

JIS

JAPANESE INDUSTRIAL STANDARD

**Basic Environmental Testing
Procedures Part 2: Tests,
Test Fc and Guidance:
Vibration (sinusoidal)**

JIS C 0040—1987

Translated and Published

by

Japanese Standards Association

Printed in Japan

In the event of any doubt arising,
the original Standard in Japanese is to be final authority.

Contents

	Page
1. Introduction and Scope	1
2. Object	1
3. General Description of Tests	2
4. Definitions	2
4.1 fixing point	2
4.2 measuring points	2
4.2.1 check point	2
4.2.2 reference point	3
4.3 control points	3
4.3.1 single point control	3
4.3.2 multipoint control	3
4.4 sweep cycle and distortion	3
4.4.1 sweep cycle	3
4.4.2 acceleration distortion	3
5. Test Apparatus	3
5.1 Required Characteristics	3
5.1.1 Basic Motion	3
5.1.2 Transverse Motion	4
5.1.3 Acceleration Distorsion	4
5.1.4 Vibration Amplitude Tolerances	4
5.1.4.1 Reference Point	4
5.1.4.2 Check Point	4
5.1.5 Frequency Tolerances	5
5.1.6 Sweep	5
5.2 Mounting	5
6. Severities	5
6.1 Frequency Range	5
6.2 Vibration Amplitude	6
6.3 Duration of Endurance	11
6.3.1 Endurance by sweeping	11
6.3.2 Endurance at Fixed Frequencies	12
6.3.2.1 Endurance at Critical Frequencies	12
6.3.2.2 Endurance at Predetermined Frequencies	12

C 0040-1987

	Page
7. Pretreatment	12
8. Initial Measurements	12
9. Test Condition	12
9.1 Vibration Presponse Investigation	13
9.2 Endurance Procedures	13
9.2.1 Endurance by Sweeping	13
9.2.2 Endurance at Fixed Frequencies	13
10. Intermediate Measurements	14
11. Recovery	14
12. Final Measurements	14
13. Information to Be Given in Relevant Specification	14
Appendix A. Guide to Execution of Sinusoidal Vibration Test	16
A 1. Introduction	16
A 2. Measurement and Control	17
A 2.1 Measuring Points	17
A 2.2 Errors Caused by Acceleration Distortion	17
A 2.3 Derivative of Control Signal	17
A 3. Testing Procedures	18
A 3.1 Vibration Response Investigation	18
A 3.2 Endurance	18
A 4. Test Severities	19
A 4.1 Selection of Test Sevirities	19
A 4.2 Selection of Test Severities for Components	20
A 4.3 Sweep	20
A 5. Equipmetn Normally Used with Vibration Isolators	22
A 5.1 Transmissibility Factors for Isolators	22
A 5.2 Temperature Effect	22
A 6. Duration	23
A 6.1 Basic Concept	23
A 6.2 Tests	23
A 7. Dynamic Response	24
A 8. Performance Evaluation	25
A 9. Initial and Final Measurements	25

	Page
Appendix B. Examples of Severities Primarily Intended for Components	26
Appendix C. Examples of Severities Primarily Intended for Equipment	28
Appendix D. Mounting of Test Specimens for Dynamic Test and Guidance	30
D 1. Object	30
D 2. Introduction and Scope	30
D 3. General	30
D 4. Mounting of Components	30
D 5. Mounting of Equipment and Other Articles	31
D 6. Information to Be Given in Relevant Specification	31
D 7. Guidance for Mounting of Specimens	36
D 7.1 Components	36
D 7.2 Equipment and Other Articles	37
D 7.3 Test Fixture	37
D 7.3.1 Shock and Bump	37
D 7.3.2 Vibration	38
D 7.3.3 Acceleration, Steady State	38
D 7.3.4 Choice of Material	38
D 7.3.5 Methods of Construction	39
D 7.4 Balancing	40
D 7.4.1 Vibration	40
D 7.4.2 Acceleration, Steady State	40
D 7.5 Positioning of Accelerometers	40
D 7.6 Performance Check of Test Fixture	40
D 7.7 Large and/or Complex Specimens	41

JAPANESE INDUSTRIAL STANDARD

J I S

Basic Environmental Testing Procedures Part 2: C 0040-1987
Tests, Test Fc and Guidance: Vibration (sinusoidal)

1. Introduction and Scope

This Standard specifies a sinusoidal vibration test method for components and equipment, hereinafter referred to as the "specimens" 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 application or as caused by machinery or 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.

