

British Standard

Basic environmental testing procedures

Part 2.1 Tests

Test Fc. Vibration (sinusoidal)

Essais fondamentaux climatiques et de robustesse mécanique

Partie 2.1 Essais

Essais Fc. Vibrations (sinusoïdales)

Grundsätzliche Umweltprüfverfahren

Teil 2.1 Prüfungen

Prüfung Fc. Schwingungen (sinusförmig)

(This Part should be read in conjunction with Part 1.1 General)

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National foreword

This revision of BS 2011 : Part 2.1Fc : 1977 has been prepared under the direction of the General Electrotechnical Engineering Standards Committee. It is identical with IEC Publication 68-2-6 : 1982 'Basic environmental testing procedures, Part 2 : Tests — Test Fc : Vibration (sinusoidal)', published by the International Electrotechnical Commission (IEC), and like all other Parts of IEC Publication 68 (except IEC 68-2-42 and IEC 68-2-43) is subject to CENELEC Harmonization Document (HD) 323.

This standard supersedes BS 2011 : Part 2.1Fc : 1977, which is withdrawn.

Terminology and conventions. The text of the international standard has been approved as suitable for publication as a British Standard without deviation. Some terminology and certain conventions are not identical with those used in British Standards; attention is especially drawn to the following.

The comma has been used in the figures as a decimal marker; in British Standards it is current practice to use a full point on the baseline as the decimal marker.

For the purposes of this Part of this standard, the scope clause is given in clause 2 of BS 2011 : Part 1.1 : 1980.

Cross-references

International standard*	Corresponding British Standard
	BS 2011 Basic environmental testing procedures
IEC 68-1 : 1978	Part 1.1 : 1980 General (Identical)
IEC 68-2-34 : 1973	Part 2.1Fd : 1973 Test Fd. Random vibration — wide band, general requirements (Technically equivalent)
IEC 68-2-35 : 1973	Part 2.1Fda : 1973 Test Fda. Random vibration — wide band, reproducibility high (Technically equivalent)
IEC 68-2-36 : 1973	Part 2.1Fdb : 1973 Test Fdb. Random vibration — wide band, reproducibility medium (Technically equivalent)
IEC 68-2-37 : 1973	Part 2.1Fdc : 1973 Test Fdc. Random vibration — wide band, reproducibility low (Technically equivalent)

The Technical Committee has reviewed the provisions of ISO 2041, to which reference is made in the text, and has decided that they are acceptable for use in conjunction with this standard.

A related British Standard to ISO 2041 : 1975 is BS 3015 : 1976 'Glossary of terms relating to mechanical vibration and shock'.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

*Undated in the text.



Amendment No. 1
published and effective from 29 June 1984
to BS 2011 : Part 2.1Fc : 1983 (IEC 68-2-6 : 1982)

Basic environmental testing procedures
Part 2.1 Tests
Test Fc. Vibration (sinusoidal)

NOTE. This amendment has been issued to implement Amendment No. 1 to IEC Publication 68-2-6 : 1982. The issue of the latter amendment was consequent upon the publication of IEC Publication 68-2-47 : 1982 with which BS 2011 : Section 4.1 : 1983 'Specification for mounting of components, equipment and other articles for dynamic tests' is identical. The opportunity has also been taken to make additions to the national foreword as a consequence of implementing this amendment.

Revised text

AMD 4465
June 1984

National foreword

In line 4 of paragraph 1, after '(IEC)', insert
'including Amendment No. 1 published in 1983'.

At the end of the list of 'Cross-references' insert the following new entry:

'IEC 68-2-47 : 1982	Section 4.1 : 1983 Specification for mounting of components, equipment and other articles for dynamic tests (Identical)'.
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AMD 4465
June 1984

Clause 4.2 Mounting

Delete the entire text and substitute the following:

' The specimens shall be mounted on the test apparatus in accordance with the requirements in IEC Publication 68-2-47. For specimens normally mounted on isolators, see in addition Sub-clause 8.2.2, Note 2 and Sub-clauses A3.1 and A3.2 and Clause A5 of Appendix A.'



Amendment No. 2
published and effective from 30 June 1986
to BS 2011 : Part 2.1Fc : 1983 (IEC 68-2-6 : 1982)

Basic environmental testing procedures

Part 2.1 Tests

Test Fc. Vibration (sinusoidal)

NOTE. This amendment has been issued to implement the changes introduced by Amendment No. 2 to IEC Publication 68-2-6 : 1982 (which also repeats the content of Amendment No. 1 which was implemented by AMD 4465).

