

Environmental testing —

Part 2: Test methods —

Test Fh: Vibration, broad-band random (digital control) and guidance

The European Standard EN 60068-2-64:1994 has the status of a British Standard

This Part should be read in conjunction with BS 2011-1.1 *General and guidance*

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- Federation of the Electronics Industry
- GAMBICA (BEAMA Ltd.)
- Society of Environmental Engineers
- Society of Motor Manufacturers and Traders Limited

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- AEA Technology
- Association of Manufacturers of Domestic Electrical Appliances
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National foreword

This British Standard has been prepared by Subcommittee GEL/15/1 and is the English language version of EN 60068-2-64:1994 *Environmental testing — Part 2: Test methods — Test Fh: Vibration, broad-band random (digital control) and guidance*, published by the European Committee for Electrotechnical Standardization (CENELEC). It is identical with IEC 60068-2-64:1993 and its corrigendum October 1993 published by the International Electrotechnical Commission (IEC). It supersedes BS 2011-2.1Fd:1973, BS 2011-2.1Fda:1973, BS 2011-2.1Fdb:1973, and BS 2011-2.1Fdc:1973 which are withdrawn.

Cross-references

Publication referred to	Corresponding British Standard
IEC 50 (301):1993 IEC 50 (302):1983 IEC 50 (503):1983	BS 4727 <i>Glossary of electrotechnical, power, telecommunication, electronics, lighting and colour terms</i> BS 4727-1:Group 04:1986 <i>Measurement terminology</i> BS 2011 <i>Environmental testing</i> Part 1.1:1989 <i>General and guidance</i> Part 2.1 Fc:1983: <i>Test Fc: Vibration (sinusoidal)</i>
HD 323.1 S2:1988 (IEC 68-1:1988)	
HD 323.2.6 S2 ^a :1988 (IEC 68-2-6:1982)	
EN 60068-2-47:1993 (IEC 68-2-47:1982)	BS EN 60068 <i>Environmental testing</i> BS EN 60068-2 <i>Test methods</i> BS EN 60068-2-47:1993 <i>Tests. Mounting of components equipment and other articles for dynamic tests and guidance</i>
HD 478 series (IEC 721 series)	BS 7527 <i>Classification of environmental conditions</i>
EN 60721 series (IEC 72 series)	BS EN 60721 <i>Classification of environmental conditions</i>
ISO 2041:1990	BS 3015:1991 <i>Glossary of terms relating to mechanical vibration and shock</i>

^a HD 323.2.6 S2 includes A1:1983 + A2:1985 to IEC 68-2-6.

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Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, the EN title page, pages 2 to 35 and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

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Environmental testing
Part 2: Test methods
Test Fh: Vibration, broad-band random (digital control)
and guidance

(IEC 68-2-64:1993 + corrigendum 1993)

Essais d'environnement
Partie 2: Méthodes d'essai
Essai Fh: Vibrations aléatoires à large bande
(asservissement numérique) et guide
(CEI 68-2-64:1993 + corrigendum 1993)

Umweltprüfungen
Teil 2: Prüfverfahren
Prüfung Fh: Schwingen, Breitbandrauschen
(digital geregelt) und Leitfaden
(IEC 68-2-64:1993 + Corrigendum 1993)

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Foreword

At the request of the CENELEC Reporting Secretariat SR 50A, the International Standard IEC 68-2-64:1993 and its corrigendum October 1993, were submitted to the CENELEC Unique Acceptance Procedure (UAP) in July 1993 for acceptance as a European Standard.

The text of the International Standard was approved by CENELEC as EN 60068-2-64 on 8 March 1994.

The following dates were fixed:

- latest date of publication of an identical national standard (dop) 1995-03-15
- latest date of withdrawal of conflicting national standards (dow) 1995-03-15

Annexes designated “normative” are part of the body of the standard. Annexes designated “informative” are given only for information. In this standard, Annex A and Annex ZA are normative and Annex B and Annex C are informative.