Remark: The units and numerical values shown in () in this Standard are based on the traditional units and are currently the criteria in force.

Reference: This Standard is based on IEC 68-2-6 (1982) Basic environmental testing procedures Part 2: Tests, Test Fc and Guidance: Vibration (sinusoidal) and IEC 68-2-47 (1982) Basic environmental testing procedures 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. However, a part of the contents is revised in conformity with the actual circumstances in Japan.

The above-mentioned IEC 68-2-47, not a part of IEC-68-2-6, is treated in the Appendix D of this Standard.

2. Object

The object of this Standard is to specify the standard testing procedures to judge the ability of specimens to withstand specified severities of sinusoidal vibration.

Applicable Standards and Corresponding International Standards: See page 41.

3. General Description of Tests

The purpose of the tests is to identify mechanical weakness and/or degradation revealed in specified performance. Tests shall be carried out in accordance with the relevant specifications to decide whether a specimen is acceptable or not, while, on the other hand, the information thus obtained may be utilized to determine the structural integrity of specimens and/or to study their dynamic behavior.

Categorization of components can also be made on the basis of 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.

This Standard specifies mainly the methods of controlling vibrations applied on specified points. The specifications of tests are so arranged that by selecting the requirements for vibration motion, the vibration frequency range, the amplitude and the endurance time a choice of the desired grade of severities of tests can be realized. The reasonable arrangement of the parameter presupposes the need of selecting, in determining the specification of products, the testing methods and the parameter values most suited for the use of the specimens. Appendices A, B and C give general guidance and an instruction for the selection of severities intended for individual components and equipment.

4. Definitions

For the purposes of this Standard, the following definitions apply. Other terms and the definitions shall conform to JIS B 0153 and JIS C 0010.

4.1 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.

4.2 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.

Remark: Measurements may be made at points within the specimen in order to assess its behaviour, but these are not considered as measuring point in the sense of this Standard. For further details, see Subclause A 2.1 of Appendix A.

4.2.1 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.

4.2.2 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.

4.3 control points

4.3.1 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 5.1.4.1).

4.3.2 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 5.1.4.1).

4.4 sweep cycle and distortion

4.4.1 sweep cycle A traverse of the specified frequency range once in each direction.

Example: 10 Hz to 150 Hz to 10 Hz

4.4.2 acceleration distortion

$$d = \frac{\sqrt{a_{\text{tot}}^2 - a_1^2}}{a_1} \times 100 \quad \times 100 \text{ (in percent)}$$

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)

5. Test Apparatus

5.1 Required Characteristics The required characteristics of the vibration generator and fixture when the generator is mounted with specimens are as follows.

5.1.1 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 5.1.2 and 5.1.3.

5.1.2 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:

- (1) Any transverse motion in excess of that stated above shall be noted and recorded in the documentation.
- (2) Transverse motion need not be monitored.

5.1.3 Acceleration Distortion The acceleration distortion measurement shall be carried out at the reference point and shall cover the frequencies up to 5000 Hz or five times the driving frequency whichever is the greater.

The distortion, as defined in 4.4.2 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⁽¹⁾.

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 (see A 2.2 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 (see A 2.2 of Appendix A).

Note (1) Tracking filter is a filter of which center frequency varies following the vibration frequency of input signal and always operates to pick up the fundamental wave components of input signal.

5.1.4 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.

5.1.4.1 Reference Point Tolerance on the control signal at the reference point: ± 15 % (see A 2.3 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 (see A 2.3 of Appendix A).

5.1.4.2 Check Point Tolerances on the amplitude at each check point:

- ± 25 % up to 500 Hz
- ± 50 % up 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.

