

Environmental testing —

Part 2-81: Tests — Test Ei: Shock — Shock response spectrum synthesis

The European Standard EN 60068-2-81:2003 has the status of a
British Standard

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National foreword

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The UK participation in its preparation was entrusted to Technical Committee GEL/104, Environmental testing, which has the responsibility to:

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- present to the responsible European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;
- monitor related international and European developments and promulgate them in the UK.

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Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CENELEC member.

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CENELEC

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Foreword

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- latest date by which the national standards conflicting
with the EN have to be withdrawn (dow) 2006-10-01

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, B, C and D are informative.

Annex ZA has been added by CENELEC.

Endorsement notice

The text of the International Standard IEC 60068-2-81:2003 was approved by CENELEC as a European Standard without any modification.

CONTENTS

1	Scope	5
2	Normative references.....	5
3	Terms and definitions	5
4	Requirements for test apparatus	10
4.1	Basic motion.....	10
4.2	Cross-motion	10
4.3	Signal tolerance.....	10
4.4	Measuring system.....	10
5	Requirements for testing.....	11
5.1	Test control	11
5.2	Tolerances on SRS.....	11
5.3	Calculation of test SRS	11
5.4	Algorithms for calculation of SRS	12
5.5	Test frequency range	12
5.6	Mounting	12
6	Severities	13
6.1	Required SRS.....	13
6.2	Duration of the synthesized time-history	13
6.3	Number of repetitions	14
6.4	Test frequency range	14
6.5	Number of high peaks in a calculated response time-history of a single-degree-of-freedom system	14
7	Preconditioning.....	14
8	Initial measurements.....	15
9	Testing	15
9.1	General	15
9.2	Vibration response investigation.....	15
9.3	Synthesis of the test time-history	16
9.4	Testing with synthesized test time-histories.....	17
10	Intermediate measurements.....	18
11	Recovery	18
12	Final measurements	18
13	Information to be given in the relevant specification.....	18
14	Information to be given in the test report	19
	Annex A (informative) Test time history – General background information	23
	Annex B (informative) Parameters for use in synthesizing a test time-history	26
	Annex C (informative) How to synthesize a test time-history	30
	Annex D (informative) Recommended frequency ranges for test SRS	34
	Annex ZA (normative) Normative references to international publications with their corresponding European publications	35
	Bibliography	36

Figure 1 – Example of a typical response of an oscillator excited by a specific time-history (specified threshold value of 70 %)	20
Figure 2 – Example of identification of the peaks of the response higher than a specified (70 %) threshold value	20
Figure 3 – Typical logarithmic plot of a required response spectrum	21
Figure 4 – Typical time-history	21
Figure 5 – Flow chart for testing with synthesized test time-histories 9.4	22
Figure B.1 – Strong part of the SRS	29
Table D.1 – Examples of test frequency range	34

ENVIRONMENTAL TESTING –

Part 2-81: Tests – Test Ei: Shock – Shock response spectrum synthesis

1 Scope

This part of IEC 60068 specifies tests using a synthesized shock response spectrum (SRS). It is intended for general application to specimens when simulation of transient excitation of a complex nature is required.

2 Normative references

The following referenced documents are indispensable for the application 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 60068-1:1988, *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, *Basic environmental testing procedures – Part 2: Tests – Test Ea and guidance: Shock*

IEC 60068-2-47:1999, *Environmental testing – Part 2-47: Test methods – Mounting of components, equipment and other articles for vibration, impact and similar dynamic tests*

IEC 60068-2-57:1999, *Environmental testing – Part 2-57: Tests – Test Ff: Vibration – Time-history method*

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

ISO 266:1997, *Acoustics – Preferred frequencies*

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

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 2041, IEC 60068-1, IEC 60068-2-6, IEC 60068-2-27, IEC 60068-2-57 and IEC 60068-2-64, together with the following definitions, apply.

3.1

–3 dB bandwidth

frequency bandwidth between two points in a frequency response function which is 0,707 of the maximum response when associated with a single resonance peak

3.2**critical damping**

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

3.3**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

3.4**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.

3.5**damping ratio**

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

3.6**decibel****dB**

relation between magnitudes written in a logarithmic form:

$$L = 20 \log_{10} \left(\frac{X}{X_0} \right) \text{ (dB)}$$

where

L is the logarithmic value in dB;

X/X_0 is the relation between magnitudes X and X_0

3.7**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.

3.8 **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, that is, 10 m/s².

3.9**Hanning window**

weighting function for time-histories that forces the start and the end of the time-history to a zero value in the selected time window. It has the shape of a cosine bell

NOTE See ISO 18431-2 for a more detailed definition.

3.10 **high-frequency asymptote** **HFA**

high-frequency asymptotic value of the SRS curve (see Figure 3)

NOTE 1 The SRS high-frequency asymptote is of practical significance as it represents the largest peak value of the excitation time-history. This is not to be confused with the peak value in the SRS.

NOTE 2 Another name of the SRS high-frequency asymptote is zero-period acceleration (ZPA).

3.11 **measuring points**

specific points at which data are gathered when conducting the test. These points are of three types, as defined below

3.11.1 **check point**

point located on the fixture, on the vibration table or on the specimen as close as possible to, or combined with, 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.

