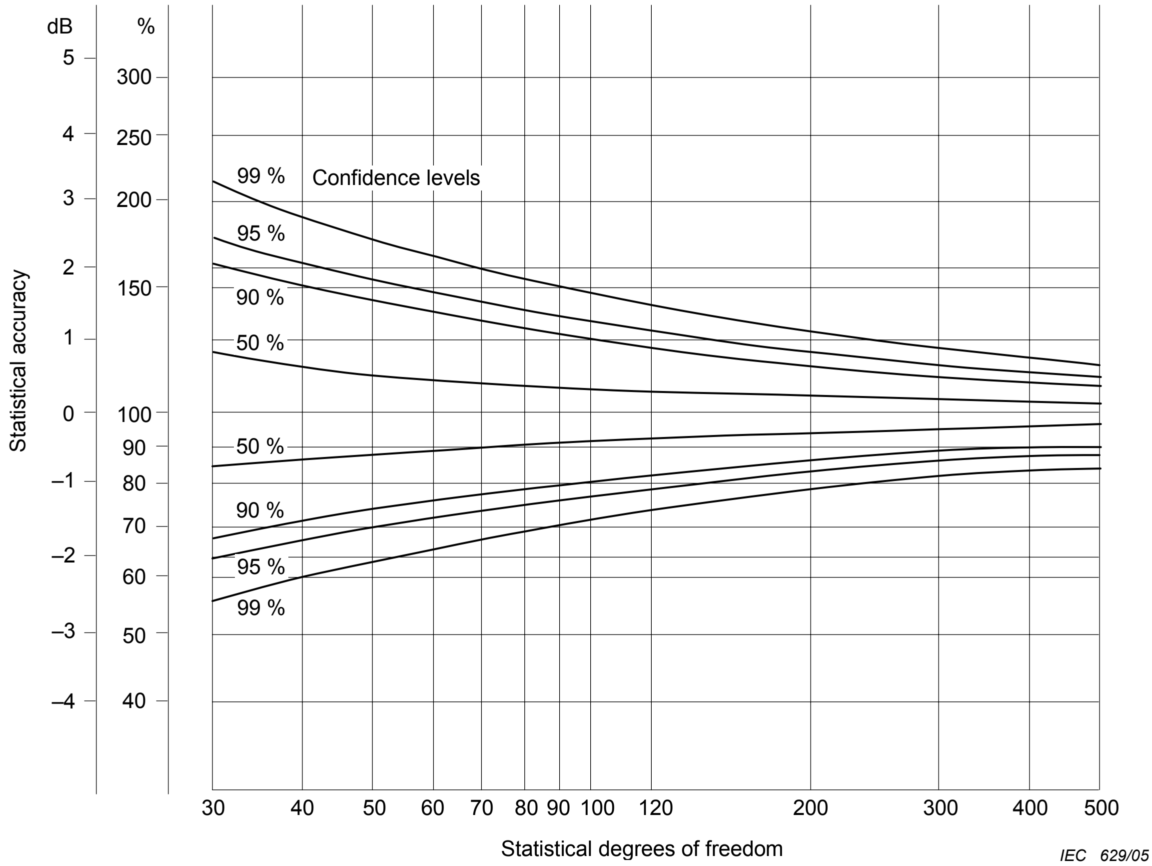

Figure 3 – Statistical accuracy of acceleration spectral density versus degrees of freedom for different confidence levels (see also 4.6.3)

4.6.4 Frequency resolution

The frequency resolution B_e in Hz necessary to minimize the difference between the true and the indicated acceleration spectral density shall be selected by taking the digital controller frequency range divided by the number of spectral lines (n).

$$B_e = f_{high}/n \tag{2}$$

where

f_{high} is the frequency range chosen from the options provided by the digital vibration control system in Hertz and should be equal or greater than $2f_2$, that is $f_{high} \geq 2f_2$, see Figure 1;

n is the number of spectral lines equally spread over the frequency range to f_{high}.

The number of spectral lines, *n,* should be at least 200. Frequency resolution shall be given in the relevant specification (see also Clause 11, item j)) and stated in the test report.

B_e shall be chosen such that, as a minimum, a frequency line coincides with the frequency f_1 in Figure 1 and the first frequency line is at 0,5 of f_1; also that two frequency lines define the initial slope. If this gives two different values then the smallest B_e shall be chosen.

NOTE There is a compromise between having a finer B_e, resulting in a longer loop control time and better definition of the spectrum, or having a coarser B_e, resulting in a shorter loop control time and worse definition of the spectrum.

4.7 Control strategy

4.7.1 Single/multipoint control

When multipoint control is specified or necessary, the control strategy shall be specified.

The relevant specification shall state whether single point or multipoint control shall be used. If multipoint control is prescribed, the relevant specification shall state whether the average value of the signals at the checkpoints or the extremal value out of the signals at the selected control points shall be controlled to the specified level. For multipoint control, the relevant specification should state whether an unprocessed spectrum of each of the control channels contributing to the control spectrum should be added to the test report.

NOTE If it is not possible to achieve single point control, then multipoint control should be used by controlling the average or extreme value of the signals at the checkpoints. In either of these cases of multipoint control, the point is a fictitious reference point. The method used should be stated in the test report.

The following strategies are available.

4.7.1.1 Averaging strategy

In this method, the control value is computed from the signals from each checkpoint. A composite control value is formed by arithmetically averaging the ASD value at each frequency line from the checkpoints. This arithmetically averaged control value is then compared with the specified ASD value of each frequency.

