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**Environmental testing—Part 2 :
Test methods Test Fe : Vibration—
Sine-beat method**

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Foreword

This translation has been made based on the original Japanese Industrial Standard established by the Minister of Economy, Trade and Industry through deliberations at the Japanese Industrial Standards Committee according to the proposal of establishing a Japanese Industrial Standard from the Reliability Center for Electronic Components of Japan (RCJ)/ the Japanese Standards Association (JSA), with a draft of Industrial Standard based on the provision of Clause 1, Article 12 of the Industrial Standardization Law.

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In the event of any doubts arising as to the contents,
the original JIS is to be the final authority.

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Environmental testing—Part 2 : Test methods Test Fe : Vibration— Sine-beat method

Introduction This Japanese Industrial Standard has been prepared based on the first edition of **IEC 60068-2-59** *Environmental testing—Part 2 : Test methods Test Fe : Vibration—Sine-beat method* published in 1990 without modifying the technical contents.

Portions underlined with dots are the matters not stated in the original International Standard.

1 Scope This Standard details methods for testing components, equipments and other electrotechnical products (hereafter referred to as “specimens”) which in service can be subjected to pulsating or oscillating forces of short duration caused, for example, by seismic or explosive phenomena or by vibration in machinery.

In this test the specimen is excited at fixed frequencies with a preset number of sine beats (see attached figure 1). These fixed test frequencies are predetermined frequencies, critical frequencies identified by means of a sinusoidal vibration test (**IEC 60068-2-6**) or both. Pauses are provided between the individual sine beats in order to allow decay of the free response of the specimen. Specification writers will find in clause 12 a list of details to be considered for inclusion in specifications and, in annex A, the guidance.

1.1 Object To provide a standard procedure for determining, by the sine-beat method, the ability of a specimen to withstand specified severities of transient vibration.

1.2 General description The purpose of this test is to determine mechanical weakness and/or degradation in specified performance and to use this information, in conjunction with the relevant specification, to decide whether a specimen is acceptable or not. It may also be used, in some cases, to demonstrate the mechanical robustness of specimens and/or to study their dynamic behaviour.

The extent to which a specimen has to function during vibration or merely to survive conditions of vibration shall be stated in the relevant specification.

Procedures are described for conducting the test and for the measurement of the vibration at given points. The requirements for the vibration motion and for the choice of severities (including frequency range, test levels, sine-beat cycles and number of sine beats) are also detailed.

It is emphasized that vibration 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.

For the purpose of this test the specimen is always fastened to the vibration table.

In order to facilitate the use of this Standard, references are given in the main part where the reader is invited to refer to annex A; additionally the clause numbers in the main part are referred to in annex A which also gives specific information on the correlation between sine beats of displacement, velocity and acceleration.

This Standard is to be used in conjunction with **JIS C 0010**.

Remarks : The International Standard corresponding to this Standard is as follows.

In addition, symbols which denote the degree of correspondence in the contents between the relevant International Standard and **JIS** are IDT (identical), MOD (modified), and NEQ (not equivalent) according to **ISO/IEC Guide 21**.

IEC 60068-2-59 : 1990 *Environmental testing—Part 2 : Test methods Test Fe : Vibration—Sine-beat method* (IDT)

2 Normative references The following standards contain provisions which, through reference in this Standard, constitute provisions of this Standard. If the indication of the year of publishing is given to these referred standards, only the edition of indicated year constitutes the provision of this Standard but the revision and amendment made thereafter are not applied.

JIS C 0010 *Environmental testing Part 1 : General and guidance*

Remarks : **IEC 60068-1** : 1988 *Environmental testing—Part 1 : General and guidance Amendment 1* is identical with the said standard.

JIS C 0040 *Environmental testing Part 2 : Tests—Test Fe : Vibration (sinusoidal)*

Remarks : **IEC 60068-2-6** : 1995 *Environmental testing—Part 2 : Tests—Test Fe : Vibration (sinusoidal)* is identical with the said standard.

JIS C 0047 *Basic environmental testing procedures Part 2 : Tests Mounting of components, equipment and other articles for dynamic tests including shock (Ea), bump (Ed), vibration (Fc and Fd) and steady-state acceleration (Ga) and guidance*

Remarks : **IEC 60068-2-47** : 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* is identical with the said standard.

JIS C 0055 *Environmental testing—Part 3 : Guidance—Seismic test method for equipments*

Remarks : **IEC 60068-3-3** : 1991 *Environmental testing—Part 3 : Guidance, Seismic test methods for equipment* is identical with the said standard.

ISO 2041 : 1990 *Vibration and shock—Vocabulary*

3 Definitions The terms used are generally defined in **ISO 2041** and in **JIS C 0010** or **JIS C 0040**. Where, for the convenience of the reader, a definition from one of those sources is included here, the derivation is indicated. Departures from the definitions in those sources are also indicated.

The additional terms and definitions that follow are also applicable for the purpose of this Standard.

3.1 critical frequency (definition technically equivalent to that of **3.9** of **JIS C 0040**): Frequencies at which:

- malfunctioning and/or deterioration of performance of the specimen which are dependent on vibration are exhibited, and/or
- mechanical resonances and/or other response effects occur, for example chatter.

3.2 crossover frequency (definition technically equivalent to that of **ISO 2041**). That frequency at which the characteristic of a vibration changes from one relationship to another.

NOTE : For example, a crossover frequency may be that frequency at which the test vibration amplitude changes from a constant displacement value versus frequency to a constant acceleration value versus frequency.

