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Descriptors: Electricity, components, equipment, mechanical test, bump, test, procedures, components specifications writing, equipment specifications writing

English version

Basic environmental testing procedures
Part 2: Tests
Test Eb and guidance: Bump

(IEC 68-2-29 : 1987 + corrigendum)

Essais fondamentaux climatiques et de robustesse mécanique
Deuxième partie: Essais
Essai Eb et guide: Secousses
(CEI 68-2-29 : 1987)

Grundlegende Umweltprüfverfahren
Teil 2: Prüfungen
Prüfung Eb und Leitfaden: Dauerschocken
(IEC 68-2-29 : 1987)

This European Standard was approved by CENELEC on 1993-03-09. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

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.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CENELEC member into its own language and notified to the Central Secretariat has the same status as the official versions.

CENELEC members are the national electrotechnical committees of Austria, Belgium, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and United Kingdom.

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

Ref. No. EN 60068-2-29 : 1993 E

Foreword

At the request of CENELEC Reporting Secretariat SR 50A, HD 323.2.29 S2 : 1989 (IEC 68-2-29 : 1987 + corrigendum) was submitted to the CENELEC voting procedure for conversion into a European Standard.

The text of the International Standard was approved by CENELEC as EN 60068-2-29 on 9 March 1993.

The following dates were fixed:

– latest date of publication of an identical national standard	(dop)	1994-03-01
– latest date of withdrawal of conflicting national standards	(dow)	–

Annexes designated 'normative' are part of the body of the standard. In this standard, annex ZA is normative.

Contents

British Standards Institution

National foreword

This Part of BS 2011 has been prepared under the direction of the General Electrotechnical Engineering Standards Committee. It is identical with IEC Publication 68-2-29 : 1987 'Basic environmental testing procedures. Part 2 : Tests — Test Eb and guidance : Bump', published by the International Electrotechnical Commission (IEC).

In 1993 the European Committee for Electrotechnical Standardization (CENELEC) accepted IEC 68-2-29 : 1987 as European Standard EN 60068-2-29 : 1993. As a consequence of implementing the European Standard this British Standard is renumbered as BS EN 60068-2-29 and any reference to BS 2011 : Part 2.1Eb should be read as a reference to BS EN 60068-2-29.

The title of this Part of BS EN 60068 has been changed to 'Environmental testing' to correspond with the change in title of IEC Publication 68. This change reflects the fact that IEC Publication 68 and BS EN 60068 are concerned with the whole subject of testing and avoids any possible confusion over whether it is the 'procedures' or the 'testing' that are basic. Amendments are not being issued to the other Parts of BS EN 60068, but their titles are being changed when these Parts are revised.

This revision supersedes BS 2011 : Part 2.1 Eb : 1977 which is withdrawn.

Terminology and conventions. The text of the international standard has been approved as suitable for publication as a British Standard without deviation. Some terminology and certain conventions are not identical with those used in British Standards; attention is drawn especially to the following.

For the purposes of this Part of this standard, the scope clause is given in BS 2011 : Part 1.1.

The comma has been used as a decimal marker. In British Standards it is current practice to use a full point on the baseline as the decimal marker.

Wherever page numbers are quoted, they are IEC page numbers.

Cross-references

International standard*	Corresponding British Standard
	BS 2011 Basic environmental testing procedures
IEC 68-1 : 1982	Part 1.1 : 1983 General and guidance (Identical)
IEC 68-2-27 : 1987	Part 2.1Ea : 1987 Test Ea. Shock (Identical)
IEC 68-2-31 : 1969	Part 2.1Ec : 1977 Test Ec. Drop and topple, primarily for equipment-type specimens (Identical)
IEC 68-2-32 : 1975	Part 2.1Ed : 1977 Test Ed. Free fall (Identical)
IEC 68-2-47 : 1982	Section 4.1 : 1983 Specification for mounting of components, equipment and other articles for dynamic tests (Identical)
† IEC 68-2-55 : 1987	Part 2.1Ee Test Ee. Bounce (Identical)

The Technical Committee has reviewed the provisions of IEC 721-3-1 and 721-3-5 and also of ISO 2041, to which reference is made in the text, and has decided that they are acceptable for use in conjunction with this standard. BS 3015 : 1976 'Glossary of terms relating to mechanical vibration and shock' is a related standard for ISO 2041.

NOTE. *Typographical error.* In A.3, in the penultimate paragraph, in line 2, 'measure or confidence' should read 'measure of confidence'.