4.7.1.2 Weighted averaging strategy

The control ASD of each frequency a_C is formed by averaging the ASD from the checkpoints a_1 to a_n according to their weighting w_1 to w_n:

$$a_C = (w_1 \times a_1 + w_2 \times a_2 + \ldots + w_n \times a_n) / (w_1 + w_2 + \ldots + w_n)$$

This control strategy offers the possibility that different checkpoint signals contribute a different portion to the control value of each frequency.

4.7.1.3 Extremal strategy

In this method, a composite control ASD is computed from the maximum (MAX) or the minimum (MIN) extreme ASD values of each frequency line measured at each checkpoint. This strategy will produce a control value of each frequency that represents the envelope of the ASD values as a function of frequency from each checkpoint (MAX) or a lower limit of the ASD values as a function of frequency from each checkpoint (MIN).

4.7.2 Multireference control

If specified by the relevant specification, multiple reference spectra may be defined for different checkpoints or measuring points or different types of controlled variables, for example, for force limited vibration testing.

When multireference control is specified, the control strategy shall be either:

Limiting: All control signals shall be beneath their appropriate reference spectrum.

Superseding: All control signals shall be above their appropriate reference spectrum.

4.8 Vibration response investigation

The vibration response investigation is a convenient and sensitive method for the evaluation of the effects of vibration testing, see IEC 60068-3-8. Aims, purposes and methods for vibration response investigations with its advantages are explained in IEC 60068-3-8. The requirements for sinusoidal excitation are given in test Fc (IEC 60068-2-6) and those for random excitation are given in this standard.

In the case of sinusoidal excitation, it should be remembered that, in the case of non-linear resonances, the resonance frequencies will change depending on the direction of the frequency variation during the sweep. For random excitation non linearities can influence the resonance behaviour. For sinusoidal and random excitation, the amplification at resonances may be dependent on the magnitude of the input vibration.

For the vibration response investigations of an ‘undefined type’ specimen or package, it may be necessary to measure different signals such as driving force or velocity. If specified by the relevant specification, for example, the spectra of the mechanical impedance of the specimen should be calculated before and after the test.

NOTE Mechanical impedance and other similar terms are defined in ISO 2041.

5 Severities

The test severity is determined by the combination of all the following parameters:

– test frequency range;
– r.m.s. value of acceleration;
– shape of acceleration spectral density;
– duration of testing.

Each parameter shall be prescribed by the relevant specification. They may be:

a) chosen from the values given in 5.1 to 5.4;
b) chosen from the examples in Annex A for different environmental conditions;
c) derived from the known environment if this gives significantly different values; or
d) derived from other known sources of relevant data (for example IEC 60721-3).

5.1 Test frequency range

If option a) is chosen, then f_1 and f_2 may be chosen from the following values in Hz:

a) f_1 : 1; 2; 5; 10; 20; 50; 100;
b) f_2: 20; 50; 100; 200; 500; 1 000; 2 000; 5 000.

Frequencies f_1 and f_2 and their relation to the acceleration spectral density are shown in the spectra examples in Annex A.

5.2 RMS value of acceleration

If option a) is chosen, then the r.m.s. value of acceleration (nominal value in Figure 1) between f_1 and f_2 may be chosen from the following values in m/s^2:

1; 1,4 ; 2; 2,8; 3,5; 5; 7; 10; 14; 20; 28; 35; 50; 70; 100; 140; 200; 280

NOTE The value of 10 m/s^2 is ascribed to g_n for the purposes of this standard.

5.3 Shape of acceleration spectral density curve

This test specifies an acceleration spectral density curve with increasing, decreasing and flat horizontal portions (see spectra A.1 – A.4). For a standard test one of the spectra shall be selected according to the dynamic environment of the test item. The relevant acceleration spectral density values shall be calculated by the control system taking the r.m.s. value, frequencies and shape of the spectrum into account. In special cases, it may be appropriate to specify an individually shaped acceleration spectral density curve. In these cases the relevant specification shall prescribe the shape as a function of frequency. The different levels and their corresponding frequency ranges, (break points) shall be selected whenever possible from the values given in 5.1 and 5.2 and the spectra A.1 – A.4.

5.4 Test duration

The duration of testing shall be given in the relevant specification or may be selected from the following series: 1; 2; 5; 10; 20; 30; 45; 60 min; 2; 5; 8; 12; 24 h, with a tolerance of +5 %.

6 Preconditioning

If the relevant specification calls for preconditioning it shall then prescribe the conditions.

7 Initial measurements and functional performance test

The specimen shall be submitted to visual, dimensional and functional and any other checks as prescribed by the relevant specification.

8 Testing

8.1 General

Testing follows the sequence prescribed by the relevant specification. The different steps are as follows:

- initial vibration response investigation, if prescribed;
- low-level excitation for equalization before proceeding to the full level test in one continuous mode;
- random vibration testing;
- final vibration response investigation, if prescribed.

The specimen shall be excited in each of the preferred testing axes in turn, unless otherwise prescribed by the relevant specification. The order of the testing along these axes is not important, unless prescribed by the relevant specification. If the specimen is sensitive to gravity, for example a mercury tilt switch, then vibration may only be applied in its normal service position and shall be prescribed by the relevant specification.

The control ASD of each frequency at the reference point shall be derived from one checkpoint if single-point control is used or from a number of checkpoints where multipoint control is utilized.