5.1.5 Frequency Tolerances

- ± 0.50 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

When the critical frequencies (see 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
- ± 10 % from 0.5 Hz to 5 Hz
- ± 0.5 Hz from 5 Hz to 100 Hz
- ± 0.5 % above 100 Hz

5.1.6 Sweep The sweeping shall be continuous and the frequency shall change exponentially with time (see A 4.3 of Appendix A).

The sweep rate shall be one octave per minute.

5.2 Mounting The test specimen shall be mounted on the test jig based on the specification in Appendix D. For specimens normally mounted on vibration isolators, see Remark 2 in 9.2.2 and appendices A 3.1, A 3.2 and A 3.5.

6. 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 (see A 4.1 and A 4.2 of Appendix A).

6.1 Frequency Range The frequency range shall be given in the relevant specification by selecting a lower frequency from Table 1 and an upper frequency from Table 2.

6
C 0040-1987

The recommended ranges are shown in Table 3.

Table 1. Lower Frequency

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

Table 2. Upper Frequency

Upper frequency (f_2) Hz
10
20
35
100
150
300
500
2000
5000

Table 3. Recommended Frequency Ranges

Recommended frequency ranges (f_1 to f_2) Hz
1 to 35
1 to 100
10 to 55
10 to 150
10 to 500
10 to 2000
10 to 5000
55 to 500
55 to 2000
55 to 5000
100 to 2000

6.2 Vibration Amplitude The vibration amplitude (displacement or acceleration or both) shall be given in the relevant specification.

Below a certain frequency known as the crossover frequency, all amplitudes are specified as constant displacement, whilst above this frequency, amplitudes are given as constant acceleration. The recommended values are given in Tables 4 and 5 and Figures 1 and 2 for the two different crossover frequencies.

Each value of displacement amplitude is associated with a corresponding value of acceleration amplitude (shown on the same line in Tables 4 and 5) so that the magnitude of vibration is the same at the crossover frequency (see A 4.1 of Appendix A).

Where it is not technically appropriate to adopt the crossover frequencies stated in this subclause, the relevant specification may couple displacement and acceleration amplitudes giving a different value of crossover frequency. In some circumstances more than one crossover frequency may also be specified.

Up to an upper frequency of 10 Hz, it is normally appropriate to specify a displacement amplitude over the whole frequency range. Therefore, in Table 4 and Figure 3 only displacement amplitudes are specified.

Table 4. Recommended Vibration Amplitudes with Lower Crossover Frequency (≈ 8 Hz to 9 Hz)

Displacement amplitude below the crossover frequency mm	Acceleration amplitude above the crossover frequency m/s ² {G}
0.35	0.98 {0.1}
0.75	1.96 {0.2}
1.5	4.9 {0.5}
3.5	9.8 {1.0}
7.5	19.6 {2.0}
10	29.4 {3.0}
15	49.0 {5.0}

- Remarks 1. All figures quoted are amplitude (peak values) (see 2039 of JIS B 0153).
2. The displacement amplitude of 15 mm is primarily intended for hydraulic vibration testing equipment.
3. The relation between the displacement amplitude d (mm) and the acceleration amplitude a (m/s²) is expressed by the following equation.

$$a = d \cdot (2\pi f)^2 \times 10^{-3} \text{ (m/s}^2\text{)}$$

$$G = d \cdot (2\pi f)^2 \times 10^{-3} / 9.8$$

Table 5. Recommended Vibration Amplitudes with
Higher Crossover Frequency (≈ 57 to 62 Hz)

Displacement amplitude below the crossover frequency mm	Acceleration amplitude above the crossover frequency m/s ²	{G}
0.035	4.9	{0.5 }
0.075	9.8	{1.0 }
0.15	19.6	{2.0 }
0.35	49	{5.0 }
0.75	98	{10}
1.0	147	{15}
1.5	196	{20}
2.0	294	{30}

Table 6. Recommended Vibration Displacement Amplitudes Applicable
Only for Frequency Ranges with an Upper Frequency of 10 Hz

Displacement amplitude mm
10
35
75
100

Remark: The displacement amplitudes
greater than 10 mm are
primarily intended for
hydraulic vibration generators.