Warning note. This British Standard calls for the use of procedures that may be injurious to health if adequate precautions are not taken. It refers only to technical suitability and does not absolve the user from legal obligations relating to health and safety at any stage.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

* Undated in the text.

† Already published and referred to in the text as IEC 68-2-XX. The identical British Standard to IEC 68-2-55 is BS 2011 : Part 2.1Ee which is in preparation.

INTRODUCTION

This test is applicable to components, equipments and other electrotechnical products, hereinafter referred to as "specimens", which, during transportation or in use, may be subjected to repetitive shocks. The bump test may also be used as a means of establishing the satisfactory design of a specimen in so far as its structural integrity is concerned and as a means of quality control. It consists basically of subjecting, on a bump tester, a specimen to repetitive shocks of a standard pulse shape with specified peak acceleration and duration.

Note. — The term "bump tester" is used throughout this standard but other means of applying "bumps" are not excluded.

Specification writers will find in Clause 11 a list of details to be considered for inclusion in specifications and in Appendix A the necessary guidance.

1. Object

To provide a standard procedure for determining the ability of a specimen to withstand specified severities of bump.

2. General description

This standard is written in terms of a prescribed number of repetitive half-sine pulses with given peak acceleration and duration.

The purpose of the test is to reveal the accumulated damage or degradation caused by repetitive shocks, and to use the 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 determine the structural integrity of specimens or as a means of quality control (see Clause A3.)

This test is primarily intended for unpackaged specimens and for items in their transport case when the latter may be considered as part of the specimen itself.

The bumps are not intended to reproduce those encountered in practice. Wherever possible, the test severity applied to the specimen should be such as to reproduce the effects of the actual transport or operational environment to which the specimen will be subjected, or to satisfy the design requirements if the object of the test is to assess structural integrity (see Clause A3).

For the purpose of this test the specimen is always fastened to the fixture or the table of the bump tester during conditioning.

In order to facilitate the use of this standard, references are given in the main part where the reader is invited to refer to Appendix A and the clause numbers in the main part are also referred to in Appendix A.

This standard is to be used in conjunction with IEC Publication 68-1: Basic Environmental Testing Procedures, Part 1: General and Guidance.

3. Definitions

The terms used are generally defined in ISO 2041 or IEC Publication 68-1.

The following additional terms and definitions are also applicable for the purposes of this standard.

3.1 *Fixing point*

Part of the specimen in contact with the fixture or the table of the bump tester and which is normally used to fasten the specimen in service.

3.2 *Check point*

Fixing point nearest to the centre of the table surface of the bump tester, unless there is a fixing point having a more rigid connection to the table, in which case this latter point shall be used.

Note. — This definition applies as there is only one nominated check point. Other standards in IEC Publication 68-2 contain definitions of "check point" applicable where provision is made for the control of the test by nomination of more than one check point.

3.3 *Bump severity*

Combination of the peak accceleration, the duration of the nominal pulse and the number of bumps.

3.4 *Velocity change*

Absolute value of the sudden change of speed resulting from the application of the specified acceleration.

Note. — The change is normally considered sudden if it takes place in a time that is short compared with the fundamental period of concern.

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 unity, that is 10 m/s^2.

4. Description of test apparatus

4.1 *Required characteristics*

When the bump tester and/or fixture are loaded with the specimen, the bumps applied at the check point shall have the following specified characteristics.

4.1.1 *Basic pulse shape*

The true value of each half-sine pulse shall be within the limits of tolerance shown by the solid line in Figure 1, page 28.

Note. — Where it is not practicable to achieve a pulse shape falling within the specified tolerance, the relevant specification should state the alternative procedure to be applied (see Clause A4).

4.1.2 *Repetition rate*

The repetition rate shall be such that the relative motion within the specimen between bumps shall be substantially zero and the value of acceleration at the check point shall be within the limits shown in Figure 1, page 28 (see Clause A6).

Note. — A rate of between one and three bumps per second is usually adequate.

4.1.3 *Velocity change tolerance*

The actual velocity change shall be within ±20% of the value corresponding to the nominal pulse.

Where the velocity change is determined by integration of the actual pulse, this shall be done from $0.4D$ before the pulse to $0.1D$ beyond the pulse, where D is the duration of the nominal pulse.