In the latter case, the relevant specification shall state which checkpoints shall be used to control to the specified level for the following control strategies, (see also 4.7):

- the average value of the ASD of each checkpoint (average control);
- the weighted average value of the ASDs at the checkpoints (weighted average control); or
- the maximum or minimum extreme values of each frequency of all checkpoints (extremal control).

In either of the above cases of multipoint control, the control spectrum becomes a fictitious one without a reference to an existing checkpoint.

Special action is necessary when a specimen normally intended for use with vibration isolators needs to be tested without them. See also IEC 60068-2-47.

8.2 Initial vibration response investigation

If not especially prescribed by the relevant specification, a vibration response investigation is not required. However, the relevant specification may prescribe a vibration response investigation in each axis either before, or both before and after, the random vibration testing.

When prescribed by the relevant specification, the dynamic response for at least one point on the specimen in the defined frequency range shall be investigated. The number and position of the response points should be clearly defined in the relevant specification. The vibration response investigation may be performed with sinusoidal or random vibration in a test frequency range and with a test level as prescribed by the relevant specification. Reference is made to IEC 60068-2-6 for sinusoidal vibration and to this standard for random vibration excitation. Also see IEC 60068-3-8 for more information and the advantages and disadvantages of each method.

The response investigation shall be carried out with a test level selected so that the response of the specimen remains less than during random testing but at a sufficiently high level to detect critical frequencies.

When sinusoidal excitation is used, at least one sweep cycle over the test frequency range prescribed by the relevant specification shall be performed with an acceleration amplitude ≤ 10 m/s^2 or a displacement amplitude of ± 1 mm, whichever is less. The vibration amplitude shall be adapted to the r.m.s. acceleration value of the random test, in order to prevent a higher stress on the specimen than during random vibration testing. A sweep rate of 1 octave per minute shall be applied to determine the frequencies and amplitudes of the resonances. If there is concern about exciting the structure to a full resonance then a faster sweep rate may be applied as an indication of frequency and relative amplitude of the resonance within the frequency band of interest. Investigations at slower sweep rates or sweeping back and forth around a known resonance may be required but should be limited to the minimum time to obtain the results required. Undue dwell time is to be avoided. The vibration amplitude may be varied as required.

The response investigation with random vibration shall be carried out taking into account that the time of the test shall be long enough to minimize stochastical variations in the response. A random vibration response test shall be carried out using a spectrum between f_1 and f_2. At the lowest resonance frequency there shall be a minimum of five spectral lines within the frequency band at –3 dB of the resonance peak.

When random excitation is used, the r.m.s. value of acceleration should be not more than 25 % of the value specified to be used during the random vibration testing. The duration shall be as short as possible, but at least long enough to make an analysis with DOF = 120 possible degrees of freedom (see Figure 3). If the resonance response is observed and documented periodically during the full level test, special resonance investigations are not necessary.

The specimen shall be in functioning mode during this investigation if required by the relevant specification. Where the mechanical vibration characteristics cannot be assessed because the specimen is functioning, an additional vibration response investigation with the specimen not functioning shall be carried out. During this stage, the specimen shall be examined in order to determine the critical frequencies which shall then be stated in the test report.

8.3 Low-level excitation for equalization prior to testing

Prior to random vibration testing at the specified level, a preliminary random excitation at lower levels with the real specimen may be necessary to equalize the signal and for preliminary analysis. It is important that at this stage the level of the acceleration spectral density applied is kept to a minimum.

The permitted durations for preliminary random excitation are the following:

- below –12 dB of the specified r.m.s. value level: no time limit;
- from –12 dB to –6 dB of the specified r.m.s. value level: not more than 1,5 times the specified test duration;
- between –6 dB and 0 dB of the specified r.m.s. value level: not more than 10 % of the specified test duration.

The duration of the preliminary random excitation shall not be subtracted from the specified test duration for random vibration testing.

8.4 Random testing

8.4.1 General

The relevant specification shall select the appropriate test frequency range (f_1 to f_2), the overall r.m.s. value of acceleration, the shape of the acceleration spectral density curve and test duration. When prescribed by the relevant specification, multiple measurements of the acceleration spectral density and of the r.m.s. value of acceleration, at the checkpoints, shall be made at appropriate intervals in order to verify that the random input spectrum is stationary, and this shall be stated in the test report.

8.4.2 Intermediate measurements and functional performance

When prescribed by the relevant specification, the specimen shall be functioning during a prescribed time interval during the testing, and its performance shall be checked (see Clause B.6).

8.5 Final vibration response investigation

If the relevant specification has prescribed an initial response investigation, it may also require an additional vibration response investigation on completion of the random testing, in order to determine whether changes or failures have occurred since the initial vibration response investigation. The final response investigation shall then be performed in the same manner at the same response points and with the same parameters as used for the initial vibration response investigation. Guidelines for the use of changes in vibration response, for example change of critical frequencies, is given in IEC 60068-3-8. The relevant specification shall state what action is to be taken if different results are obtained in the two investigations.

9 Recovery

It is sometimes necessary to provide a period of time after testing and before final measurements in order to allow the specimen to attain the same conditions, for example of temperature, as existed for the initial measurements. The relevant specification shall then prescribe the conditions for recovery.

10 Final measurements and functional performance

The specimen shall be submitted to visual, dimensional and functional checks and any others as prescribed by the relevant specification.

The relevant specification shall provide the criteria upon which the acceptance or rejection of the specimen shall be based.

For the evaluation of vibration response results see IEC 60068-3-8.

