IEC 60068-2-85

Edition 1.0 2019-06

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Environmental testing –
Part 2-85: Tests – Test Fj: Vibration – Long time history replication

Essais d'environnement –
Partie 2-85: Essais – Essai Fj: Vibrations – Reproduction dans le temps par accélérogrammes

IEC 60068-2-85:2019-06(en-fr)

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CONTENTS

FOREWORD 3
INTRODUCTION 5
1 Scope 6
2 Normative references 6
3 Terms and definitions 7
4 Requirements for test apparatus 9
4.1 General 9
4.2 Basic motion 9
4.3 Cross-axis motion 9
4.4 Mounting 10
4.5 Measuring systems 10
5 Severities 10
6 Preconditioning 10
7 Initial measurements and functional performance test 10
8 Testing 10
8.1 General 10
8.2 Initial vibration response investigation 11
8.3 Low-level excitation for equalization prior to testing 12
8.4 Testing with specimen functioning 12
8.5 Final vibration response investigation 12
9 Recovery 12
10 Final measurements and functional performance 13
11 Information to be given in the relevant specification 13
12 Information to be given in the test report 13
Annex A (informative) Guidance 15
A.1 General 15
A.2 Requirements for testing 15
A.2.1 Single-point control 15
A.2.2 Controlled input testing 16
A.2.3 Controlled response testing 16
A.2.4 Verification parameters 16
A.3 Testing procedures 18
A.4 Equipment normally used with vibration isolators 18
A.4.1 Transmissibility factors for isolators 18
A.4.2 Temperature effect 18
A.5 Test severities 18
A.6 Equipment performance 18
A.7 Initial and final measurements 19
A.8 Frequency range 19
Bibliography 21

INTERNATIONAL ELECTROTECHNICAL COMMISSION

ENVIRONMENTAL TESTING –

**Part 2-85: Tests – Test Fj: Vibration –
Long time history replication**

FOREWORD

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International Standard IEC 60068-2-85 has been prepared by IEC technical committee 104: Environmental conditions, classification and methods of test.

The text of this International Standard is based on the following documents:

FDIS	Report on voting
104/833/FDIS	104/840/RVD

Full information on the voting for the approval of this International Standard can be found in the report on voting indicated in the above table.

This document has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts in the IEC 60068 series, published under the general title *Environmental testing*, can be found on the IEC website.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

INTRODUCTION

This first edition of IEC 60068-2-85 was initiated in 2008 and a first proposal was prepared in 2011. It was developed out of the existing standard IEC 60068-2-64:2008 which contains a technically similar test method and modified accordingly. This facilitates usage and maintenance of both standards.

Differences are that this document relies on a specified time history. A test spectrum is not specified.

This part of IEC 60068 deals with long time history replication vibration testing intended for general application to components, equipment and other products, hereinafter referred to as ”specimens”, that may be subjected to vibrations of an arbitrary nature not covered by the other existing methods for vibration testing. The methods and techniques in this document are based on digital control of vibration in the time domain which allow a more flexible definition of the vibration input signal to suit individual cases that are specified in the relevant specification.

Compared with most other tests, test Fj is based on deterministic techniques, and the time history is supposed to have a long duration. There are nearly no restrictions to the vibration characteristics besides the technical limitations of the test apparatus.

As the vibration input signal in this test is specified by a digital time history stored in a file, there are no general methods for comparing two different test severities. The vibration tolerances cannot be given in a single measure, as this depends on the purpose of the test. Therefore, it is emphasized that long time history replication testing always demands a high degree of engineering judgement by the user and specifier. The writer of the relevant specification is expected to select the testing procedure, test time history and its severity, tolerances and analysis methods, appropriate to the specimen and its use.

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.

Long time history replication vibration testing can be used to identify accumulated stress effects and the resulting mechanical weakness and degradation in the specified performance. This information, in conjunction with the relevant specification, can be used to assess the acceptability of specimens.