Note. — If the velocity change tolerance cannot be achieved without the use of elaborate facilities, the relevant specification should state the alternative procedure to be adopted (see Clauses A4 and A5).

4.1.4 *Transverse motion*

The positive or negative peak acceleration at the check point, perpendicular to the intended bump direction, shall not exceed 30% of the value of the peak acceleration of the nominal pulse in the intended direction, when determined with a measuring system in accordance with Sub-clause 4.2 (see Clause A4).

Note. — If the transverse motion tolerance cannot be achieved the relevant specification should state the alternative procedure to be adopted (see Clause A4).

4.2 *Measuring system*

The characteristics of the measuring system shall be such that it can be determined that the true value of the actual pulse as measured in the intended direction at the check point is within the tolerance prescribed by Sub-clause 4.1.1.

The frequency response of the overall measuring system, which includes the accelerometer, can have a significant effect on the accuracy and shall be within the limits shown in Figure 2, page 29 (see Clause A4).

4.3 *Mounting*

The specimen shall be fastened to the fixture or the table of the bump tester by its normal mounting means during conditioning. Mounting requirements are prescribed in IEC Publication 68-2-47.

5. Severities

The relevant specification shall prescribe the appropriate bump severity. Unless otherwise specified, one of the combinations of acceleration and duration shown in the same line of Table I in Sub-clause 5.1 and a number of bumps from Sub-clause 5.2 shall be selected (see Clause A3).

5.1 *Acceleration and duration of the pulse*

TABLE I

Acceleration and duration of the pulse

Peak acceleration (A)		Corresponding duration of the nominal pulse (D)	Corresponding velocity change (ΔV)
g_n	(equivalent in m/s²)	ms	m/s
10	(100)	16	1.0
15	(150)	6	0.6
25	(250)	6	0.9
40	(400)	6	1.5
100	(1 000)	2	1.2

5.2 *Number of bumps in each direction*

100 ± 5
1 000 ± 10
4 000 ± 10

6. **Pre-conditioning**

The relevant specification may call for preconditioning.

7. **Initial measurements**

The specimen shall be submitted to the visual, dimensional and functional checks prescribed by the relevant specification.

8. **Conditioning**

8.1 *Application of bumps*

8.1.1 *Component type specimens*

Unless otherwise prescribed by the relevant specification, the specified number of bumps shall be applied in each direction of three mutually perpendicular axes of the specimen.

When testing a number of identical specimens they may be so oriented that the bumps are applied simultaneously along the axes and in the directions referred to above (see Clause A6).

8.1.2 *Equipment type specimens*

Where the attitude of the specimen when mounted or transported is known and since bumps are generally of greatest significance in one direction of one axis (usually vertical), the specified number of bumps shall be applied in that direction and attitude only. Where the attitude is unknown, the specified number of bumps shall be applied in each of the directions prescribed by the relevant specification (see Clause A6).

8.2 *Operating mode and functional monitoring*

The relevant specification shall state whether the specimen shall

a) operate during bump and if any functional monitoring is required;

and/or

b) survive the conditions of bump.

For both cases the relevant specification shall provide the criteria upon which the acceptance or rejection of the specimen is to be based.

9. **Recovery**

The relevant specification may call for recovery.

10. **Final measurements**

The specimen shall be submitted to the visual, dimensional and functional checks prescribed by the relevant specification.

The relevant specification shall provide the criteria upon which the acceptance or rejection of the specimen is to be based.

11. **Information to be given in the relevant specification**

When this test is included in a relevant specification, the following details shall be given as far as they are applicable:

	Clause or Sub-clause
a) Tolerances, special cases (Clause A4)	4.1.1
b) Velocity change, special cases (Clause A5)	4.1.3
c) Transverse motion, special cases	4.1.4
d) Method of mounting	4.3
e) Severity (Clause A3)	5.1, 5.2
f) Pre-conditioning	6
g) Initial measurements	7
h) Directions and number of bumps in special cases only (Clause A6)	8.1
i) Operating modes and functional monitoring	8.2
j) Acceptance and rejection criteria	8.2, 10
k) Recovery	9
l) Final measurements	10

APPENDIX A

GUIDANCE

A1. Introduction

The test provides a method by which effects on a specimen comparable with those likely to be experienced in practice in the environment to which the specimen will be subjected during either transportation or operation can be reproduced in the test laboratory. The basic intention is not necessarily to reproduce the real environment.