11 Information to be given in the relevant specification

When this test is included in a relevant specification the following details shall be given in so far as they are applicable, paying particular attention to the items marked with an asterisk (*) as this information is always required.

	Clause
a) Control point*	3.4
b) Measuring points*	3.6
c) Basic motion*	4.2
d) Fixing points*	4.2
e) Cross axis motion	4.3
f) Mounting of the specimen*	4.4
g) Vibration tolerances for testing large-size or high-mass specimens	4.6
h) Crest factor* / distribution / drive signal clipping	4.6.2
i) Statistical accuracy (number of DOFs)	4.6.3
j) Frequency resolution*	4.6.4
k) Control strategy	4.7
l) Test frequency range*	5.1
m) RMS value of acceleration*	5.2
n) Shape of acceleration spectral density curve*	5.3
o) Test duration*	5.4
p) Preconditioning	6
q) Initial measurements*	7
r) Preferred testing axes and order of testing*	8.1
s) Critical frequencies	8.2
t) Initial and final vibration response investigation	8.2 & 8.5
u) Intermediate measurements	8.4.2
v) Recovery	9
w) Final measurements and acceptance or rejection criteria*	10
x) Uncertainty of measuring system	B.1
y) Performance and functional check	10

12 Information to be given in the test report

As a minimum the test report shall show the following information:

1)	Customer	(name and address)
2)	Test laboratory	(name and address)
3)	Test Report identification	(date of issue, unique number)
4)	Test dates	
5)	Purpose of the test	(development test, qualification, etc)
6)	Test standard, edition	(relevant test procedure)
7)	Test specimen description	(initial status, unique ID, quantity, photo, drawing, etc.)
8)	Mounting of test specimen	(fixture id, drawing, photo, etc.)

9)	Performance of test apparatus	(cross motion, etc.)
10)	Measuring system, sensor location	(description, drawing, photo, etc.)
11)	Uncertainties of measuring system, if required by relevant specification	(overall uncertainty, calibration data, last/next date of calibration)
12)	Control strategy	(single/multipoint control, multi reference control)
13)	Initial, intermediate and/or final measurements	
14)	Required severities	(as specified in test specification)
15)	Test severities with documentation, if required by the relevant specification	(measuring points, test spectra, test duration, frequency resolution, number of DOFs, distribution, etc.)
16)	Test results	(final status of test specimen)
17)	Observations during testing and actions taken	
18)	Summary of test	
19)	Test manager	(name and signature)
20)	Distribution	(list of those receiving the report)

NOTE 1 A test log should be written for the testing, where the test is documented by, for example, a chronological list of test runs with test parameters, observations during testing and actions taken and data sheets on measurements made. The test log can be attached to the test report.

NOTE 2 See also ISO/IEC 17025.

Annex A
(informative)

Standardized test spectra

For several environmental conditions standard input spectra are derived from different specifications such as MIL-STD 810F, EN 61373, RTCA DO-160D as well as internal specifications of automobile and electronic companies. The test parameters are examples for tests with the following standard environmental conditions. For details see specifications referenced in the tables.

Spectrum A.1 Transportation

For details see specifications referenced in Tables A.1 and A.2 below.

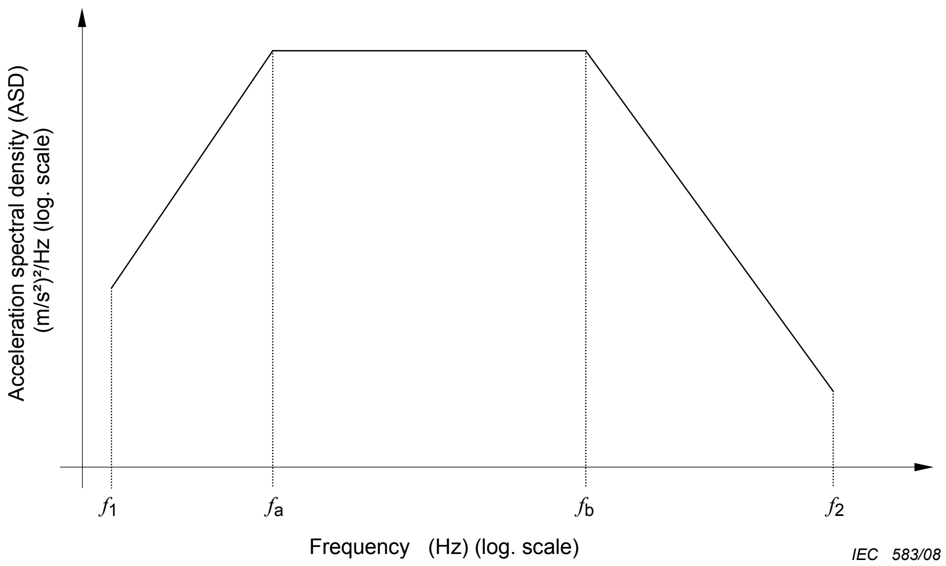

Figure A.1 – Frequency/amplitude break points – Transportation

Table A.1 – Categories for spectrum – Transportation

Category No.	Description	Suggested time per axis h	Axes No.	Specification/ reference
1	Truck transportation over U.S. highways; restrained cargo.			
1 a	Vertical	1	1	MIL-STD 810F
1 b	Horizontal	1	2	derived from MIL-STD 810F
2	Transportation; water, land; hard conditions. Railcar with hard suspension trailers.	0,5	3	
3	Telecommunications equipment; portable and non-stationary use; Rough handling and transfer.	0,5	3	ETSI 300 019-2-7
4	Portable equipment; operating.	0,5	3	