If the specimens are subjected to vibration of a deterministic transient or periodic nature resulting from transportation or real life environments that are covered by other test methods, these are generally preferred. See IEC 60068-3-8 [1][1] for estimating the dynamic vibration environment of the specimen and based on that, selecting the appropriate test method.

Annex A provides guidance and a list of details that can be considered for inclusion in specifications.

[1] Numbers in square brackets refer to the bibliography.

ENVIRONMENTAL TESTING –

Part 2-85: Tests – Test Fj: Vibration – Long time history replication

1 Scope

This part of IEC 60068 demonstrates the adequacy of specimens to resist dynamic loads without unacceptable degradation of its functional and/or structural integrity when subjected to the specified vibration test requirements as defined by a time history (long time history replication). These can either be recorded in measurement exercises or generated artificially. In both cases, this method allows for generating a test tailored to very specific applications.

Typical applications are tests in which very specific deterministic transient, periodical or random excitation is necessary and the characteristics of the motion are not covered by other test standards. This includes time histories not sufficiently represented by the standard shock tests of IEC 60068-2-27 [2] or a general description by a shock response spectrum as in IEC 60068-2-81 [3], periodical vibration that is not covered by a sinusoidal waveform as in IEC 60068-2-6, and random vibration that is not covered by the description of Gaussian or non-Gaussian (high kurtosis) broad-band random vibration of IEC 60068-2-64. However, the user is made aware that long time history replication uses a deterministic time history. Simulation of random vibration of any kind is approximated by quasi-random.

In addition, additional mixed mode tests are possible with this test method by generating time histories that are representations of the required test signals. This includes tests of high complexity.

The purpose of this test is different from IEC 60068-2-57 [4]. The purpose of IEC 60068-2-57 is an evaluation for a transient vibration using mainly a synthesized time history. A long time history test is mainly used for a durability and functionality test using an actual time history measured in a real field environment. It can also be used as a method to apply a simulated non-gaussian time history.

This document is applicable to specimens which can be subjected to vibration of a very specific nature resulting from transportation or operational environments, for example in aircraft, space vehicles and land vehicles. It is primarily intended for unpackaged specimens, and for items in their transportation container when the latter can be considered as part of the specimen itself. 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. This document can be used in conjunction with IEC 60068-2-47, for testing packaged products.

Although primarily intended for electrotechnical specimens, this document is not restricted to them and can be used in other fields where desired (see Annex A).

This document is applicable for single axis excitation.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 60068-2-6, *Environmental testing – Part 2-6: Tests – Test Fc: Vibration (sinusoidal)*

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

IEC 60068-2-64:2008, *Environmental testing – Part 2-64: Tests – Test Fh: Vibration, broadband random and guidance*

3 Terms and definitions

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

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

NOTE The terms used are generally defined in IEC 60050-300 [5], IEC 60068-1 [6], IEC 60068-2-6, and IEC 60068-5-2 [7] and ISO 2041 [8].

3.1
cross-axis motion
motion not in the direction of the stimulus, generally specified in the two axes orthogonal to the direction of the stimulus

Note 1 to entry: The cross-axis motion should be measured close to the fixing points.

[SOURCE: IEC 60068-2-64:2008, 3.1]

3.2
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 to entry: 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.

[SOURCE: IEC 60068-2-64:2008, 3.3]

3.3
measuring points
specific points at which data are gathered for conducting the test

Note 1 to entry: These points are of three types, as defined in 3.4 to 3.6.

[SOURCE: IEC 60068-2-64:2008, 3.6]

3.4
checkpoint
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

[SOURCE: IEC 60068-2-64:2008, 3.7, modified – The notes to entry have been deleted.]

3.5
control point
point, chosen from amongst the checkpoints, whose signal is used to control the test, such that the requirements of IEC 60068-2-85 are satisfied

[SOURCE: IEC 60068-2-64:2008, 3.8, modified – The term “reference point (single-point control)” has been replaced with "control point" and in the definition "this standard" has been replaced with "IEC 60068-2-85".]