The parameters given are standardized and suitable tolerances are chosen in order to obtain similar results when a test is carried out at different locations by different people. The standardization of values also enables components to be grouped into categories corresponding to their ability to withstand certain severities given in this standard.

In order to facilitate the use of this appendix the related clause numbers of the main part are referred to herein.

A2. Applicability of test

This test reproduces those effects on a specimen which result from transportation by or use in overland transport. This causes repeated bumping and jolting which is generally severe and can be of a complex and random nature occurring over various periods of time, depending on the length of journey, the track conditions, the type of vehicle or trailer, etc. Repetitive bumping during transportation by rail is mainly due to rail discontinuities and is of moderate intensity. Shunting, coupling, etc., of rail vehicles also give rise to bumps of higher intensity. For impacts of a non-repetitive nature, Test Ea: Shock (IEC Publication 68-2-27) is considered to be more appropriate (see Appendix B).

The test is applicable for specimens installed or transported either as secured or loose cargo. Where the specimen is carried in an unsecured manner the applicability of Test Ee: Bounce (IEC Publication 68-2-XX) may need to be considered as an alternative.

The bump test is performed, with the specimen rigidly attached to the fixture or the table of the bump tester, by subjecting it to a controlled impulse injected at the points of attachment.

The specification writer intending to call up this test should refer to Clause 11 "Information to be given in the relevant specification" in order to ensure that all such information is so provided.

A3. Test severity (Clauses 2 and 5)

Wherever possible, the test severity applied to the specimen should be related to the environment to which the specimen will be subjected during either transportation or operation, or to the design requirements if the object of the test is to assess structural integrity.

The transportation environment is frequently more severe than the operational environment and in these circumstances the test severity chosen may need to be related to the former. The specimen will always need to survive the transportation environment. If it is required to function during the operational environment, it may be necessary to carry out bump tests under both conditions with measurements of parameters after the "transportation environment" test and functional checks during the "operational environment" test.

When determining the test severity to be applied, consideration should be given to the possible need to allow an adequate safety margin between it and the conditions of the real environment.

When the real operational or transportation environment is unknown, the appropriate severity should be selected from Table II which lists the test severities applicable for various classes of transportation and operational use.

It is emphasized that the bump test is empirical and is basically a robustness test conducted in order to give a measure or confidence. It is not intended to simulate precisely the real environment.

In determining the test severity, the specification writer should take into account the information given in relevant standards in IEC Publication 721: Classification of Environmental Conditions, for example in the future IEC Publication 721-3-1: Part 3: Classification of Groups of Environmental Parameters and Their Severities—Storage, and IEC Publication 721-3-5: Part 3: Classification of Groups of Environmental Parameters and Their Severities—Ground Vehicle Installations, remembering that these publications list values of shocks encountered in practice whereas the intention of this standard is to standardize shock pulses for testing that are likely to produce the same effects as the real life shocks.

A4. Tolerances

The test method described in this standard is capable of a high degree of reproducibility when the tolerance requirements relating to the pulse shape, velocity change, repetition rate and transverse motion are complied with.

However, there are certain exceptions to these tolerance requirements and these are primarily applicable to specimens which provide a highly reactive load, that is with mass and/or dynamic responses which would influence the characteristics of the bump tester. In these cases it is expected that the relevant specification will specify relaxed tolerances or state that the values obtained will be recorded in the test report (see Sub-clauses 4.1.1, 4.1.3 and 4.1.4).

When testing highly reactive specimens it may be necessary to carry out preliminary bump conditioning to check the characteristics of the loaded bump tester. With complex specimens, where only one or a limited number is provided for test, the repeated application of bumps prior to the definitive test, particularly for the lower number of bumps, could result in an over-test and possibly unrepresentative cumulative damage. In such instances it is recommended that, whenever possible, the preliminary checking should be carried out using a representative specimen (such as rejected equipment), or, when this is not available, it may be necessary to use a weighted space model having the correct mass and centre of gravity disposition. However, it needs to be noted that a space model is unlikely to have the same dynamic response as the real specimen.

If a low-pass filter is used, its cut-off frequency should be so chosen that the basic pulse deformation is negligible. Potentially damaging high-frequency effects should previously have been determined by other means, for example a vibration test.