Table A.2 – Break points for spectrum: transportation

Category	f_1	ASDf_1	f_a	f_b	ASDf_a,f_b	f_2	ASDf_2	$a_{r.m.s.}$ value.
No.	Hz	$(m/s^2)^2$/Hz	Hz	Hz	$(m/s^2)^2$/Hz	Hz	$(m/s^2)^2$/Hz	m/s^2
1 a	(10)[a]	1,44	5	40	1,44	500	0,0144	(10,2)
1 b	5	0,65	5	20	0,65	500	0,015	6,5
2	10	1,0	10	200	1,0	500	0,3	18,7
3	10	2,0	10	12	2,0	150	0,16	8,0
4	10	0,037	30	200	0,33	500	0,053	9,9

[a] Values in brackets: for details see specification.

Spectrum A.2 Stationary installation

For details see specifications referenced in the Tables A.3 and A.4 below.

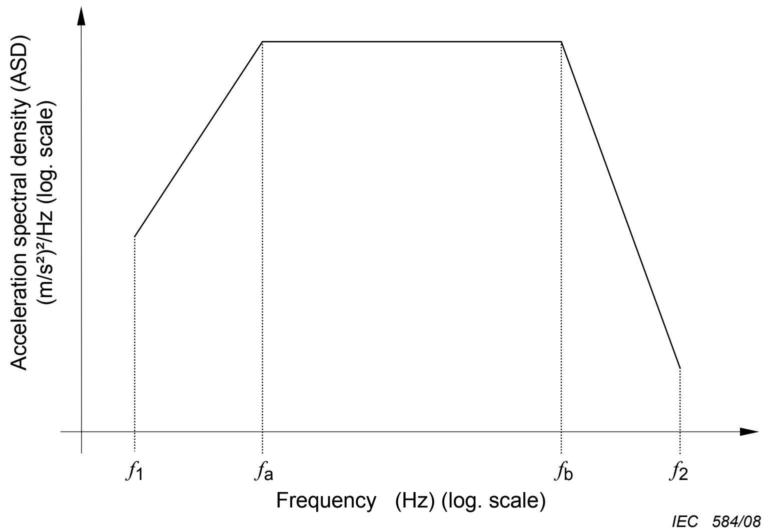

Figure A.2 – Stationary installation spectrum – Frequency/amplitude break points

Table A.3 – Categories for spectrum: stationary installation

Category	Description	Suggested time per axis	axes	Specification/ reference
No.		h	No.	
1	Telecommunications equipment; stationary use at weather protected locations; partly temperature-controlled locations; in-use. NOTE Stationary used equipment as Central Computers, PCs, Printers; operating. Equipment with highly sensitive components; operating. Buildings with no noticeable vibration.	0,5	3	ETSI EN 300 019-2-3, T 3.2
2	Telecommunications equipment; stationary use at weather protected locations; sheltered locations; in-use. NOTE Buildings with noticeable vibration but not externally induced.	0,5	3	ETSI EN 300 019-2-3, T 3.5
3	Buildings with externally induced vibration; non operating.	1	3	

Table A.4 – Break points for spectrum: stationary installation

Category	f_1	ASDf_1	f_a	f_b	ASDf_a,f_b	f_2	ASDf_2	$a_{r.m.s.}$ value.
No.	Hz	$(m/s^2)^2$/Hz	Hz	Hz	$(m/s^2)^2$/Hz	Hz	$(m/s^2)^2$/Hz	m/s^2
1	5	0,001 3	10	50	0,02	100	0,001 3	1,1
2	5	0,002 5	10	50	0,04	100	0,002 5	1,5
3	10	0,022	30	200	0,20	500	0,005 2	7,0

Spectrum A.3 Equipment in wheeled vehicles

For details see specifications referenced in the Tables A.5 and A.6 below.

