

Environmental testing —

Part 2-57: Tests — Test Ff: Vibration — Time-History method

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European Committee for Electrotechnical Standardization
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Foreword

The text of document 104/130/FDIS, future edition 2 of IEC 60068-2-57, prepared by IEC TC 104, Environmental conditions, classification and methods of test, was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as EN 60068-2-57 on 2000-01-01.

This European Standard supersedes EN 60068-2-57:1993.

The following dates were fixed:

- latest date by which the EN has to be implemented
at national level by publication of an identical
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- latest date by which the national standards conflicting
with the EN have to be withdrawn (dow) 2003-01-01

This standard is intended to be used in conjunction with EN 60068-1:1994.

Annexes designated "normative" are part of the body of the standard.

Annexes designated "informative" are given for information only.

In this standard, annex ZA is normative and annexes A and B are informative.

Annex ZA has been added by CENELEC.

Endorsement notice

The text of the International Standard IEC 60068-2-57:1999 was approved by CENELEC as a European Standard without any modification.

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INTRODUCTION

This part of IEC 60068 details a method for testing components, equipment and other electrotechnical products, hereinafter referred to as "specimens", which in service can be subjected to short-duration random-type dynamic forces of which typical examples are the stresses induced in equipment as a result of earthquakes, explosions and during transport and operation of different kinds of vehicles.

The characteristics of these forces and the damping of the specimen may be such that the vibration response of the specimen will not reach a steady-state condition.

The test consists, after any preliminary vibration response investigation with sinusoidal or random vibration has been performed, of subjecting the specimen to a vibration time-history specified by a response spectrum with characteristics simulating the effects of the dynamic forces.

A time-history may be developed or obtained from:

- a natural event (natural time-history);
 - a random sample, or
 - a synthesized signal.
- } artificial time-history

In general, some modification is necessary in order to adapt to the required testing severity.

The use of a time-history allows a single test wave to envelop a broadband response spectrum.

It is possible for all the modes of the specimen in the excitation axis (or axes) to be excited at the same time and consequently the stresses derived from the combined effects of the coupled modes are generally taken into account.

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, that is frequency range, required response spectrum, number of high-peaks of the response and number and duration of time-histories, are also detailed.

Specification writers will find in clause 13 a list of details to be considered for inclusion in specifications, in annex A, on the guidance, and in annex B, on recommended test frequency ranges.

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.

ENVIRONMENTAL TESTING –

Part 2-57: Tests – Test Ff: Vibration – Time-history method

1 Scope and object

This part of IEC 60068 aims to provide a standard procedure for determining, by the time-history method, the ability of a specimen to withstand specified severities of transient vibration.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of IEC 60068. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this part of IEC 60068 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of IEC and ISO maintain registers of currently valid International Standards.

IEC 60068-1:1988, *Environmental testing – Part 1: General and guidance*

IEC 60068-2-6:1995, *Environmental testing – Part 2: Tests – Test Fc: Vibration (sinusoidal)*

IEC 60068-2-27:1987, *Environmental testing – Part 2: Tests – Test Ea and guidance: Shock*

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*

IEC 60068-2-64:1993, *Environmental testing – Part 2: Tests – Test Fh: Vibration, broad-band random (digital control) and guidance*

IEC 60068-3-3:1991, *Environmental testing – Part 3: Guidance – Seismic test methods for equipment*

ISO 266:1997, *Acoustics – Preferred frequencies*

ISO 2041:1990, *Vibration and shock – Vocabulary*

3 Definitions

For the purpose of this part of IEC 60068, the terms and definitions given in ISO 2041, IEC 60068-1, IEC 60068-2-6, IEC 60068-2-64 and the following apply.

3.1

critical frequency

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

damping

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

critical damping

minimum viscous damping that will allow a displaced system to return to its initial position without oscillation in the shortest time possible

3.4

damping ratio

ratio of actual damping to critical damping in a system with viscous damping

3.5

signal tolerance

signal tolerance:
$$T = \left(\frac{NF}{F} - 1 \right) \times 100 \quad (\text{in percentage})$$

where

NF is the r.m.s. value of the unfiltered signal;

F is the r.m.s. value of the filtered signal.