The requirements of Figure 2, page 29, apply to the frequency response of the measuring system with the filter switched out. The characteristics of the filter should be such that its cut-off frequency f_g (−3 dB point) is not lower than:

$$f_g = \frac{1.5}{D}$$

where:

f_g is the cut-off frequency (kHz)

D is the pulse duration (ms)

The frequency response of the overall measuring system including that of the accelerometer is an important factor in the achievement of the required pulse shape and severity and needs to be within the tolerance limits shown in Figure 2, page 29. When it is necessary to employ a low-pass filter to reduce the effect of any high frequency resonances inherent in the accelerometer, the amplitude and phase characteristics of the measuring system will need to be considered in order to avoid distortion of the reproduced waveform (see Sub-clause 4.2).

A5. **Velocity change** (Sub-clause 4.1.3)

For the purpose of this test it is necessary to determine the actual velocity change. This can be done in a number of ways, amongst which are:

— the impact velocity for pulses not involving rebound motion;

— integration of the acceleration/time curve.

When specifying integrating techniques, unless otherwise stated, the actual velocity change should be determined by integrating between the limits of 0.4 D before the start of the pulse and 0.1 D beyond the pulse, where D is the duration of the nominal pulse. It should be noted, however, that determination of the velocity change using the electronic integrating method can be difficult and may require the use of elaborate facilities. The cost implication should be considered before invoking this method.

One purpose of specifying the velocity change, and its associated tolerance, is to encourage the test laboratory to achieve a pulse equivalent to the nominal pulse, that is central within the tolerance boundaries of the pulse (see Figure 1, page 28). In this way, the reproducibility of the test is maintained.

Another purpose is associated with the fact that at frequencies up to $fD = 0.2$, where f is the resonance frequency of the shock response spectrum and D is the duration of the pulse, the residual spectrum is nearly proportional to the velocity change of the pulse. For further information, see Appendix B of IEC Publication 68-2-27: Basic Environmental Testing Procedures, Part 2: Tests — Test Ea and Guidance: Shock.

A6. **Conditioning** (Sub-clause 8.1)

The axes and directions chosen for the test should be representative, as far as is practicable, of those in which the specimens will receive such bumps during transportation or in operational use.

Depending on the number of identical specimens available and the mounting arrangements, particularly in the case of components, the specimens may be oriented to allow the requirements of the specification to be satisfied with a minimum number of bumps. For example, if six specimens are available, they may be mounted with six different orientations so that the specification requirements are satisfied by the application of bumps in one direction only by the bump tester. If three to five specimens are available, the bumps would need to be applied to the mounted specimens in two directions. Similarly, for two specimens, three directions would be required and for a single specimen, all six directions would be required (see Sub-clause 8.1.1).

Equipment type specimens which will always be either operational or transported on their normal base need only be subjected to bumps when mounted on that base. A specimen which, during transportation, may be placed on more than one of its faces should be tested in each of the axes and directions defined in the relevant specification. Bearing in mind the empirical nature of the test, three mutually perpendicular directions would normally be adequate (see Sub-clause 8.1.2).

The requirement that between bumps any relative motion within the specimen be substantially zero is intended to ensure reproducibility of the test. Otherwise, re-excitation of the resonance(s) of

the specimen at different phases of its resonance(s) decay is possible which could give varying results for identical specimens.

Note. — In order to assess whether the conditions stated have been satisfied, the test engineer may make use of the following formula which is not intended for general use and should not be referred to in specifications:

$$R \simeq \frac{f_{\text{res min}}}{10}$$

where R is the repetition rate and $f_{\text{res min}}$ is the lowest resonance frequency.

Where the internal motion of the specimen cannot be observed, for example in an enclosed item, the relevant specification will need to indicate the course of action. In many cases, particularly for components, no action will be necessary (see Sub-clause 4.1.2).

TABLE II

Examples of severities typically employed for various applications

This table lists severities which are not mandatory but which are typical of the various applications. It should be remembered that there will be instances where the real severities differ from those shown in the table.