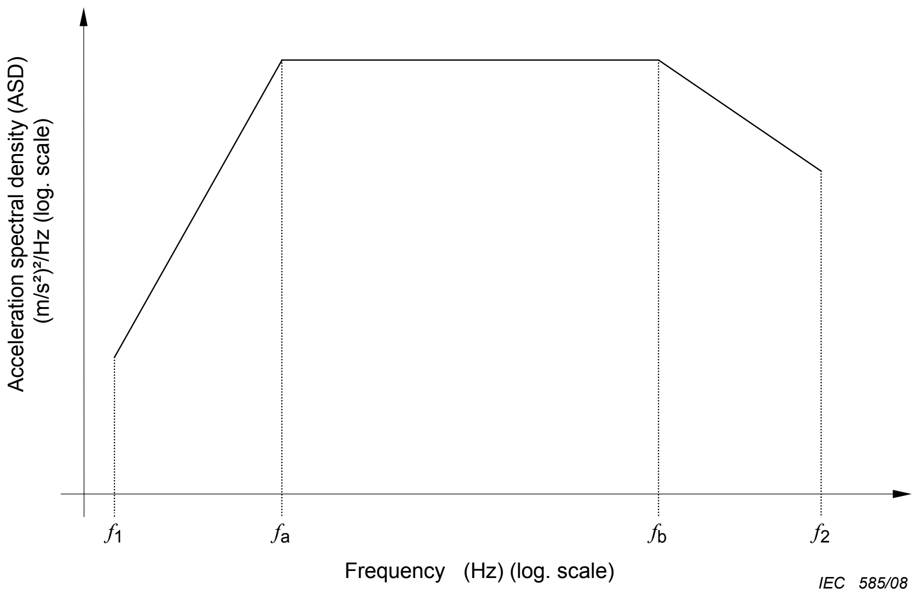

Figure A.3 – Equipment in wheeled vehicles – Frequency/amplitude break points

Table A.5 – Categories for spectrum: equipment in wheeled vehicles

Category No.	**Description**	**Suggested time per axis** h	**axes** No.	**Specification/ reference**
1	Automobile; chassis mounted.	8	3	
	Automobile; Installation area: Engine compartment (bay); attached to body or on the radiator.			
2 a	Vertical	8	1	
2 b	Horizontal longitudinal	8	1	
2 c	Horizontal transversal	8	1	
	Railcars; body mounted; mass of test specimen < 500 kg.			IEC 61373, Cat. 1 B
3 a	Vertical	5	1	
3 b	Horizontal longitudinal	5	1	
3 c	Horizontal transversal	5	1	
	Railcars; bogie mounted; mass of test specimen < 100 kg.			IEC 61373, Cat. 2
4 a	Vertical	5	1	
4 b	Horizontal longitudinal	5	1	
4 c	Horizontal transversal	5	1	
	Railcars; axle mounted; mass of test specimen < 50 kg.			IEC 61373, Cat. 3
5 a	Vertical	5	1	
5 b	Horizontal longitudinal	5	1	
5 c	Horizontal transversal	5	1	

Table A.6 – Break points for spectrum: equipment in wheeled vehicles

Category	f_1	ASDf_1	f_a	f_b	ASDf_a,f_b	f_2	ASDf_2	$a_{r.m.s.}$ value.
No.	Hz	$(m/s^2)^2/Hz$	Hz	Hz	$(m/s^2)^2/Hz$	Hz	$(m/s^2)^2/Hz$	m/s^2
1	10	10	10	50	10	1 000	0,1	33,8
2 a	5	0,4	11	15	4,0	200	0,1	11,0
2 b	5	0,15	12	18	0,9	200	0,07	6,7
2 c	5	0,15	10	15	1,9	200	0,15	10,0
3 a	5	1,86	5	20	1,86	150	0,034	7,8
3 b	5	0,9	5	20	0,9	150	0,016	5,4
3 c	5	0,37	5	20	0,37	150	0,0067	3,5
4 a	5	1,49	10	100	11,8	250	1,9	42,4
4 b	5	0,33	10	100	2,62	250	0,42	20,0
4 c	5	1,13	10	100	8,96	250	1,44	37,0
5 a	10	68,6	20	100	545	500	22	300
5 b	10	13,9	20	100	110	500	4,45	135
5 c	10	55,5	20	100	441	500	17,84	270

Spectrum A.4 Equipment installed in airplanes and helicopters

For details see specifications referenced in the Tables A.7 and A.8 below.

