



JAPANESE
INDUSTRIAL
STANDARD

Translated and Published by
Japanese Standards Association

JIS C 60068-2-80 : 2009

(RCJ/JSA)

**Environmental testing — Part 2-80 :
Tests — Test Fi : Vibration — Mixed
mode**

ICS 19.040 ; 29.020

Reference number : JIS C 60068-2-80 : 2009 (E)

PROTECTED BY COPYRIGHT

Date of Establishment: 2009-02-20

Date of Public Notice in Official Gazette: 2009-02-20

Investigated by: Japanese Industrial Standards Committee

Standards Board

Technical Committee on Electricity Technology

JIS C 60068-2-80 : 2009, First English edition published in 2009-08

Translated and published by: Japanese Standards Association
4-1-24, Akasaka, Minato-ku, Tokyo, 107-8440 JAPAN

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

© JSA 2009

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from the publisher.

Printed in Japan

PROTECTED BY COPYRIGHT

Contents

	Page
Introduction	1
1 Scope	1
2 Normative references	2
3 Terms and definitions	3
4 Requirements for testing	8
4.1 General	8
4.2 Control systems	9
4.3 Basic motion	9
4.4 Cross axis motion	9
4.5 Mounting	10
4.6 Measuring systems	10
5 Requirements for testing mixed mode	11
5.1 Vibration tolerances — Random	11
5.2 Vibration tolerances — Sine	15
5.3 Control strategy	16
5.4 Vibration response investigation	17
6 Severities	17
6.1 Broadband random vibration	18
6.2 Random narrowbands	18
6.3 Sine tones	19
7 Preconditioning	20
8 Initial measurements	20
9 Testing	20
9.1 General	20
9.2 Initial vibration response investigation	21
9.3 Low-level excitation for equalization prior to testing	22
9.4 Mixed mode testing	22
9.5 Final vibration response investigation	23
10 Intermediate measurements	23
11 Recovery	23
12 Final measurements	23
13 Information to be given in the relevant specification	24
14 Information to be given in the test report	24

Annex A (informative) Mixed mode general information 26

Annex B (informative) Guidance 32

Annex JA (informative) Comparison table between JIS and the correspond-
ing International Standard 40

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 for establishment of Japanese Industrial Standard submitted by Reliability Center for Electronic Components of Japan (RCJ) / Japanese Standards Association (JSA) with the draft being attached, based on the provision of Article 12 Clause 1 of the Industrial Standardization Law.

This **JIS** document is protected by the Copyright Law.

Attention is drawn to the possibility that some parts of this Standard may conflict with a patent right, application for a patent after opening to the public, utility model right or application for registration of utility model after opening to the public which have technical properties. The relevant Minister and the Japanese Industrial Standards Committee are not responsible for identifying the patent right, application for a patent after opening to the public, utility model right or application for registration of utility model after opening to the public which have the said technical properties.

JIS C 60068-2 consists of the following 47 parts under the general title “*Environmental testing, (or Basic environmental testing procedures) Tests*”:

- Part 2-1 Tests A : Cold*
- Part 2-2 Test B : Dry heat*
- Part 2-6 Test Fc : Vibration (sinusoidal)*
- Part 2-7 Test Ga and guidance : Acceleration, steady state*
- Part 2-11 Test Ka : Salt mist*
- Part 2-13 Test M : Low air pressure*
- Part 2-17 Test Q : Sealing*
- Part 2-18 Test R and guidance : Water*
- Part 2-20 Test T : Soldering*
- Part 2-21 Test U : Robustness of termination and integral mounting devices*
- Part 2-27 Test Ea and guidance : Shock*
- Part 2-29 Test Eb and guidance : Bump*
- Part 2-30 Test Db : Damp heat, cyclic (12 + 12-Hour cycle)*
- Part 2-31 Test Ec : Drop and topple, primarily for equipment-type specimens*
- Part 2-32 Test Ed : Free fall*
- Part 2-38 Test Z/AD : Composite temperature / humidity cyclic test*
- Part 2-39 Test Z/AMD : Combined sequential cold, low air pressure, and damp heat test*
- Part 2-40 Test Z/AM : Combined cold / low air pressure tests*
- Part 2-41 Test Z/BM : Combined dry heat/low air pressure tests*
- Part 2-42 Test Kc : Sulphur dioxide test for contacts and connections*
- Part 2-43 Test Kd : Hydrogen sulphide test for contacts and connections*