3.6

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 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.

3.7

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 rounded up to the nearest whole number, that is, 10 m/s².

3.8

high peaks of the response

calculated peaks of the response of a single-degree-of-freedom system (oscillator), excited by a time-history, exceeding a specified threshold value (see figure 2)

NOTE 1 In practice, reference is made to high peaks of the response since it is difficult to identify complete response cycles due to a transient excitation (time-history).

NOTE 2 The peak is a positive or a negative maximum deviation from the zero-line between two consecutive zero-crossing points (see figure 3).

3.9**measuring points**

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.

3.9.1**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.

3.9.2**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

3.10**natural frequency**

frequency of free vibration of a structure depending only on its own physical characteristics (mass, stiffness and damping)

3.11**natural time-history**

recording, as a function of time, of for example acceleration, velocity or displacement, resulting from a given event

3.12**oscillator**

single-degree-of-freedom system intended to produce or be capable of maintaining mechanical oscillations

3.13**pause**

interval between two consecutive time-histories

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:

$$T > \left(\frac{1}{f} \times \frac{100}{d} \right)$$

where

T is the duration (s);

f is the lowest natural frequency (Hz);

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

3.14

preferred testing axes

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

3.15

random motion sample

sample of random motion record modified in frequency range and amplitude so as to produce a required response spectrum

3.16

required response spectrum

response spectrum specified in the relevant specification

3.17

response spectrum

plot of the maximum response to a defined input motion of a family of single-degree-of-freedom bodies as a function of their natural frequencies and at a specified damping ratio

3.18

sampling frequency

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

3.19

strong part of the required response spectrum

part of the spectrum for which the response acceleration is higher than for the -3 dB bandpass of the required response spectrum (see figure 4)

NOTE Generally, for seismic applications, the strong part of the response spectrum is located in the first third of the frequency band.

3.20

strong part of the time-history

part of the time-history from the time when the plot first reaches 25 % of the maximum value to the time when it falls for the last time to the 25 % level (see figure 5)

3.21

sweep cycle

traverse of the specified frequency range once in each direction, for example 1 Hz to 35 Hz to 1 Hz

3.22

synthesized time-history

artificially generated time-history such that its response spectrum envelops the required response spectrum

3.23

test level

largest peak value within a test wave

3.24

test response spectrum

response spectrum derived from the real motion of the vibration table either analytically or by using response spectrum analysis equipment

3.25**time-history**

recording, as a function of time, of acceleration, velocity or displacement

NOTE A definition of the mathematical term "time-history" is given in ISO 2041 and relates to the magnitude of a quantity expressed as a function of time.

3.26**zero period acceleration**

high-frequency asymptotic value of acceleration of the response spectrum (as an example see figure 6)

NOTE The zero period acceleration is of practical significance as it represents the largest peak value of acceleration, for example in a time-history. This is not to be confused with the peak value of acceleration in the response spectrum.

4 General requirements

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.

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 inviting the reader to refer to the flow chart of figure 1 and to annex A; the clause numbers in the main part are also referred to in annex A.

5 Requirements for testing

The requirements for a vibration response investigation are given in 5.1, those for time-history testing in 5.2, while 5.3 deals with mounting for testing.

5.1 Vibration response investigation

When prescribed by the relevant specification, the vibration response investigation may be carried out with reference to IEC 60068-2-6, taking account of 5.1.1 to 5.1.9 below, in order to determine the critical frequencies and, where required, the damping ratio.

Random vibration testing may also be used as an alternative method for the vibration response investigation (see IEC 60068-2-64, 4.3 and clause A.3).

5.1.1 Basic motion

The basic motion shall be a sinusoidal function of time and shall be 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 5.1.2 and 5.1.3.