3.3 damping (not identical with **ISO 2041** definitions): Damping is the generic term ascribed to the numerous energy dissipation mechanisms in a system. In practice, damping depends on many parameters, such as the structural system, mode of vibration, strain, applied forces, velocity, materials, joint slippage, etc.

3.3.1 critical damping: Minimum viscous damping that will allow a displaced system to return to its initial position without oscillation.

3.3.2 damping ratio: Ratio of actual damping to critical damping in a system with viscous damping.

3.4 distortion (not identical with **ISO 2041** definition):

$$\text{distortion } d = \sqrt{\frac{a_{\text{tot}}^2 - a_1^2}{a_1^2}} \cdot 100 (\%)$$

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)

Information : In **JIS C 0040 : 1995**, “signal tolerance” is specified instead of “distortion”.

3.5 fixing point (definition technically equivalent to that of **3.1** of **JIS C 0040**): 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.

3.6 “ g_n ” standard acceleration due to the earth’s gravity, which itself varies with altitude and geographical latitude.

NOTE : For the purpose of this Standard, the value of g_n is grounded up to the nearest whole number, that is 10 m/s².

Information : In Japan, SI Unit System is adopted and, therefore, this unit is not used in the Measurement Law, but this is remained here as it is.

3.7 measuring points (definition technically identical with that of 3.2 of JIS C 0040): Specific points at which data are gathered for conducting the test. These points are of two main types as defined below.

NOTE : Measurements may be made at points within the specimen in order to assess its behaviour; these are not considered as measuring points in the sense of this Standard.

3.7.1 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.

- NOTES 1 A number of check points are used as a means of ensuring that the test requirements are satisfied.
- 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.
 - 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.
 - 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.

3.7.2 reference point (definition technically identical with that of 3.2.2 of JIS C 0040): Point, chosen from the check points, whose signal is used to control the test, so that the requirements of this Standard are satisfied.

3.8 modulating frequency: Frequency with which the test frequency is modulated (see clauses A.2 and A.3 and attached figure 1).

3.9 high-stress cycles: Response cycles giving rise to values of stress which would cause fatigue in the specimen.

3.10 pause: Interval between two consecutive sine beats.

NOTE : A pause should be such as to result in no significant superposition of the response motion of the specimen and can be obtained from:

$$T > \frac{1}{f} \cdot \frac{100}{d}$$

where

T is the duration (s)

f is the test frequency (Hz)

d is the critical damping at the test frequency (in per cent).

3.11 preferred testing axes: Three orthogonal axes which correspond to the most vulnerable axes of the specimen.

3.12 sine beat: Continuous sinusoidal wave of one frequency which is modulated by a sinusoidal wave of a lower frequency. The duration of one sine beat is half the period of the modulating frequency (see attached figure 5).

NOTE : See clause A.2 for a mathematical explanation of the sine-beat signal.

3.13 sweep cycle (definition technically equivalent to that of clause 3 of JIS C 0040): Traverse of the specified frequency range once in each direction, for example 1 Hz to 35 Hz to 1 Hz.

3.14 test frequency: Frequency at which the specimen is to be excited during a test.

A test frequency is one of two types which are defined below.

3.14.1 predetermined test frequency: Frequency prescribed by the relevant specification.

3.14.2 investigated test frequency: Frequency obtained by a vibration response investigation.

3.15 test level: Largest peak value within a test wave.

NOTE : This is equal to or negligibly smaller than the peak value of the modulating half-wave.

4 Requirements for conditioning The requirements for a vibration response investigation are given in 4.1, those for sine-beat conditioning in 4.2 while 4.3 deals with mounting for conditioning. The tolerances applicable to the vibration response investigation and to sine-beat conditioning are compared in table 1.

Table 1 Comparison of tolerances

	Tolerance	
	Vibration response investigation	Sine-beat conditioning
Distortion	25 % (see 4.1.5) of basic motion	Not applicable
Vibration at reference point	± 15 % (see 4.1.6.1) of basic motion	
Vibration at check points	± 25 % up to 500 Hz (see 4.1.6.2) of acceleration ± 50 % above 500 Hz (see 4.1.6.2) of acceleration	
Transverse motion	50 % (see 4.1.2) or 25 % (for special cases)	25 % (see 4.2)
Test frequency	(See 4.1.7) ± 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	a) Predetermined (see 4.2.5.1) ± 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 b) Investigated (see 4.2.5.2): ± 2 %

4.1 Vibration response investigation When prescribed by the relevant specification, the vibration response investigation shall be carried out in a manner based on that of **JIS C 0040** particularly taking account of 4.1.1 to 4.1.8 below.

4.1.1 Basic motion The basic motion shall be a sinusoidal function of time and such that the fixing points of the specimen on the vibration table, which shall be prescribed by the relevant specification, move substantially in phase and in straight parallel lines, subject to the limitations imposed in 4.1.2, 4.1.3 and 4.1.5.

4.1.2 Transverse motion The maximum vibration at the check points in any axis perpendicular to the specified axis shall not exceed 50 % of the basic motion. In special cases, for example for a small specimen, the peak value of the permissible transverse motion may be limited to 25 % if prescribed by the relevant specification.

At some frequencies or with large size or high mass specimens, it may be difficult to achieve these values (see also clause A.1). In such cases, the relevant specification shall state which of the following applies:

- a) transverse motion in excess of that stated above shall be reported in the test report;
- b) transverse motion need not be monitored.

4.1.3 Rotational motion Where spurious rotational motion of the vibration table is likely to be important, a tolerable level, which shall then be reported in the test report, may be prescribed by the relevant specification.

4.1.4 Measuring points