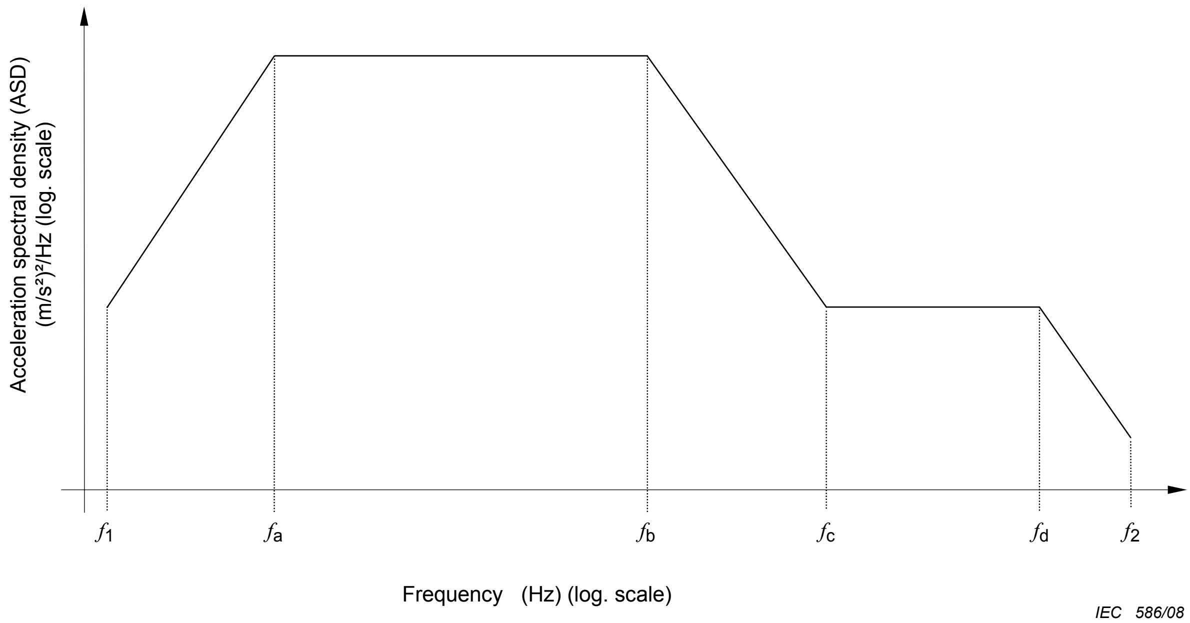

Figure A.4 – Equipment installed in airplanes and helicopters

Table A.7 – Categories for spectrum: equipment in airplanes and helicopters

Category	Descripition	Suggested time per axis	axes	Specification/ Reference
No.		h	No.	
	Fixed wing turbojet or turbofan engines (subsonic & supersonic).			RTCA DO-160D
1 a	Fuselage.	1	3	
	NOTE Fuselage, except structure parts; directly subjected to the engine; standard.			
1 b	Fuselage.	1	3	
	NOTE Fuselage, except structure parts; directly subjected to the engine; robust.			
1 c	Instrument panel, console & equipment rack.	1	3	
1 d	Wing & wheel well, empennage.	1	3	
	NOTE Engine pods, pylons, wings, empennages, landing gear bays.			
2	Propeller aircraft.	1	3	
	Helicopter			
3 a	Except drive elements.	1	3	
3 b	Drive elements.	1	3	

Table A.8 – Break points for spectrum: equipment in airplanes and helicopters

Cat.	f_1	ASDf_1	f_a	f_b	ASDf_a,f_b	f_c	f_d	ASDf_c,f_d	f_2	ASDf_2	$a_{r.m.s.}$ value
No.	Hz	$(m/s^2)^2/Hz$	Hz	Hz	$(m/s^2)^2/Hz$	Hz	Hz	$(m/s^2)^2/Hz$	Hz	$(m/s^2)^2/Hz$	m/s^2
1 a	10	1,2	10	40	1,2	52	500	2,0	2 000	0,13	41,4
1 b	10	2,4	10	40	2,4	52	500	4,0	2 000	0,25	58,3
1 c	10	1,2	10	40	1,2	100	500	0,2	2 000	0,0126	14,9
1 d	10	4,0	10	100	4,0	200	500	8,0	2 000	0,5	79,7
2	10	2,4	10	40	2,4	52	500	4,0	2 000	0,25	58,3
3 a	5	0,2	70	300	2,0	500	500	2,0	500	0,2	26,0
3 b	10	0,012	150	2 000	2,58	2 000	2000	2,58	2 000	2,58	70,0

Annex B
(informative)

Guidance

B.1 General introduction

To achieve reproducibility is not easy. Because of the statistical nature of the random signal, the complex response of the specimen and the errors arising from the analysing process, it is not possible to predict with certainty whether the true acceleration spectral density of the random input at the specimen will match the indicated acceleration spectral density at the specimen within a predefined set of tolerances. A complex, time-consuming analysis after the test is required, as estimation on line is not possible.

The performance of most digital vibration control equipment likely to be employed for random vibration testing can be expected to be similar. Using some selectable parameters of the vibration control equipment, a preliminary calculation can be made to estimate the statistical accuracy associated with the difference between the indicated and the true acceleration spectral density. This does not take into account other sources of uncertainty as defined in ISO/IEC 17025 which refers to ENV 13005, Guide to the expression of uncertainty in measurement. These parameters, which are dependent on each other, can therefore be chosen so that an optimum similarity between the two acceleration spectral densities is achieved.

Equalization of the specified acceleration spectral density requires several repetitions of the control loop, the duration depending on several factors, such as hardware configuration, total system transfer function, shape of the specified acceleration spectral density, control algorithm and test parameters, which can be adjusted prior to the test. The relevant test parameters are: maximum analysing frequency, frequency resolution and drive signal clipping.

The control algorithm of the random vibration involves a compromise between control accuracy and control loop time, which is affected, for example, by the number of records per loop. High control accuracy requires more input data and therefore longer loop times and slower response to dynamic changes in the actual acceleration spectral density. Also, the frequency resolution has great influence on the errors and the loop time. Normally a narrow resolution bandwidth yields a higher control accuracy but a longer control loop time. In order to minimize the deviation between the true and the indicated acceleration spectral density at the specimen, optimization of the mentioned test parameters is required.

A vibration response investigation gives essential information about the specimen/vibrator interaction. For example, this investigation could reveal excessive test fixture vibration amplification or coincident resonance between fixture and specimen. It is therefore recommended that prior to mounting a specimen in its fixture a dynamic response survey or modal test be performed on the fixture and necessary modifications performed to avoid putting unrealistic loads into the specimen.

B.2 Requirements for testing

B.2.1 Single-point and multipoint control

The test requirements are confirmed by the acceleration spectral density computed from the random signal measured at the reference point.

For stiff or small-size specimens, for example in component testing, or if it is known that the dynamic influence of the specimen is low and the test fixture is stiff in the test frequency range there need only be one checkpoint, which then becomes the reference point.

In the case of large or complex specimens, for example equipment with well-spaced fixing points, either one of the checkpoints, or some other point is specified for reference. For a fictitious point, the acceleration spectral density is computed from the random signals measured at the checkpoints. It is recommended that for large and/or complex specimens a fictitious point is used.

B.2.1.1 Single-point control

Measurements are made at one reference point and the indicated acceleration spectral density is directly compared with the specified acceleration spectral density.

B.2.1.2 Multipoint control

When multipoint control is specified or necessary, two frequency domain control strategies are available.

B.2.1.2.1 Averaging strategy

In this method the acceleration spectral density is computed from the signal of each checkpoint. A composite acceleration spectral density is found by arithmetically averaging the acceleration spectral density of these checkpoints.

The arithmetically averaged acceleration spectral density is then compared to the specified acceleration spectral density.