- Part 2-45 Electronic and electrical resistance to solvents (immersion in cleaning solvents)*
- Part 2-46 Guidance to Test Kd : Hydrogen sulphide test for contacts and connections*
- Part 2-47 Mounting of specimens for vibration, impact and similar dynamic tests*
- Part 2-48 Guidance on the application of the tests of JIS environmental testing series to simulate the effects of storage*
- Part 2-49 Guidance to test Kc : Sulphur dioxide test for contacts and connections*
- Part 2-50 Tests Z/AFc : Combined cold / vibration (sinusoidal) tests for both heat-dissipating and non-heat-dissipating specimens*
- Part 2-51 Tests Z/BFc : Combined dry heat/vibration (sinusoidal) tests for both heat-dissipating and non-heat-dissipating specimens*
- Part 2-52 Test Kb : Salt mist, cyclic (sodium, chloride solution)*
- Part 2-53 Guidance to tests Z/AFc and Z/BFc : Combined temperature (cold and dry heat) and vibration (sinusoidal) tests*
- Part 2-54 Test Ta : Soldering. Solderability testing by the wetting balance method*
- Part 2-57 Electrotechnical products — Time-history vibration test method*
- Part 2-58 Test Td : Test methods for solderability, resistance to dissolution of metallization and to soldering heat of surface mounting devices (SMD)*
- Part 2-59 Test Fe : Vibration — Sine-beat method*
- Part 2-60 Test Ke : Flowing mixed gas corrosion test*
- Part 2-61 Test Z/ABDM : Climatic sequence*
- Part 2-64 Tset Fh : Vibration, broad-band random (digital control) and guidance*
- Part 2-65 Vibration, acoustically induced*
- Part 2-66 Test Cx : Damp heat, steady state (unsaturated pressurized vapour)*
- Part 2-67 Test Cy : Damp heat, steady state, accelerated test primarily intended for components*
- Part 2-68 Electrotechnical products — Dust and sand test*
- Part 2-70 Test Xb : Abrasion of markings and letterings caused by rubbing of fingers and hands*
- Part 2-75 Test Eh : Hammer tests*
- Part 2-77 Test 77 : Body strength and impact shock*
- Part 2-78 Test Cab : Damp heat, steady state*
- Part 2-80 Test Fi : Vibration — Mixed mode*
- Part 2-81 Shock — Shock response spectrum synthesis*

Environmental testing — Part 2-80 : Tests —

Test Fi : Vibration — Mixed mode

Introduction

This Japanese Industrial Standard has been prepared based on the first edition of **IEC 60068-2-80** published in 2005 with some modifications of the technical contents to resolve the inadequacies that were found in the corresponding International Standard (such as use of important terms without giving them a definition).

The portions given dotted underlines are the matters in which the contents of the corresponding International Standard have been modified. A list of modifications with explanations is given in Annex JA.

This method for mixed mode vibration testing requires the digital control of broadband random vibrations and techniques associated with the combination of sinusoidal vibration and/or specified narrowband random with a broadband random background.

This Standard is intended for general application to components, equipment and other products, when simulation is required of broadband responses of a complex nature for the specimens.

The test method is based primarily on the use of an electrodynamic or a servo-hydraulic vibration generator with an associated computer based control system used as a vibration testing system.

It is emphasized that mixed mode 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 aiding the understanding of the users of this Standard, particularly the writer of the relevant specification and the test engineers, information on mixed mode and information on random vibration of the mixed mode signals are given in Annexes A and B, respectively.

1 Scope

This Standard specifies the test method for mixed mode vibration.

The purpose of the test is to demonstrate the adequacy of components, equipment and other products (hereafter referred to as "specimens") to resist the specified mixed mode excitation without unacceptable degradation of its functional and/or structural performance. It is particularly useful for tailoring mixed mode environments where measured data are available for the real life environment.

The test also helps reveal the accumulated effects of stress induced by random vibration, mixed with sine and/or random, and the resulting mechanical weakness and degradation in specified performances, 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.

This Standard is applicable to specimens which may be subjected to vibration of a random and/or a combination of random and deterministic nature resulting from transportation or real life environments, for example in aircraft, space vehicles and for items in their transportation container when the latter may be considered as part of the specimen itself.

Although primarily intended for electrotechnical specimens, this Standard is not restricted to such specimens and may be used in other fields where desired.

NOTE : The International Standard(s) corresponding to this Standard and the symbol of degree of contents are as follows :

IEC 60068-2-80 : 2005 *Environmental testing — Part 2-80 : Tests — Test Fi : Vibration — Mixed mode* (MOD)

The 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**.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this Standard. For standards with the year indication, only the editions of the indicated year shall apply but the revisions (including amendments) made thereafter shall not apply

JIS B 0153 : 2001 *Glossary of terms used in mechanical vibration and shock*

NOTE : Corresponding International Standard : **ISO 2041** : 1990 *Vibration and shock — Vocabulary* (MOD)

JIS C 60068-1 : 1993 *Environmental testing Part 1 : General and guidance*

NOTE : Corresponding International Standard : **IEC 60068-1** : 1988 *Environmental testing — Part 1 : General and guidance* (IDT)