3.6
response points
specific points on the specimen from which data is gathered for the purpose of the vibration response investigation

Note 1 to entry: These points are not the same as checkpoints or control points.

[SOURCE: IEC 60068-2-64:2008, 3.10]

3.7
preferred testing axes
three orthogonal axes that correspond to the most vulnerable axes of the specimen

[SOURCE: IEC 60068-2-64:2008, 3.11]

3.8
specified time history
data file containing digital acceleration values varying with time to be replicated during the test

Note 1 to entry: The specified time history is usually based on recorded ‘real life’ digitized data, properly modified (e.g. filtered) for reproducibility on a shaker.

3.9
control time history
time history measured at the control point simulating the specified time history

3.10
error time history
difference between the specified time history and the control time history

3.11
equalization
minimization of the RMS of error time history

3.12
RMS value
root-mean-square value
square root of the average of the squared values of all functions over the total frequency interval f_1 and f_2

[SOURCE: IEC 60068-2-64:2008, 3.33, modified – The definition has been simplified.]

3.13
test frequency range
frequency range to use for processing control, as given in the relevant specification

3.14
probability density function
at a specified amplitude, ratio of the probability that the amplitude will be within a given incremental range, to the size of the incremental range

3.15
maximum response spectrum
curve giving the value of the highest peak of the response of a linear single degree of freedom system (SDOF system) to vibration, according to its natural frequency, for a given damping ratio

Note 1 to entry: The response is described by the relative movement of the mass of this system in relation to its support.

3.16
fatigue damage spectrum
FDS
spectrum obtained by tracing the fatigue damage experienced by a linear single degree of freedom system (SDOF) according to its natural frequency, for a given damping ratio and for a given value of parameter b

Note 1 to entry: Parameter b comes from the Basquin law representing the Wöhler curve of the material constituting the structure.

Note 2 to entry: This note applies to the French language only.

4 Requirements for test apparatus

4.1 General

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.

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

1) an initial vibration response investigation, with low level sinusoidal excitation, or low level random excitation, (see 8.2 and Clause A.1);
2) the long time history replication as the mechanical load or stress test;
3) a final vibration response investigation to compare the results with the initial one and to detect possible mechanical failures due to a change of the dynamic behaviour (see 8.2 and 8.5).

Where the dynamic behaviour is known, and it is not considered relevant, or sufficient data can be gathered during the test at full level, the relevant specification may not require pre and post test vibration response investigations.

4.2 Basic motion

The basic motion of the fixing points of the specimen shall be specified by the relevant specification. The fixing points shall have substantially identical motions in phase and amplitude and shall be rectilinear relative to the direction of excitation.

4.3 Cross-axis motion

Cross-axis motion shall be checked, if required by the relevant specification, either before the test is applied by conducting a sine or random investigation at a level specified by the relevant specification, or during testing by utilizing additional monitoring channels in the two perpendicular axes.

The maximum cross axis amplitude at the control point shall not exceed 50 % of the value of the specified axis. With large-size or high mass specimens it may be difficult to achieve this requirement. In such cases, the relevant specification shall state which of the following requirements applies:

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

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

4.4 Mounting

The specimen shall be mounted in accordance with IEC 60068-2-47.

4.5 Measuring systems

The characteristics of the measuring system shall be such that it can be determined whether the value of the vibration as measured in the intended axis at the control point is within the tolerance required for the test.

The frequency range for long time history replication needs to extend to higher frequencies than the conventional vibration test.

The frequency response of the overall measuring system, which includes the transducer, the signal conditioner and the data acquisition and processing device, has a significant effect on the accuracy of the measurements. The frequency response of the measuring system shall be flat within ±5 % over the test frequency range. Outside of this range any further deviation shall be stated in the test report. See Clause A.8.