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Introduction

This standard for broad-band random vibration testing is intended for general application to specimens of electrotechnical products 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. The standard provides an alternative to the established analogue versions of the random vibration wide-band tests (test Fd, IEC 68-2-34 to IEC 68-2-37).

It should be noted that random vibration testing is a complex subject requiring both a good basic understanding of the philosophy of the test and the exercise of considerable engineering judgement.

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.

Annex A is a normative annex giving the requirements for the vibration response investigation.

Specification writers will find in clause 11 a list of details to be considered for inclusion in specifications, and in Annex B (informative), the guidance.

Annex C is an informative annex, cross-referenced to the relevant clauses, giving the conversion between the quoted values (in dB or percentages) and the values with the alternative magnitudes.

1 Object

The object of this International Standard is to provide two standard test methods (method 1 and method 2) for determining the ability of a specimen to withstand specified severities of broad-band random vibration. Neither test method can be considered more severe than the other, the difference being primarily that method 2 provides more information to quantify the applied test, and is therefore more reproducible.

It is also to reveal the accumulated effects of stress induced by random vibration, and the resulting mechanical weakness and degradation in specified performance and to use this information, in conjunction with the relevant specification, to assess the acceptability of specimens. In some cases, this standard may also be used to demonstrate the mechanical robustness of specimens and/or to study their dynamic behaviour.

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.

Although primarily intended for electrotechnical products, this standard is not restricted to them and may be used in other fields where desired.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of IEC 68. At the time of publication, the editions indicated were valid. All normative documents are subject to revision and parties to agreements based on this part of IEC 68 are encouraged to investigate the possibility of applying the most recent editions of the normative documents listed below. Members of IEC and ISO maintain registers of current valid International Standards.

IEC 50(301, 302, 303):1983, *International Electrotechnical Vocabulary (IEV)* —

Chapter 301: *General terms on measurements in electricity* —

Chapter 302: *Electrical measuring instruments* —

Chapter 303: *Electronic measuring instruments*. (Advance edition)

IEC 68, *Environmental testing*.

IEC 68-1:1988, *Environmental testing — Part 1: General and guidance*.

IEC 68-2, *Environmental testing — Part 2: Tests*.

IEC 68-2-6:1982, *Environmental testing — Part 2: Tests — Test Fc and guidance: Vibration (sinusoidal)*.

IEC 68-2-47:1982, *Environmental testing — Part 2: Tests — Mounting of components, equipment and other articles for dynamic tests including shock (Ea), bump (Eb), vibration (Fc and Fd) and steady-state acceleration (Ga) and guidance*.

IEC 721, *Classification of environmental conditions*.

ISO 2041:1990, *Vibration and shock — Vocabulary*.

3 Definitions

The terms used are generally defined in ISO 2041 or IEC 50 (301, 302, 303) and in IEC 68-1 or IEC 68-2-6. Where, for the convenience of the reader, 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.

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

3.1

– **3 dB bandwidth, B_r** (ISO 2041 modified)

frequency bandwidth between two points in a frequency response function which is 0,707 of the maximum response when associated with a single resonance peak (see 4.3.6.2)

3.2

acceleration spectral density (ISO 2041 modified)

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 (see 4.3.4)

3.3

bias error

systematic error in the estimate of the acceleration spectral density due to the finite frequency resolution used in practice (see 4.3.6.2)

3.4

check-point

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 (see A.2.4.1)

NOTE 1 A number of check-points 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 check-point. If more than four fixing points exist, four representative fixing points will be defined in the relevant specification to be used as check-points.

NOTE 3 In special cases, for example for large or complex specimens, the check-points 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 where there are several fixing points, a single check-point (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.