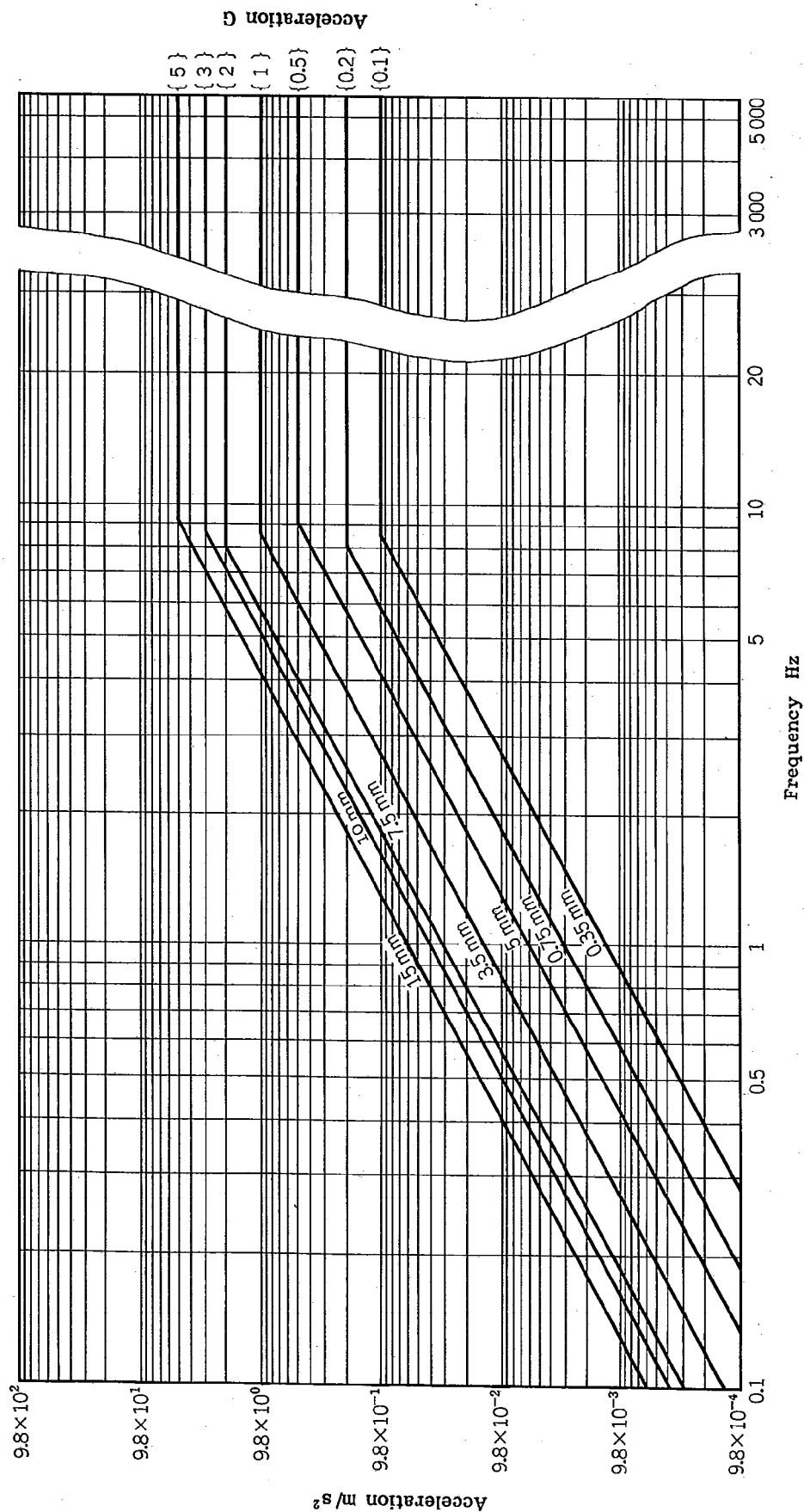
Fig. 1. Vibration Amplitude with Lower Crossover Frequency (≈ 8 to 9 Hz)

Fig. 2. Vibration Amplitude with Higher Crossover Frequency (≈ 57 to 62 Hz)