5 Severities

The parameters for this test shall be based on the purpose for which it is being conducted and on the conditions the equipment is likely to experience in-service. Test time history is normally based on measured data derived from in-service conditions and usage. The time history may be edited to make it suitable for the system to handle. The test parameters may contain the number of repetitions of the time history, as long as fulfilling the intended purpose of the test is not endangered by the modifications.

6 Preconditioning

If the relevant specification calls for preconditioning it shall then specify the conditions.

7 Initial measurements and functional performance test

The specimen shall be submitted to visual, dimensional and functional and any other checks as specified by the relevant specification.

8 Testing

8.1 General

Testing follows the sequence specified by the relevant specification. The different steps are as follows:

– initial vibration response investigation, if specified;
– low-level excitation for equalization before proceeding to the full level test in one continuous mode;
– long time history replication;
– final vibration response investigation, if specified.

The specimen shall be excited in each of the preferred testing axes in turn, unless otherwise specified by the relevant specification. The order of the testing along these axes is not important, unless specified by the relevant specification. If the specimen is sensitive to gravity, for example a mercury tilt switch, then vibration may only be applied in its normal service position and shall be specified by the relevant specification.

Special action is necessary when a specimen normally intended for use with vibration isolators needs to be tested without them. See Clause A.3 and Clause A.4. See also IEC 60068-2-47.

8.2 Initial vibration response investigation

The relevant specification may specify a vibration response investigation in each axis either before, or both before and after long time history replication testing.

When specified in the relevant specification, the dynamic response for at least one point on the specimen in the defined frequency range shall be investigated. The number and position of the response points shall be clearly defined in the relevant specification. The vibration response investigation may be performed with sinusoidal or random vibration in a test frequency range and with a test level as specified by the relevant specification. Reference shall be made to IEC 60068-2-6 for sinusoidal vibration and to IEC 60068-2-64 for random vibration excitation. Also see IEC 60068-3-8 for more information and the advantages and disadvantages of each method.

The response investigation shall be carried out with a test level selected so that the response of the specimen remains less than during long time history replication but at a sufficiently high level to detect critical frequencies.

When sinusoidal excitation is used, at least one sweep cycle over the test frequency range specified by the relevant specification shall be performed with an acceleration amplitude ≤ 10 m/s^2 or a displacement amplitude of ± 1 mm, whichever is less. The vibration amplitude shall be adapted in order to prevent a higher stress on the specimen than during long time history replication. A sweep rate of one octave per minute shall be applied to determine the frequencies and amplitudes of the resonances. If there is concern about exciting the structure to a full resonance then a faster sweep rate may be applied as an indication of frequency and relative amplitude of the resonance within the frequency band of interest. Investigations at slower sweep rates or sweeping back and forth around a known resonance may be required but shall be limited to the minimum time to obtain the results required. Undue dwell time is to be avoided. The vibration amplitude may be varied as required.

In the case of sinusoidal excitation, it should be remembered that, in the case of non-linear behaviour, the frequency corresponding to the maximum response will change depending on the direction of the frequency variation during the sweep. For random excitation non-linearities can influence the resonance behaviour. For sinusoidal and random excitation, the amplification at resonances may be dependent on the magnitude of the input vibration.

The response investigation with random vibration shall be carried out taking into account that the time of the test shall be long enough to minimize stochastical variations in the response. A random vibration response test shall be carried out over the specified test frequency range. At the lowest resonance frequency there shall be a minimum of five spectral lines within the frequency band at –3 dB of the resonance peak.

When random excitation is used, the RMS value of acceleration shall be selected in order to prevent a higher stress on the specimen of not more than 25 % of that during long time history replication. The duration shall be as short as possible, but at least long enough to make an analysis with degrees of freedom (DOF) = 120 possible. If the resonance response is observed and documented periodically during the full level test, special resonance investigations are not necessary.

The specimen shall be in functioning mode during this investigation if required by the relevant specification. Where the mechanical vibration characteristics cannot be assessed because the specimen is functioning, an additional vibration response investigation with the specimen not