3.5

control acceleration spectral density

acceleration spectral density measured at the reference point (see 4.3.3)

3.6

control system loop

sum of the following actions

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

3.7

crest factor (ISO 2041)

ratio of the peak value to the r.m.s. value (see 4.3.3)

3.8

damping ratio

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

3.9**distortion**

(definition identical to that in clause 3 of IEC 68-2-6, not identical with ISO 2041 definition)

$$\text{Distortion } d = \frac{\sqrt{a_{\text{tot}}^2 - a_1^2}}{a_1} \times 100 \text{ (per cent)}$$

where

- a_1 is the r.m.s value of the acceleration at the driving frequency;
 a_{tot} is the total r.m.s value of the applied acceleration, including a_1 .

3.10**drive signal clipping**

limitation of the instantaneous value of the drive signal (see 4.3.3)

3.11**effective frequency range**

range from the actual frequency below f_1 to the actual frequency above f_2 due to initial and final slopes (see Figure 2)

3.12**error acceleration spectral density**

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

3.13**equalization**

minimization of the error acceleration spectral density

3.14**final slope**

part of the specified acceleration spectral density above f_2 (see B.2.4)

3.15**frequency resolution**

width of the frequency intervals in the acceleration spectral density in Hertz. It is equal to the reciprocal of the record length in digital analysis. The number of frequency lines is equal to the number of intervals in a given frequency range (see 4.3.6)

3.16**“ g_n ”**

standard acceleration due to the earth's gravity, which itself varies with altitude and geographical latitude (see 5.3)

NOTE For the purposes of this standard, the value of g_n is rounded up to the nearest whole number, that is 10 m/s².

3.17**indicated acceleration spectral density**

estimate of the true acceleration spectral density read from the analyser presentation corrupted by the instrument error, the random error and the bias error (see 4.3.6)

3.18**initial slope**

part of the specified acceleration spectral density below f_1 (see B.2.4)

3.19**instrument error**

error associated with each analogue item of the input to the control system and control system analogue items (see B.2.3.2)

3.20**multipoint control, averaging**

control acceleration spectral density formed from the arithmetic average of the acceleration spectral densities at more than one check-point (see **B.2.1.2**)

3.21**multipoint control, extremal**

control acceleration spectral density formed from the maximum of the acceleration spectral density of each frequency line at more than one check-point (see **B.2.1.2**)

3.22**preferred testing axes**

three orthogonal axes which correspond, as far as is practicable, to the most vulnerable axes of the specimen (see **8.1**)

3.23**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 (see **B.2.3.3**)

3.24**record**

collection of equally spaced data points in the time domain that are used in the calculation of the Fast Fourier Transform (see **B.1**)

3.25**reference point**

point, chosen from the check-points, whose signal is used to control the test, so that the requirements of this standard are satisfied

NOTE The point may be a fictitious reference point (see **A.2.4.2**).

3.26**reproducibility** [IEC 50 (301, 302, 303)]

the 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.

3.27**response points**

specific locations on the specimen at which data are gathered for the purpose of the vibration response investigation. These points are not check or reference points (see **A.3.1**)

3.28**root-mean-square value** (ISO 2041 modified)

the root-mean-square value (r.m.s. value) of a single-valued function over an interval between f_1 and f_2 is the square root of the average of the squared values of the function over the interval (see **4.3.4**)

NOTE In this test method, the r.m.s. values of acceleration, velocity and displacement can be calculated according to **B.2.5**.

3.29**standard deviation, σ** (ISO 2041 modified)

in vibration theory, the mean value of vibration is equal to zero. Therefore, the standard deviation is equal to the r.m.s. value

3.30**statistical accuracy**

ratio of true acceleration spectral density to indicated spectral density (see 4.3.5)

3.31**statistical degrees of freedom** (ISO 2041 modified)

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 (see 4.3.5)

3.32**sweep cycle** (IEC 68-2-6)

traverse of the specified frequency range once in each direction, for example 5 Hz to 500 Hz to 5 Hz (see A.2.5)

3.33**true acceleration spectral density**

acceleration spectral density of the random waveform acting on the specimen (see 4.3.6)

3.34**window function** (ISO 2041)

truncated function that is used for reducing the errors in processing weighted data points (see 4.3.6.2)

4 Requirements for testing**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.

This standard provides for two test methods.