JIS C 60068-2-6 : 1999 *Environmental testing Part 2 : Tests — Test Fc : Vibration (sinusoidal)*

NOTE : Corresponding International Standard : **IEC 60068-2-6** : 1995 *Environmental testing — Part 2-6 : Tests — Test Fc : Vibration (sinusoidal)* (IDT)

JIS C 60068-2-47 : 2008 *Environmental testing — Part 2-47 : Tests — Mounting of specimens for vibration, impact and similar dynamic tests*

NOTE : Corresponding International Standard : **IEC 60068-2-47** : 1999 *Envi-*

ronmental testing — Part 2-47 : Test methods — Mounting of components, equipment and other articles for vibration, impact and similar dynamic tests (IDT)

JIS C 60068-2-64 : 1997 *Environmental testing Part 2 : Test methods — Test Fh :*

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

NOTE : Corresponding International Standard : **IEC 60068-2-64** : 1993 *Environmental testing — Part 2-64 : Test methods — Test Fh : Vibration, broadband random (digital control) and guidance (IDT)*

JIS C 60068-3-8 : 2006 *Environmental testing — Part 3-8 : Supporting documentation and guidance — Selecting amongst vibration tests*

NOTE : Corresponding International Standard : IEC 60068-3-8 : 2003 *Environmental testing — Part 3-8 : Supporting documentation and guidance — Selecting amongst vibration tests (IDT)*

IEC 60050-300 : 2001 *International Electrotechnical Vocabulary— Electrical and electronic measurements and measuring instruments—*

Part 311 : General terms relating to measurements

Part 312 : General terms relating to electrical measurements

Part 313 : Types of electrical measuring instruments

Part 314 : Specific terms according to the type of instrument

IEC 60068-5-2 : 1990 *Environmental testing. Part 5 : Guide to drafting of test methods — Terms and definitions*

3 Terms and definitions

For the purpose of this Standard, the terms and definitions in **JIS B 0153**, **JIS C 60068-1**, **JIS C 60068-2-6**, **JIS C 60068-2-64**, **IEC 60050-300** and **IEC 60068-5-2** and the following apply.

3.1 cross axis motion

motion not in the direction of the external stimulus, generally specified in the two orthogonal axes

3.2 actual motion

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

3.3 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 are taken as those of the mounting structure and not of the specimen.

3.4 control point

point used for controlling the test, by either of the two methods defined below

It can be also referred to as the reference point (see 3.6.2) or fictitious reference point (see 3.6.3).

3.4.1 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

3.4.2 multipoint control

control method 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 also 3.9).

3.5 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, i.e. 10 m/s².

3.6 measuring points

specific points at which data are gathered for conducting the test

These points are of three types, as defined below.

3.6.1 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. 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 a number of 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.

3.6.2 reference point

point, chosen from the check points, signal of which is used to control the test, such

that the requirements of this Standard are satisfied

3.6.3 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

3.6.4 response points

specific points on the specimen from which data is gathered for the purpose of the vibration response investigation

NOTE : These points are not check or reference points.

3.7 preferred testing axes

three orthogonal axes that correspond to the most vulnerable axes of the specimen

3.8 sampling frequency

number of discrete magnitude values taken per second to record or represent a time-history in a digital form

3.9 multipoint control strategies

method for calculating the reference control signal when using multipoint control (see also 3.4.2)

The following frequency domain control strategies are available.

3.9.1 averaging

process of determining the control value as the arithmetic average of the signal value (see also 3.31) of each frequency at more than one check point

3.9.1A weighted averaging

process of determining the reference control signal by averaging the signal value (see 3.31) from two or more check points according to their weighting (see 5.3.1.2)

3.9.2 extremal

process of determining the control value as the maximum or minimum of the signal value (see also 3.31) of each frequency from each check point

3.10 MAX

random-on-random severities in order to define the ASD (see 3.14) value of the narrow bands

MAX means the maximum of either the background or narrow band ASD values.

3.10A SUM

random-on-random severities in order to define the ASD (see 3.14) value of the narrow bands

SUM means adding the background and narrow band ASD values.

3.11 crest factor

ratio of the peak value to the r.m.s. value of the complex mixed-mode waveform (see JIS B 0153)

3.12 super positional strategy

strategy which defines the method for calculating the reference acceleration spectral density at each frequency line from the sine tones and the random ASD

3.13 – 3 dB bandwidth, B

frequency bandwidth between two points in a frequency response function which is 0.708 of the maximum response when associated with a single resonance peak

3.14 acceleration spectral density, ASD

mean-square value of that part of an acceleration signal passed by a narrowband filter of a centre frequency, per unit bandwidth, to the extent that the bandwidth approaches zero and the averaging time approaches infinity

3.15 bias error

for the random signal, systematic error in the estimate of the acceleration spectral density due to the finite frequency resolution used in practice

For the sinusoidal signal, systematic error in the estimate of the amplitude of the sinusoidal component within the mixed mode signal due to the averaging time.

