

Railway applications — Rolling stock equipment — Shock and vibration tests

The European Standard EN 61373:1999 has the status of a
British Standard

ICS 17.160; 45.060.01

National foreword

This British Standard is the English language version of EN 61373:1999. It is identical with IEC 61373:1999.

The UK participation in its preparation was entrusted by Technical Committee GEL/9, Railway electrotechnical applications, to Subcommittee GEL/9/2, Rolling stock, which has the responsibility to:

- aid enquirers to understand the text;
- present to the responsible international/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.

A list of organizations represented on this subcommittee can be obtained on request to its secretary.

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Summary of pages

This document comprises a front cover, an inside front cover, the EN title page, pages 2 to 40, an inside back cover and a back cover.

This British Standard, having been prepared under the direction of the Electrotechnical Sector Committee, was published under the authority of the Standards Committee and comes into effect on 15 June 1999

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ISBN 0 580 32563 6

Amendments issued since publication

Amd. No.	Date	Comments

English version

**Railway applications
Rolling stock equipment
Shock and vibration tests
(IEC 61373:1999)**

Applications ferroviaires
Matériel roulant
Essais de chocs et vibrations
(CEI 61373:1999)

Bahnanwendungen
Betriebsmittel von Bahnfahrzeugen
Prüfungen für Schwingen und Schocken
(IEC 61373:1999)

This European Standard was approved by CENELEC on 1999-04-01. 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.

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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

The text of document 9/475/FDIS, future edition 1 of IEC 61373, prepared by IEC TC 9, Electric traction equipment, was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as EN 61373 on 1999-04-01.

The following dates were fixed:

- latest date by which the EN has to be implemented
at national level by publication of an identical
national standard or by endorsement (dop) 2000-01-01
- latest date by which the national standards conflicting
with the EN have to be withdrawn (dow) 2003-04-01

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 61373:1999 was approved by CENELEC as a European Standard without any modification.

CONTENTS

	Page
INTRODUCTION	5
Clause	
1 Scope	6
2 Normative references	7
3 Definitions	8
4 General	8
5 Order of testing	9
6 Reference information required by the test house	9
6.1 Method of mounting and orientation of equipment under test	9
6.2 Reference and control points	9
6.2.1 Fixing point	10
6.2.2 Control point	10
6.2.3 Reference point	10
6.2.4 Response point (measuring points)	10
6.3 Mechanical state and functioning during test	11
6.3.1 Mechanical state	11
6.3.2 Functional tests	11
6.3.3 Performance tests	11
6.4 Reproducibility for random vibration tests	11
6.4.1 Acceleration spectral density (ASD)	11
6.4.2 Root Mean Square Value (r.m.s.)	12
6.4.3 Probability density function (PDF)	12
6.4.4 Duration	12
6.5 Measuring tolerances	12
6.6 Recovery	12
7 Initial measurements and preconditioning	12
8 Random vibration test conditions	13
8.1 Test severity and frequency range	13
8.2 Duration of functional vibration tests	13
8.3 Functioning during test	13
9 Simulated long life testing at increased random vibration levels	14
9.1 Test severity and frequency range	14
9.2 Duration of accelerated vibration tests	14

Clause	Page
10 Shock testing conditions	14
10.1 Pulse shape and tolerance	14
10.2 Velocity changes	15
10.3 Mounting	15
10.4 Repetition rate	15
10.5 Test severity, pulse shape and direction	15
10.6 Number of shocks	15
10.7 Functioning during test	15
11 Transportation and handling	16
12 Final measurements	16
13 Acceptance criteria	16
14 Report	16
15 Attestation of testing	17
16 Disposal	17
Annex A (informative) Explanation of service measurements, measuring positions, methods of recording service data, summary of service data, and method used to obtain random test levels from acquired service data	24
Annex B (informative) Guidance for deriving design levels from random vibration test data	31
Annex C (informative) Figure identifying general location of equipment on railway vehicles and their resulting test category	38
Annex D (informative) Example of type test attestation	39
Annex ZA (normative) Normative references to international publications with their corresponding European publications	40

INTRODUCTION

This standard covers the requirements for random vibration and shock testing items of mechanical, pneumatic, electrical and electronic equipment/components (hereafter only referred to as equipment) to be fitted on to railway vehicles. Random vibration is the only method to be used for equipment/component approval.