Method 1 normally uses only random vibration. However, the relevant specification may require a vibration response investigation, with either sinusoidal or random vibration excitation, before, or before and after, the random vibration (see 8.2 and 8.6).

Method 2 uses a vibration response investigation, with either sinusoidal or random vibration excitation, prior to the random vibration testing to search for the resonance with the narrowest – 3 dB bandwidth. In certain circumstances, the relevant specification may require an additional vibration response investigation (see 8.6).

4.2 Vibration response investigation

The requirements for sinusoidal excitation, which are derived from those of test Fc (IEC 68-2-6), are prescribed in the normative Annex A. Those for random excitation, which are derived from those of random vibration testing in 4.3, are also prescribed in Annex A.

4.3 Testing with random excitation**4.3.1 Basic motion**

The basic motion of the fixing points of the specimen, which shall be prescribed by the relevant specification and have substantially identical motions, shall be rectilinear and of a stochastic nature. The instantaneous acceleration shall have a normal (Gaussian) distribution. If substantially identical motions are difficult to achieve, then multipoint control shall be used.

4.3.2 Transverse motion

The acceleration spectral density at the check-points in any axis perpendicular to the specified axis shall not exceed the specified value by more than 5 dB, and the associated r.m.s. acceleration value shall not exceed 50 % of that specified for the basic motion. In special cases, for example a small specimen, the acceleration spectral density of the permissible transverse motion may be limited so as not to exceed the basic motion by more than 3 dB, 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. In such cases, the relevant specification shall state which of the following applies:

- a) any transverse motion in excess of that given above shall be stated in the test report; or
- b) transverse motion which is known to offer no hazard to the specimen need not be monitored.

4.3.3 Distribution

The instantaneous acceleration values at the reference point shall have a normal (Gaussian) distribution within the tolerance band given in Figure 1. For most random vibration testing systems, the distribution falls approximately within this tolerance band. A validation shall be performed during normal system calibration (see B.2.2).

If a fictitious reference point is used for control, the requirement for the distribution applies to all the check-points used to form the control acceleration spectral density.

The crest factor or drive signal clipping shall be prescribed by the relevant specification and shall have a value of at least 2,5. The acceleration waveform from the check-points shall be examined to ensure that the signal present contains peaks of at least 2,5 times the specified r.m.s value.

4.3.4 Vibration tolerances

The indicated acceleration spectral density in the required axis at the check and reference points between f_1 and f_2 in Figure 2 shall be within ± 3 dB allowing for the instrument error, referred to the specified acceleration spectral density (see B.2.3.2). The random error and the bias error are not included in the tolerances. The random error can be calculated (see B.2.3.3). When using method 2 the highest permitted bias error shall be prescribed by the relevant specification (see 8.1 and B.2.3.4).

The r.m.s. value of acceleration, computed or measured, between f_1 and f_2 , shall be within ± 10 % of the r.m.s. value associated with the specified acceleration spectral density. These values are valid for both single-point and multipoint control.

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

The initial and final slope shall be not less than $+6$ dB/octave and not more than -24 dB/octave respectively. (See B.2.4.)

4.3.5 Statistical accuracy

The statistical accuracy is determined from the statistical degrees of freedom (N_d) as follows:

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

where

B_e is the frequency resolution; and

T_a is the effective averaging time.

N_d shall not be less than 120 (see also Table B.2 and Figure 6).

4.3.6 Frequency resolution

The frequency resolution necessary to minimize the difference between the true and the indicated acceleration spectral density shall be within the limits given in 4.3.6.1 for method 1, or in 4.3.6.2 for the calculation in the case of method 2.

4.3.6.1 Method 1

The maximum value of the frequency resolution shall be selected from Table 1.

Table 1 — Frequency resolution, method 1

Test frequency range		Upper limit value of frequency resolution Hz
f_1 Hz	f_2 Hz	
1	100	0,5
5	500	2,5
20	2 000	10
50	5 000	25