Revised text

AMD 5115
June 1986

National foreword (as amended by Amendment No. 1)

In line 4 of paragraph 1, after 'published in 1983' insert 'and Amendment No. 2 published in 1985'.

After the list of 'Cross-references' insert the following new paragraph.

'Although BS 4727 'Glossary of electrotechnical, power, telecommunication, electronics, lighting and colour terms' is only related to IEC 50(55), the definitions of terms 303 2026 and 303 6033 are technically equivalent, differing only in minor details of presentation, to IEC 55-55-130 and 55-75-165 respectively.'

AMD 5115
June 1986

Clause 5.2 Vibration amplitude

In line 3 of paragraph 2, delete 'and Figures 1, 2 and 3'. After paragraph 2 insert the following note:

'Note. – Nomograms relating vibration amplitude to frequency are given in Figures 1, 2 and 3 but, before their use in the low-frequency region, consideration should be given to the guidance in Sub-clause A4.1.'

AMD 5115
June 1986

Figures 1, 2 and 3

Amend the beginning of the existing captions as follows:

'Nomogram relating vibration amplitude to frequency with . . . '

and add the following note:

'Note. – This nomogram should not be taken as being a precise graphical representation of the severities.'

AMD 5115
June 1986

Clause A2.3 Derivation of control signal

Insert, after the existing paragraph 2, the following new paragraph.

'If time-division multiplexing (IEV 55-55-130, see IEC Publication 50(55): International Electrotechnical Vocabulary, Chapter 55: Telegraphy and Telephony) is used to establish in turn an intermittent channel to each check point, the frequency of this intermittent connection by the distributor (IEV 55-75-165) should not exceed the driving frequency so as to ensure that at least one period of each signal is taken into account. For example, if four transducers are used, at 100 Hz the frequency of interrogating each check point should not exceed 25 Hz.'

Delete the first sentence of the existing paragraph 3.

INTRODUCTION

This standard 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. It consists basically of subjecting a specimen to sinusoidal vibration over a given frequency range or at discrete frequencies for a given period of time.

1. Object

To provide a standard procedure to determine the ability of components, equipment and other articles to withstand specified severities of sinusoidal vibration.

2. General description

The purpose of this test is to determine mechanical weakness and/or degradation in specified performance and to use the information, in conjunction with the relevant specification, to decide whether an equipment or component, hereinafter referred to as a specimen, is acceptable or not. It may be used, in some cases, to determine the structural integrity 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.

Whether a specimen has to function during vibration or merely to survive conditions of vibration will need to be stated in the relevant specification.

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.

The main part of this standard deals primarily with the methods of controlling the test at specified points, 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.

Appendices A to D give general guidance and a selection of severities for components and for equipment. In addition, in order to assist users, information is given regarding the correlation between this standard and the previous fourth edition.

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

In order to facilitate the use of this standard, references are given in the main part where the reader is invited to refer to Appendix A and the clause numbers in the main part are also referenced in Appendix A.

3. Definitions

The terms used are generally as defined in ISO Standard 2041: Vibration and Shock—Vocabulary. However, the two following terms have specific meanings in this standard:

– sweep cycle: a traverse of the specified frequency range once in each direction, for example 10 Hz to 150 Hz to 10 Hz;

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

where:

a_1 = r.m.s. value of the acceleration at the driving frequency

a_{tot} = total r.m.s. value of the applied acceleration (including the value of a_1)

Finally, the following terms are not defined in ISO Standard 2041.

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. If a part of the real mounting structure is used as the fixture, the fixing points shall be taken as those of the mounting structure and not of the specimen.

3.2 Measuring points

The test shall be carried out using data gathered at certain specific points. These are of two main types, the definitions of which are given below.

Note. — 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 Sub-clause A2.1 of Appendix A.

3.2.1 Check point

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

A number of check points are used as a means of ensuring that the test requirements are satisfied.

If four or fewer fixing points exist, each shall be used as a check point. If more than four fixing points exist, four representative fixing points shall be defined in the relevant specification and these shall be used as check points.

In special cases, for example for large or complex specimens, the check points shall be prescribed in the relevant specification if required to be other than close to the fixing points.