3.16 control acceleration spectral density

acceleration spectral density measured at the reference point or the fictitious point

3.17 control system loop

sum of the following actions :

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

3.18 drive signal clipping

limitation of the maximum value of the drive signal, expressed as a crest factor

3.19 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 also figure 1)

3.20 error acceleration spectral density

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

3.21 equalization

minimization of the error acceleration spectral density

3.22 final slope

part of the specified acceleration spectral density above f_2 (see also figure 1)

3.23 frequency resolution

width of the frequency intervals in the acceleration spectral density in hertz

NOTE : It is equal to the reciprocal of the length of each of the samples into which the record is partitioned in order to calculate the indicated acceleration spectral density in digital analysis. The number of frequency lines is equal to the number of intervals in a given frequency range.

3.24 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

3.25 initial slope

part of the specified acceleration spectral density below f_1 (see also figure 1)

3.26 instrument error

error associated with each analogue item of the input to the control system and control system analogue items

3.27 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

3.28 record

collection of equally spaced data points in the time domain that are used in the calculation of the fast Fourier transform

3.29 reproducibility

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 (see also IEC 60050-300).

3.30 root-mean-square value

the root-mean-square value (r.m.s. value) of a flat spectrum over an interval between f_1 and f_2 (see figure 1), is the square root of the average of the squared values of the function over the interval

NOTE : In this test method, the r.m.s. values of acceleration, velocity and displacement can be calculated for the random content only or for the mixed mode Sine on Random (SoR) and Random on Random (RoR) (see B.2.4).

3.31 signal value

for the random component of the mixed mode signal, it refers to the acceleration spectral density value and for the sinusoidal component of the mixed mode signal, it refers to the amplitude value

3.32 standard deviation σ

root-mean-square deviation of the values from their mean

In vibration theory, the mean value of vibration is equal to zero. Therefore for a random time history, the standard deviation is equal to the r.m.s. value.

3.33 statistical accuracy

ratio of true acceleration spectral density to indicated acceleration spectral density

NOTE : Refers to the random portion only of the mixed mode signal.

3.34 statistical degrees of freedom

number of independent variables when a certain quantity is estimated (see JIS B 0153)

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

3.35 sweep cycle

traverse of the specified frequency range once in each direction (see JIS C 60068-2-6)

Example : 5 Hz $\rightarrow$ 500 Hz $\rightarrow$ 5 Hz

NOTE : In contrast to 'sweep cycle' one sweep denotes a sweep in one direction only, either up or down.

3.36 sweep rate

rate at which the sinusoidal frequency is varied, either in octaves per minute or hertz per second

3.37 true acceleration spectral density

acceleration spectral density of the random waveform acting on the specimen

4 Requirements for testing

4.1 General

The characteristics apply to the complete vibration testing system, which for an electro-dynamic and a servo-hydraulic testing system includes the power amplifier, vibrator and loaded test fixture and control system.

The basic and cross axis motions described below shall be checked either before starting the test or during testing by using an additional input monitor channel of the controller. The relevant specification shall state the investigation test levels and procedures to be used.

The standardized test method consists of the following test sequence and shall be applied in each of the mutually perpendicular axes of the test specimen :

- a) An initial vibration response investigation, with low level sinusoidal or random excitation (see also 5.4 and 9.2).
- b) The mixed mode excitation as the load or stress test.
- c) A final vibration response investigation (see also 5.4 and 9.5) to compare the results with the initial one and to detect possible mechanical failures due to a change of the dynamic behaviour.

However, the relevant specification may renounce the requirement for a response investigation, or part thereof, if the dynamic behaviour of the test specimen is known or not of interest.

4.2 Control systems

Special software control packages are required for the control system which have the capability of analysing and controlling tests where a mixture of random on random or sine on random excitations / specifications is required.

4.3 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. If substantially identical motions are difficult to achieve, then multipoint control shall be used.

The characteristics of the basic motion shall be nominally a Gaussian distribution for the random waveform and sinusoidal for the periodic components.

4.4 Cross axis motion

Cross axis motion should be checked either before the test is applied by conducting a sine or random investigation at a level prescribed by the relevant specification or during testing by utilizing an additional monitoring channel.

The signal value of each frequency at the check points in any axis perpendicular to the specified axis shall not exceed the specified signal values above 500 Hz and below 500 Hz shall not exceed – 3 dB of the specified signal values. The total r.m.s. acceleration in any axis perpendicular to the specified axis shall not exceed 50 % of the r.m.s. value for the specified axis. For example for a small specimen, the signal value of the permissible cross motion may be limited such that it does not exceed – 3 dB of the basic