Severity				Component use	Equipment use
Peak acceleration		Duration	No. of bumps in each specified direction		
g_n	(equivalent m/s²)	ms			
10	(100)	16	1 000	Transportation of fragile items by road, excluding cross-country	General robustness test and for items installed or transported in a secured position in wheeled vehicles with no cross-country requirement
15	(150)	6	4 000	Minimal robustness test and for items of general application with main mechanical load occurring during transportation	Items installed in control equipment of stationary or heavy mobile machinery, for example, in the vicinity of power plants
25	(250)	6	1 000		Items installed or transported in a secured position in full cross-country vehicles. Items installed in mechanical handling equipment, for example, dock cranes, fork-lift trucks
40	(400)	6	1 000	Transportation of items intended for use in equipment of a non-portable nature	Items which may be carried loose in wheeled vehicles (road or rail) for occasional journeys, for example, delivery
40	(400)	6	4 000	Items for use in transportable equipment	Transportable items which are repeatedly carried loose in any type of vehicle, rail, road or cross-country
100	(1 000)	2	4 000	Lamps and spring contacts, for example for keys, telephones or switchboards	

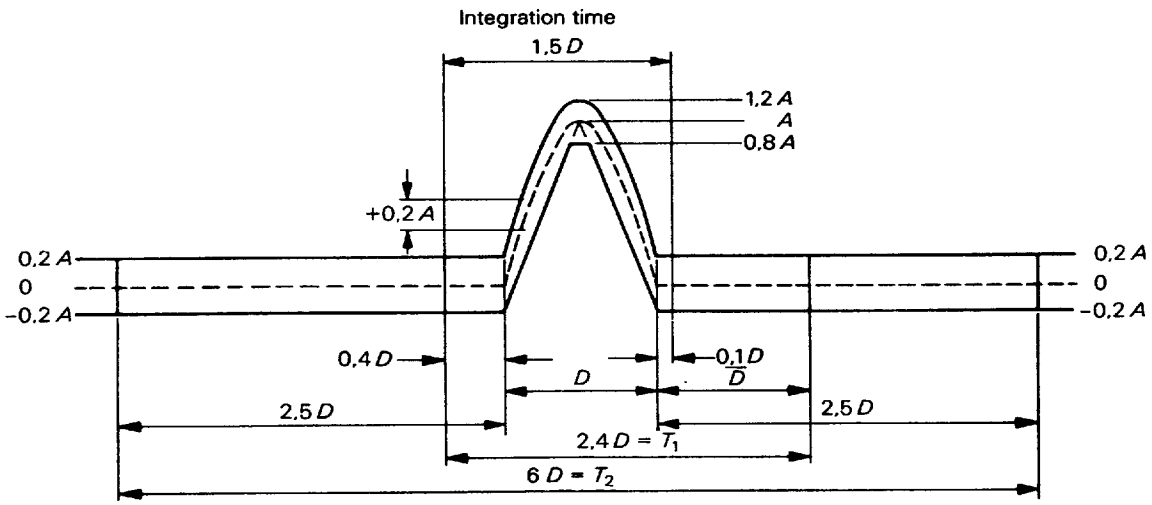
Note. — It is recommended that the test severities of 250 m/s² and 400 m/s² should only be specified for specimens with a nominal mass of less than 100 kg. For heavier specimens the 100 m/s² severity is generally more appropriate.

APPENDIX B

COMPARISONS BETWEEN IMPACT TESTS

Test Ea and guidance: Shock (IEC Publication 68-2-27)	— is intended to reproduce the effects of non-repetitive shocks likely to be encountered by components and equipment in service and during transportation.
Test Eb and guidance: Bump (IEC Publication 68-2-29)	— is intended to reproduce the effects of repetitive shocks likely to be experienced by components and equipment during transportation or when installed in various classes of vehicles.
Test Ec: Drop and topple, primarily for equipment-type specimens (IEC Publication 68-2-31)	— is a simple test intended to assess the effects of knocks or jolts likely to be received primarily by equipment-type specimens during repair work or rough handling on a table or bench.
Test Ed: Free fall (IEC Publication 68-2-32, Procedure 1 — Free fall)	— is a simple test intended to assess the effects of falls likely to be experienced due to rough handling. It is also suitable for demonstrating a degree of robustness.
Test Ed: Free fall (IEC Publication 68-2-32, Procedure 2 — Free fall repeated)	— is intended to reproduce the effects of repetitive shocks likely to be received by certain component type specimens, for example connectors in service.
Test Ee and guidance: Bounce (IEC Publication 68-2-XX) (In preparation)	— is intended to reproduce the effects of the random shock conditions experienced by specimens which may be carried as loose cargo in wheeled vehicles travelling over irregular surfaces.

Shock and bump tests are performed on the specimen when fixed to the shock testing machine. Drop and topple, free fall, repeated free fall and bounce tests are performed with the specimen free.