B.2.1.2.2 Extremal strategy

In this method, a composite acceleration spectral density is computed from the maximum or the minimum extreme value of each frequency line of the acceleration spectral density measured at each checkpoint. This method is also called ‘maximum’ or ‘minimum’ strategy, because it produces an acceleration spectral density which represents the envelope of the acceleration spectral densities of each checkpoint.

B.2.2 Distribution

B.2.2.1 Distribution of the instantaneous values

The distribution of the instantaneous values of the random drive signal employed during the testing is known as the normal or Gaussian distribution, and is defined by the equation:

$$p(\chi) = \frac{1}{\sigma\sqrt{2\pi}} e^{-1/2(\chi/\sigma)^2} \quad \text{(B.1)}$$

where

$p(\chi)$ is the probability density;

σ is the r.m.s. value of the drive signal = standard deviation;

χ is the instantaneous random drive signal value.

The mean value of the random drive signal time history is assumed to be zero.

The normal probability density function for random is shown in Figure 2.

B.2.2.2 Crest factor

The crest factor characterises the distribution of the excitation (control) signal by the ratio of the maximum of the instantaneous value to the r.m.s. value (see also Figure 2).

The crest factor can only be applied to the digital vibration control system output drive signal, since non-linearities in the system, that is power amplifier, vibrator, test fixture and specimen, may modify the random waveform at the checkpoint. These non-linearities over a wide frequency band are generally beyond any control.

The crest factor is required by this standard to be not less than 2,5 (see also 4.6.2). For normally distributed random amplitudes, if the crest factor of 2,5 is used, approximately 99 % of all instantaneous drive values are applied to the power amplifier.

B.2.3 Initial and final slope

This standard calls for a shaped or flat acceleration spectral density that is specified between f_1 and f_2 (see spectra A.1 to A.4). However, a practical test can only be run with an initial and final slope. In order to keep the r.m.s. value of acceleration as close as possible to the specified values, the slopes should be as steep as possible.

Normally the initial slope should be not less than 6 dB/octave. In circumstances where the acceleration spectral density level at f_1 is high, and it is necessary to reduce displacement amplitudes to be compatible with vibration facility capabilities, then the initial slope may be increased.

In general, digital vibration control equipment has a dynamic range for the acceleration spectral density of the order of 8 dB between two adjacent frequency lines. To achieve a steeper slope, it may be necessary to employ a narrower frequency resolution B_e than originally defined. If this is not possible, or the maximum achievable slope does not produce the required reduction in displacement, the negative acceleration spectral density tolerance value may need to be modified in the lower frequency range.

These problems do not apply to the final slope above f_2. This slope should be equal to –24 dB/octave or steeper.

B.3 Testing procedures

Where the test is simply to demonstrate the ability of a specimen to survive and operate at the appropriate excitation levels, the test need only continue for a duration sufficient to demonstrate this requirement over the specified frequency range. In cases where the ability of an item to withstand the cumulative effects of vibration is to be demonstrated, for example fatigue and mechanical deformation, the test should be of a sufficient duration to accumulate the necessary stress cycles, although this may give a duration outside the values specified in 5.4.

For endurance testing of an equipment normally mounted on isolators, the isolators are usually fitted. If it is not possible to perform the test with the appropriate isolators, for example if the equipment is installed together with other equipment on a common mounting device, the equipment may be tested without them with a prescribed different severity. The severity should be determined by taking into account the transmissibility of the isolating system in each axis used for the test. When the characteristics of the isolators are not known, reference should be made to B.4.1.

The relevant specification may require an additional test on a specimen with the external isolators removed or blocked in order to demonstrate that minimum acceptable structural resistance has been achieved. In this case, the severity to be applied should be prescribed by the relevant specification.

B.4 Equipment normally used with vibration isolators

B.4.1 Transmissibility factors for isolators

IEC 60068-2-47 provides a full description of what to do for situations where testing should be conducted with isolators but they are not available for test.

B.4.2 Temperature effect

It is important to note that many isolators contain material whose mechanical properties may be temperature sensitive. If the fundamental resonance frequency of the specimen on the isolators is within the test frequency range, caution needs to be exercised in deciding the length of time for which any excitation should be applied. However, under some circumstances it may be unreasonable to apply excitation continuously without permitting recovery. If the actual time distribution of excitation of this fundamental resonance frequency is known, an attempt should be made to simulate it. If the actual time distribution is not known excessive overheating should be avoided by limiting the periods of excitation in a manner that will require engineering judgement.

B.5 Test severities

The frequency range and acceleration spectral density given have been selected to cover a wide range of applications. When an item is for use in one application only, it is preferable to base the severity on the vibration characteristics of the real environment if known.

Wherever possible, the test severity applied to the specimen should be related to the environment to which the specimen will be subjected, during either transportation or operation or to the design requirements if the object of the test is to assess mechanical robustness.

When determining the test severity, consideration should be given to the possible need to allow an adequate safety margin between the test severity and the conditions of the real environment.

B.6 Equipment performance

When appropriate, specimens should be operated either throughout the test or at appropriate phases of the test, in a manner representative of their functioning conditions.

For specimens in which vibration may influence the switch-on and switch-off function, for example interfering with the operation of a relay, such functioning should be repeated to demonstrate a satisfactory performance in this respect during the test.

If the test is to demonstrate survival only, the functional performance of specimens should be assessed after the completion of the vibration test.

B.7 Initial and final measurements

The purpose of the initial and final measurements is to compare particular parameters in order to assess the effect of vibration on the specimen.

The measurements may include, as well as visual requirements, electrical and mechanical operational and structural characteristics.

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