IEC 60068-2-6

Edition 7.0 2007-12

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Environmental testing –
Part 2-6: Tests – Test Fc: Vibration (sinusoidal)

Essais d'environnement –
Partie 2-6: Essais – Essai Fc: Vibrations (sinusoïdales)

IEC 60068-2-6:2007

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ENVIRONMENTAL TESTING –

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FOREWORD

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International Standard IEC 60068-2-6 has been prepared by IEC technical committee 104: Environmental conditions, classification and methods of test.

This seventh edition cancels and replaces the sixth edition, published in 1995. It consitutes a technical revision.

The major changes with regard to the previous edition concern:

— The agreed wording from IEC technical committee 104 meeting held in Stockholm:2000 on the testing of soft packages.

— Reference to the latest version of IEC 60068-2-47:Mounting

— Simplification of the layout of the standard by replacing some tables with text.

— Addition of the test report requirements (see Clause 13).

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

FDIS	Report on voting
104/439/FDIS	104/449/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.

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- withdrawn,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 gives a method of test applicable to components, equipment and other articles which, during transportation or in service, may be subjected to conditions involving vibration of a harmonic pattern, generated primarily by rotating, pulsating or oscillating forces, such as occur in ships, aircraft, land vehicles, rotorcraft and space applications or are caused by machinery and seismic phenomena.

This standard consists basically of subjecting a specimen to sinusoidal vibration over a given frequency range or at discrete frequencies, for a given period of time. A vibration response investigation may be specified which aims at determining critical frequencies of the specimen.

The relevant specification shall indicate whether the specimen shall function during vibration or whether it suffices that it still works after having been submitted to vibration.

It is emphasized that vibration testing always demands a certain degree of engineering judgement, and both the supplier and purchaser should be fully aware of this fact. However, sinusoidal testing is deterministic and, therefore, relatively simple to perform. Thus it is readily applicable to both diagnostic and service life testing.

The main part of this standard deals primarily with the methods of controlling the test at specified points using either analogue or digital techniques, and gives, in detail, the testing procedure. The requirements for the vibration motion, choice of severities including frequency ranges, amplitudes and endurance times are also specified, these severities representing a rationalized series of parameters. The relevant specification writer is expected to choose the testing procedure and values appropriate to the specimen and its use.

Certain terms have been defined to facilitate a proper understanding of the text. These definitions are given in Clause 3.

Annex A gives general guidance for the test and Annexes B and C provide guidance on the selection of severities for components and equipment.

ENVIRONMENTAL TESTING –

Part 2: Tests – Test Fc: Vibration (sinusoidal)

1 Scope

This part of IEC 60068 gives a method of test which provides a standard procedure to determine the ability of components, equipment and other articles, hereinafter referred to as specimens, to withstand specified severities of sinusoidal vibration. If an item is to be tested in an unpackaged form, that is without its packaging, it is referred to as a test specimen. 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.

The purpose of this test is to determine any mechanical weakness and/or degradation in the specified performance of specimens and to use this information, in conjunction with the relevant specification, to decide upon the acceptability of the specimens. In some cases, the test method may also be used to demonstrate the mechanical robustness of specimens and/or to study their dynamic behaviour. Categorization of components can also be made on the basis of a selection from within the severities quoted in the test.

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 60068-1, *Environmental testing – Part 1: General and guidance*

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

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

ISO 2041, *Vibration and shock – Vocabulary*

ISO/IEC 17025:2005, *General requirements for the competence of testing and calibration laboratories*

3 Terms and definitions

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

NOTE 1 The terms used are generally taken from ISO 2041 and IEC 60068-1. However, “sweep cycle” (3.4) and “signal tolerance” (3.5) have specific meanings in this standard.

Definitions in alphabetical order:

Actual motion	3.7
Basic motion	3.6
Centred resonance frequency	3.10
Check point	3.2.1

NOTE 2 Terms described below are either not identical to, or not defined in ISO 2041 or in IEC 60068-1.

3.1
fixing point
part of the specimen in contact with the fixture or vibration table at a point where the specimen is normally fastened in service

NOTE 1 If a part of the real mounting structure is used as the fixture, the fixing points are those of the mounting structure and not of the specimen.

NOTE 2 Where the specimen consists of a packaged product, fixing point may be interpreted as the surface of the specimen which is in contact with the vibration table.

3.2
measuring points
specific points at which data are gathered conducting the test

NOTE 1 These are of two main types, the definitions of which are given below.

NOTE 2 Measurements may be made at points within the specimen in order to assess its behaviour, but these are not considered as measuring points in the sense of this standard. For further details, see A.2.1.

3.2.1
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

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. For packaged products, where a fixing point may be interpreted as the packaging surface in contact with the vibration table, one check point 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 check points.

