

# Environmental testing —

## Part 2-80: Tests — Test Fi: Vibration — Mixed mode

The European Standard EN 60068-2-80:2005 has the status of a  
British Standard

ICS 19.040; 29.020

# National foreword

This British Standard is the official English language version of EN 60068-2-80:2005. It is identical with IEC 60068-2-80:2005.

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 international/European committee any enquiries on the interpretation, or proposals for change, and keep UK interests informed;
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English version

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

Essais d'environnement  
Partie 2-80: Essais –  
Essai Fi: Vibration - Mode mixte  
(CEI 60068-2-80:2005)

Umgebungseinflüsse  
Teil 2-80: Prüfverfahren –  
Prüfung Fi: Mixed-Mode Vibrationsprüfung  
(IEC 60068-2-80:2005)

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# CENELEC

European Committee for Electrotechnical Standardization  
Comité Européen de Normalisation Electrotechnique  
Europäisches Komitee für Elektrotechnische Normung

**Central Secretariat: rue de Stassart 35, B - 1050 Brussels**

## Foreword

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|------------------------------------------------------------------------------------------------------------------------------------------|-------|------------|
| – latest date by which the EN has to be implemented at national level by publication of an identical national standard or by endorsement | (dop) | 2006-03-01 |
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Annex ZA has been added by CENELEC.

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## Endorsement notice

The text of the International Standard IEC 60068-2-80:2005 was approved by CENELEC as a European Standard without any modification.

In the official version, for Bibliography, the following note has to be added for the standard indicated:

ISO/IEC 17025    NOTE    Harmonized as EN ISO/IEC 17025:2000 (not modified).

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## INTRODUCTION

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, hereinafter referred to as "specimens", 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.

## ENVIRONMENTAL TESTING –

### Part 2-80: Tests – Test Fi: Vibration – Mixed mode

#### 1 Scope

This part of IEC 60068 is intended for general application for testing specimens when simulation is required of vibration excitation of a complex and mixed nature.

The purpose of the test is to demonstrate the adequacy of the specimen 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.

#### 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 60050(300):2001, *International Electrotechnical Vocabulary (IEV) – 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 60068-1:1988, *Environmental testing – Part 1: General and guidance*

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

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

IEC 60068-3-8:2003, *Environmental testing – Part 3-8: Supporting documentation and guidance – Selecting amongst vibration tests*

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

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

### 3 Terms and definitions

For the purposes of this document, the following terms and definitions are generally defined in ISO 2041, IEC 60050(300), IEC 60068-1, IEC 60068-2-6, IEC 60068-2-64 and IEC 60068-5-2. Where, for the convenience of the reader, a definition from one of those sources is included here, the derivation is indicated and departures from the definitions in those sources are also indicated.

The additional terms and definitions that follow are also applicable.

#### 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

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.

#### 3.4

##### **control point**

##### 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/s<sup>2</sup>

### 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. The following frequency domain control strategies are available, see also 3.4.2

#### **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

### 3.9.2

#### **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/SUM**

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

NOTE MAX means the maximum of either the background or narrow band ASD values, SUM means adding the two ASD values.

### 3.11

#### **crest factor**

ratio of the peak value to the r.m.s. value of the complex mixed-mode waveform

[ISO 2041]

### 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 (see also Figure 1)**

range from the actual frequency below  $f_1$  to the actual frequency above  $f_2$  due to initial and final slopes

**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 (see also Figure 1)**

part of the specified acceleration spectral density above  $f_2$

**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 (see also Figure 1)**

part of the specified acceleration spectral density below  $f_1$

**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.

[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**

$\sigma$

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**

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, for example 5 Hz to 500 Hz to 5 Hz

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

[IEC 60068-2-6]

**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 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.