3.11.2 **reference point**

point, chosen from the check points, whose signal is used to control the test

3.11.3 **response point**

point on the specimen used for measurement of the response during vibration response investigation or during testing. This point is not a check or a reference point

NOTE More than one response point can be used.

3.12 **natural frequency**

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

3.13 **number of high peaks of the response time-history**

measured number of peaks at the response point or number of peaks of the calculated response time-history of one single-degree-of-freedom system (oscillator), excited by a time-history, exceeding a specified threshold value (see Figure 1)

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

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

NOTE 3 Calculated peaks instead of measured peaks are preferred in this standard, as it is not always possible to obtain measured peaks of response time-histories.

3.14**oscillator**

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

3.15**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

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

where

T is the duration in seconds (s);

f is the lowest undamped natural frequency in hertz (Hz);

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

3.16**preferred testing axes**

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

3.17 **Q -factor**

quantity, which is a measure of the sharpness of resonance, or frequency selectivity of a resonant oscillatory mechanical system having a single degree of freedom. The Q -factor is one-half the reciprocal of the damping ratio

3.18**required SRS**

SRS specified in the relevant specification (see Figure 3)

NOTE The relevant specification can contain more than one SRS with different Q -factors for a certain test case.

3.19**shock response spectrum****SRS**

plot of the maximum response (displacement, velocity or acceleration) of a base-excited series of single-degree-of-freedom systems to a defined input motion as a function of their undamped natural frequencies and at a specified Q -factor

NOTE 1 For calculation purposes, linear fixed-base single-degree-of-freedom systems and viscous damping are assumed, if not otherwise defined.

NOTE 2 The relevant specification can contain several SRS with different Q -factors for a given test case, from which the required SRS shall be selected depending on the Q -factor of the test specimen.

3.20**sampling frequency**

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

3.21

signal tolerance

signal tolerance S_t in per cent is defined as

$$S_t = \left(\frac{NF}{F} - 1 \right) \times 100 \text{ (per cent)}$$

where

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

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

NOTE 1 This parameter applies to whichever signal, i.e. acceleration, velocity or displacement, is being used to control the test.

NOTE 2 This parameter applies only to excitation with sinusoidal vibration.

3.22

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 4)

3.23

synthesized time-history

artificially generated time-history such that its SRS envelops the required SRS

3.24

test frequency range

frequency range chosen for testing depending on the synthesizing of the required SRS and on the capabilities of the test apparatus with the test specimen attached. It has a lower (f_1) and an upper (f_2) frequency limit, corresponding to the lowest and highest wavelet frequency that may be used

NOTE The frequency range of the SRS is larger than the test frequency range and extends to infinite frequency (see definition 3.10).

3.25

test SRS

SRS derived from the real motion of the reference point on the vibration generator table, either analytically or by using SRS analysis equipment (see Figure 3)

3.26

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.

3.27

time window

duration of synthesis of the test time-history in which all the wavelets are contained

NOTE In some test control systems, this time window is doubled in duration and the synthesized time-history centred in the middle of the new time frame.

3.28

wavelet

time-history with a single frequency that is a component of the synthesized time-history for SRS testing

NOTE The term 'wavelet' as used in this standard should not be mixed up with wavelet as used in wavelet theory and wavelet analysis.

4 Requirements for test apparatus

The required characteristics apply to the complete test apparatus, which for an electrodynamic testing system includes the control system, power amplifier, vibrator, test fixture and specimen when loaded for testing. The components are similar for a servo-hydraulic testing system.

The requirements for the test apparatus according to 4.1 to 4.3 shall be verified by means of sinusoidal vibration excitation.

4.1 Basic motion

The basic motion during verification shall be a sinusoidal function of time and such that the fixing points of the specimen move substantially in phase and straight parallel lines, subject to the limitation of 4.2 and 4.3.

4.2 Cross-motion

The maximum vibration amplitude of acceleration or displacement at the check points in any axis perpendicular to the specified axis shall not exceed 50 % of the vibration amplitude of the basic motion up to 1 000 Hz and is allowed to go up to 100 % above 1 000 Hz. The measurements need only cover the specified test frequency range. In special cases, for example small specimens, the maximum permissible cross-motion may be limited to 25 % if required by the relevant specification.

Where rotational motion of the vibration table is likely to be important, a tolerable level shall be prescribed by the relevant specification and then be stated in the test report.

In some cases, for example with large-size or high-mass specimens or at certain frequencies, it may be difficult to achieve the figures quoted above. In such cases the relevant specification shall state which of the following requirements applies:

- a) cross-motion in excess of that specified above shall be stated in the test report; or
- b) cross-motion which is known to offer no hazard to the specimen need not be monitored.

4.3 Signal tolerance

Unless otherwise stated in the relevant specification, acceleration signal tolerance measurements shall be performed. They shall be carried out at the reference point and shall cover the frequencies up to 5 000 Hz, or five times the upper test frequency (f_2), whichever is the lesser value. However, this maximum analysing frequency may be extended to the upper test frequency, or beyond if specified by the relevant specification. Unless otherwise stated in the relevant specification, the signal tolerance shall not exceed 5 %.

In the case of large or complex specimens, where the specified signal tolerance values cannot be satisfied at some parts of the frequency range the signal tolerance shall be stated in the test report.

4.4 Measuring system

The characteristics of the measuring system shall be such that it can be determined that the true value of the time-history, as measured in the intended axis at the reference point, is within the tolerances required for the test.