NOTE 3 In special cases, for example for large or complex specimens, the check points will be prescribed in 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 (i.e. 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 is only valid when the lowest resonance frequency of the loaded fixture is well above the upper frequency of the test.

3.2.2
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

3.2.3
fictitious reference point
point, derived from multiple check points, either manually or automatically, the result of which is used to control the test, so that the requirements of this standard are satisfied

3.3
control methods

3.3.1
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 (see 4.1.4.1)

3.3.2
multipoint control
control method achieved by using the signals from each of the transducers at the check points

NOTE The signals are either continuously averaged arithmetically or processed by using comparison techniques, depending upon the relevant specification (see 4.1.4.1)

3.4
sweep cycle
traverse of the specified frequency range once in each direction, for example 10 Hz to 150 Hz to 10 Hz

NOTE Manufacturers' handbooks for digital sine control systems often refer to a sweep cycle as f_1 to f_2, and not f_1 to f_2 to f_1.

3.5
signal tolerance

$$\text{signal tolerance } T = \left(\frac{NF}{F} - 1\right) \times 100\ \%$$

where

NF is the r.m.s value of the unfiltered signal;

F is the r.m.s value of the filtered signal.

NOTE This parameter applies to whichever signal, i.e. acceleration, velocity or displacement, is being used to control the test (see A.2.2).

3.6
basic motion
motion at the driving frequency of vibration at the reference point (see also 4.1.1)

3.7
actual motion
motion represented by the wideband signal returned from the reference point transducer

3.8
damping
generic term ascribed to the numerous energy dissipation mechanisms in a system

NOTE In practice, damping depends on many parameters, such as the structural system, mode of vibration, strain, applied forces, velocity, materials, joint slippage, etc.

3.9
critical frequencies
frequencies at which

– malfunctioning and/or deterioration of performance of the specimen are exhibited which are dependent on vibration, and/or

– mechanical resonances and/or other response effects occur, for example, chatter

3.10
centred resonance frequency
frequency automatically centred on the actual resonance frequency derived from the vibration response investigation

3.11
restricted frequency sweeping
sweeping over a restricted frequency range between 0,8 and 1,2 times the critical frequency

3.12
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.

4 Requirements for testing

4.1 Required characteristics

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.

4.1.1 Basic motion

The basic motion shall be a sinusoidal function of time and such that the fixing points of the specimen move substantially in phase and in straight parallel lines, subject to the limitations of 4.1.2 and 4.1.3.

4.1.2 Spurious motion

4.1.2.1 Cross-axis motion

The maximum vibration amplitude at the check points in any axis perpendicular to the specified axis shall not exceed 50 % of the specified amplitude up to 500 Hz or 100 % for frequencies in excess of 500 Hz. The measurements need only cover the specified frequency range. In special cases, e.g. small specimens, the amplitude of the permissible cross axis motion may be limited to 25 %, if required by the relevant specification.

In some cases, for example for large size or high mass specimens or at some frequencies, it may be difficult to achieve the figures quoted above. In such cases, the relevant specification shall state which of the following requirements apply:

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

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

4.1.2.2 Rotational motion

In the case of large size or high mass specimens, the occurrence of spurious rotational motion of the vibration table may be important. If so, the relevant specification shall prescribe a tolerable level. The achieved level shall be stated in the test report (see also A.2.4).

4.1.3 Signal tolerance

Acceleration signal tolerance measurements shall be performed if stated in the relevant specification. They shall be carried out at the reference point and shall cover the frequencies up to 5 000 Hz or five times the driving frequency whichever is the lesser. However, this maximum analysing frequency may be extended to the upper test frequency for the sweep, or beyond, if specified in the relevant specification. Unless otherwise stated in the relevant specification, the signal tolerance shall not exceed 5 % (see 3.5).

If stated in the relevant specification, the acceleration amplitude of the control signal at the fundamental driving frequency shall be restored to the specified value by use of a tracking filter (see A.4.4).

In the case of large or complex specimens, where the specified signal tolerance values cannot be satisfied at some parts of the frequency range, and it is impracticable to use a tracking filter, the acceleration amplitude need not be restored, but the signal tolerance shall be stated in the test report (see A.2.2).

NOTE If a tracking filter is not used and the signal tolerance is in excess of 5 %, the reproducibility may be significantly affected by the choice of either a digital or analogue control system (see A.4.5).

The relevant specification may require that the signal tolerance, together with the frequency range affected, is stated in the test report whether or not a tracking filter has been used (see A.2.2).

4.1.4 Vibration amplitude tolerances

The basic motion amplitude in the required axis at the check and reference points shall be equal to the specified value, within the following tolerances. These tolerances include instrumentation errors. The relevant specification may require that the confidence level used in the assessment of measurement uncertainty is stated in the test report.