Where a large number of small specimens are mounted on one fixture, or in the case of a small specimen, having a number of fixing points, a single check point (i.e. the reference point) may be selected for the derivation of the control signal which is related to the fixture rather than to the fixing points of the specimens. 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.

3.3 *Control points*

3.3.1 *Single point control*

This is achieved by using the signal from the transducer at the reference point in order to maintain this point at the specified level (see Sub-clause 4.1.4.1).

3.3.2 *Multipoint control*

This is achieved by using the signals from each of the transducers at the check points. The signals are either continuously averaged arithmetically or processed by using comparison techniques depending upon the relevant specification (see Sub-clause 4.1.4.1).

4. **Description of test apparatus**

4.1 *Required characteristics*

The required characteristics of the vibration generator and fixture when the generator is loaded for the conditioning process shall be as follows.

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 Sub-clauses 4.1.2 and 4.1.3.

4.1.2 *Transverse 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 transverse motion may be limited to 25%, if required by the relevant specification.

In some cases, for example for large specimens or high 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 transverse motion in excess of that stated above shall be noted and recorded in the documentation,
- b) transverse motion need not be monitored.

4.1.3 *Distortion*

The acceleration distortion measurement 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 greater.

The distortion, as defined in Clause 3, shall not exceed 25%. In some instances, it may not be possible to achieve this, in which case a distortion value greater than 25% is acceptable if the acceleration amplitude of the control signal at the fundamental frequency is restored to the specified value, for example by use of a tracking filter.

In the case of large or complex specimens, where the specified distortion 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 distortion shall be noted and recorded in the documentation (Sub-clause A2.2 of Appendix A).

The relevant specification may require that the distortion defined as above together with the frequency range affected is noted, whether or not a tracking filter has been used (Sub-clause A2.2 of Appendix A).

4.1.4 *Vibration amplitude tolerances*

The actual vibration 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.

4.1.4.1 *Reference point*

Tolerance on the control signal at the reference point: $\pm 15\%$ (Sub-clause A2.3 of Appendix A).

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 averaged value of the signal at the check points or the value of the signal at a selected point (for example, that with the largest amplitude) shall be controlled to the specified level (Sub-clause A2.3 of Appendix A).

4.1.4.2 *Check points*

At each check point:

$\pm 25\%$ up to 500 Hz

$\pm 50\%$ above 500 Hz

In some cases, for example for low frequencies or large specimens at some frequencies, it may be difficult to achieve the figures quoted at some discrete frequencies within the frequency range. In such cases, it is expected that a wider tolerance or an alternative method of assessment will be stated in the documentation.

4.1.5 *Frequency tolerances*

± 0.05 Hz up to 0.25 Hz

$\pm 20\%$ from 0.25 Hz to 5 Hz

± 1 Hz from 5 Hz to 50 Hz

$\pm 2\%$ above 50 Hz

When the critical frequencies (see Sub-clause 8.1) before and after endurance are to be compared, i.e. during a vibration response investigation, the following tolerances shall apply:

± 0.05 Hz up to 0.5 Hz

$\pm 10\%$ from 0.5 Hz to 5 Hz

± 0.5 Hz from 5 Hz to 100 Hz

$\pm 0.5\%$ above 100 Hz

4.1.6 Sweep

The sweeping shall be continuous and the frequency shall change exponentially with time (Sub-clause A4.3 of Appendix A).

The sweep rate shall be one octave per minute $\pm 10\%$.

4.2 Mounting

Mounting of specimens is dealt with in IEC Publication 68-2-47. For specimens normally mounted on isolators, see in addition Sub-clauses A3.1 and A3.2 and Clause A5 of Appendix A.

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).

For each parameter, the relevant specification shall choose the appropriate requirements from those listed below. If the known environment, however, is substantially different, the requirements shall be related to it by the relevant specification.

Examples of severities for components are given in Appendix B and for equipment in Appendix C (Sub-clauses A4.1 and A4.2 of Appendix A).

5.1 Frequency range

The frequency range shall be given in the relevant specification by selecting a lower frequency from Table I and an upper frequency from Table II.

TABLE I

Lower frequency
f_1 (Hz)
0.1
1
5
10
55
100

TABLE II

Upper frequency
f_2 (Hz)
10
20
35
55
100
150
300
500
2 000
5 000