--- nominal pulse

— limits of tolerance

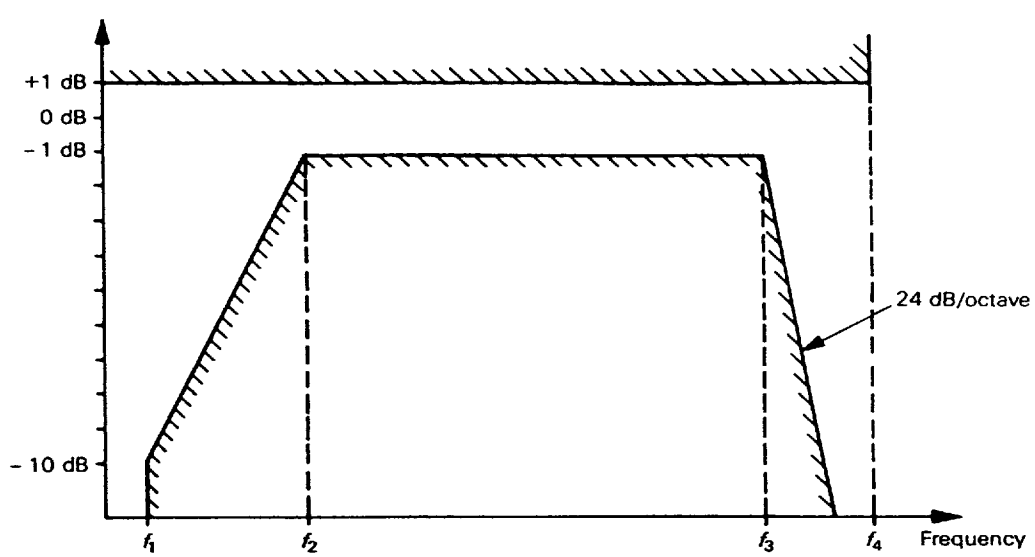
D = duration of nominal pulse

A = peak acceleration of nominal pulse

T_1 = minimum time during which the pulse shall be monitored for bumps produced using a conventional bump tester

T_2 = minimum time during which the pulse shall be monitored for bumps produced using a vibration generator

FIG. 1.— Pulse shape for the bump test (half-sine).



Duration of pulse (ms)	Low frequency cut-off (Hz)		High frequency cut-off (kHz)	Frequency beyond which the response may rise above +1 dB (kHz)
	f_1	f_2	f_3	f_4
2	2	10	5	10
6	1	4	2	4
16	0,2	1	1	2

FIG. 2. — Frequency characteristics of the measuring system.

[IEC page 29]

Publications referred to

See national foreword.

Annex ZA (normative)
Other international publications quoted in this standard with the references of the relevant European publications

When the international publication has been modified by CENELEC common modifications, indicated by (mod), the relevant EN/HD applies.

IEC Publication	Date	Title	EN/HD	Date
68-1	1982*	Basic environmental testing procedures Part 1: General and guidance	HD 323.1 S1	1988
68-2-27	1987	Part 2: Tests – Test Ea and guidance: Shock	EN 60068-2-27	1993
68-2-31	1969	Test Ec: Drop and topple, primarily for equipment-type specimens	EN 60068-2-31*	1993
68-2-32	1975	Test Ed: Free fall	EN 60068-2-32*	1993
68-2-47	1982	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	EN 60068-2-47	1993
68-2-55	1987	Test Ee and guidance: Bounce	EN 60068-2-55	1993
721-3-1	1987	Classification of environmental conditions – Part 3: Classification of groups of environmental parameters and their severities – Storage	EN 60721-3-1*	1993
721-3-5	1985	Ground vehicle installations	EN 60721-3-5*	1993

* IEC 68-1 : 1982 is superseded by IEC 68-1 : 1988 which is harmonized as HD 323.1 S2 : 1988.
EN 60068-2-31 includes A1 : 1982 to IEC 68-2-31.
EN 60068-2-32 includes A1 : 1982 + A2 : 1990 to IEC 68-2-32.
EN 60721-3-1 includes A1 : 1991 to IEC 721-3-1.
EN 60721-3-5 includes A1 : 1991 to IEC 721-3-5.

BS 2011 : Part 2.1Eb : 1987
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The Committees responsible for this British Standard are shown in Part 1.1.

The following BSI references relate to the work on this standard:
Committee reference GEL/15 Drafts for comment 83/27947DC and 85/25959DC

Amendments issued since publication

Amd. No.	Date of issue	
7827	3-6-93	B. Hicks.

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