At low frequencies or with large size or high mass specimens it may be difficult to achieve the required tolerances. In these cases, it is expected that a wider tolerance or the use of an alternative method of assessment shall be prescribed in the relevant specification and stated in the test report.

4.1.4.1 Reference point

Tolerance on the control signal at the reference point shall be ±15 % (see A.2.3).

4.1.4.2 Check points

Tolerance on the control signal at each check point:

±25 % up to 500 Hz;

±50 % above 500 Hz.

(See A.2.3.)

4.1.5 Frequency tolerances

The following frequency tolerances apply.

4.1.5.1 Endurance by sweeping

±0,05 Hz up to 0,25 Hz;

±20 % from 0,25 Hz to 5 Hz;

±1 Hz from 5 Hz to 50 Hz;

±2 % above 50 Hz.

4.1.5.2 Endurance at fixed frequency

a) Fixed frequency:

±2 %.

b) Almost fixed frequency:

±0,05 Hz up to 0,25 Hz;

±20 % from 0,25 Hz to 5 Hz;

±1 Hz from 5 Hz to 50 Hz;

±2 % above 50 Hz.

4.1.5.3 Measurement of critical frequency

When the critical frequencies (see 8.2) before and after endurance have to be compared, i.e. during vibration response investigations, the following tolerances shall apply:

±0,05 Hz up to 0,5 Hz;

±10 % from 0,5 Hz to 5 Hz;

±0,5 Hz from 5 Hz to 100 Hz;

±0,5 % above 100 Hz.

4.1.6 Sweep

The sweeping shall be continuous and the frequency shall change exponentially with time (see A.4.3). The sweep rate shall be one octave per minute with a tolerance of ±10 %. This may be varied for a vibration response investigation (see 8.2).

NOTE With a digital control system, it is not strictly correct to refer to the sweeping being “continuous”, but the difference is of no practical significance.

4.2 Control strategy

4.2.1 Single/multipoint control

When multipoint control is specified or necessary, the control strategy has to 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 amplitude of the signals at the check points or the amplitude of the signal at a selected point (for example, that with the largest amplitude) shall be controlled to the specified level, see also A.2.3.

If it is not possible to achieve single point control, as required by the relevant specification, then multipoint control shall be used by controlling the average or extreme value of the signals at the check points. In either of these cases of multipoint control, the reference point is a fictitious reference point. The method used shall be stated in the test report.

Use of multipoint control does not assure that the tolerances of each checkpoint are met. In general it reduces the deviation from the nominal values, when compared with single-point control, at the fictitious reference point.

The following strategies are available.

4.2.1.1 Averaging strategy

In this method, the control amplitude is computed from the signal from each check point. A composite control amplitude is formed by arithmetically averaging the signal amplitudes from the check points. This arithmetically averaged control amplitude is then compared with the specified amplitude.

4.2.1.2 Weighted averaging strategy

The control amplitude a_C is formed by averaging the signal amplitude from the check points a_1 to a_n according to their weighting w_1 to w_n:

$$a_C = (w_1 \text{ x } a_1 + w_2 \text{ x } a_2 + ... + w_n \text{ x } a_n) / (w_1 + w_2 + ... + w_n)$$

This control strategy offers the possibility that different check point signals contribute a different portion to the control.

4.2.1.3 Extremal strategy

In this method, a composite control amplitude is computed from the maximum (MAX) or the minimum (MIN) extreme amplitudes of the signal amplitude measured at each check point. This strategy will produce a control amplitude that represents the envelope of the signal amplitudes from each check point (MAX) or a lower limit of the signal amplitudes from each check point (MIN).

4.2.2 Multi-reference control

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

When multi-reference control is specified, the control strategy shall be prescribed as follows:

Limiting: All control signals shall be beneath their appropriate reference;

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

4.3 Mounting

Unless otherwise stated in the relevant specification, the specimens shall be mounted on the test apparatus in accordance with the requirements in IEC 60068-2-47. For specimens normally mounted on vibration isolators, see the note in 8.3.2 as well as A.3.1, A.3.2 and Clause A.5.

5 Severities

A vibration severity is defined by the combination of the three parameters: frequency range, vibration amplitude and duration of endurance (in sweep cycles or time).

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

a) chosen from the values in 5.1 to 5.3;

b) chosen from examples in Annex A or Annex C;

c) derived from the known environment;

d) derived from other known sources of relevant data, for example, the IEC 60721-3 series.

To permit some flexibility in situations where the real environment is known, it may be appropriate to specify a shaped acceleration versus frequency curve and, in these cases, the