The tests contained within this standard are specifically aimed at demonstrating the ability of the equipment under test to withstand the type of environmental vibration conditions normally expected for railway vehicles. In order to achieve the best representation possible, the values quoted in this standard have been derived from actual service measurements submitted by various bodies from around the world.

This standard is not intended to cover self-induced vibrations as these will be specific to particular applications.

Engineering judgement and experience is required in the execution and interpretation of this standard.

This standard is suitable for design and validation purposes; however, it does not exclude the use of other development tools (such as sine sweep), which may be used to ensure a predetermined degree of mechanical and operational confidence. To assist product design for compliance with this standard, guidance is given in annex B which allows comparison with alternative design methods.

The test levels to be applied to the item under test are dictated only by its location on the train (i.e. axle, bogie or body-mounted).

It should be noted that these tests may be performed on prototypes in order to gain design information about the product performance under random vibration. However, for attestation of testing purposes the tests have to be carried out on equipment taken from normal production.

RAILWAY APPLICATIONS – ROLLING STOCK EQUIPMENT – SHOCK AND VIBRATION TESTS

1 Scope

This International Standard specifies the requirements for testing items of equipment intended for use on railway vehicles which are subsequently subjected to vibrations and shock owing to the nature of railway operational environment. To gain assurance that the quality of the item is acceptable, it has to withstand tests of reasonable duration that simulate the service conditions seen throughout its expected life.

Simulated long-life testing can be achieved in a number of ways each having their associated advantages and disadvantages, the following being the most common:

- a) amplification: where the amplitudes are increased and the time base decreased;
- b) time compression: where the amplitude history is retained and the time base is decreased;
- c) decimation: where time slices of the historical data are removed when the amplitudes are below a specified threshold value.

The amplification method as stated in a) above, is used in this standard and together with the publications referred to in clause 2; it defines the default test procedure to be followed when vibration testing items for use on railway vehicles. However, other standards do exist and may be used with prior agreement between the manufacturer and the customer. In such cases attestation of testing against this standard will not apply. Where service information is available comparison with the standard can be performed using the method outlined in annex A.

Whilst this standard is primarily concerned with railway vehicles on fixed rail systems, its wider use is not precluded. For systems operating on pneumatic tyres, or other transportation systems such as trolleybuses, where the level of shock and vibration clearly differ from those obtained on fixed rail systems, the supplier and customer can agree at the tender stage, the test levels. It is recommended that the frequency spectra and the shock duration/amplitude be determined using the guidelines set out in annex A. Items tested at levels outside those quoted in this standard can not be certified against the requirements of this standard.

An example of this is trolleybuses, whereby body-mounted trolleybus equipment could be tested in accordance with category 1 equipment referred to in the standard.

This standard applies to single axis testing. Multi-axis testing is outside the scope of this standard.

The test values quoted in this standard have been divided into three categories dependent only upon the equipment's location within the vehicle.

Category 1 Body mounted

Class A Cubicles, subassemblies, equipment and components mounted directly on or under the car body.

Class B Anything mounted inside an equipment case which is in turn mounted directly on or under the car body.

NOTE – Class B should be used when it is not clear where the equipment is to be located.

Category 2 Bogie mounted

Cubicles, subassemblies, equipment and components which are to be mounted on the bogie of a railway vehicle.

Category 3 Axle mounted

Subassemblies, equipment and components or assemblies which are to be mounted on the wheelset assembly of a railway vehicle.

NOTE – In the case of equipment mounted on vehicles with one level of suspension such as wagons and trucks, unless otherwise agreed at the tender stage, axle mounted equipment will be tested as category 3, and all other equipment will be tested as category 2.

The cost of testing is influenced by the weight, shape and complexity of the item under test. Consequently at the tender stage the supplier may propose a more cost effective method of demonstrating compliance with the requirements of this standard. Where alternative methods are agreed it will be the responsibility of the supplier to demonstrate to his customer or his representative that the objective of this standard has been met. If an alternative method of evaluation is agreed, then the item tested cannot be certified against the requirement of this standard.

This standard is intended to evaluate equipment which is attached to the main structure of the vehicle (and/or components mounted thereon). It is not intended to test equipment which forms part of the main structure. There are a number of cases where additional or special vibration tests may be requested by the customer, for example:

- a) equipment mounted on, or linked to, items which are known to produce fixed frequency excitation;
- b) equipment such as traction motors, pantographs, shoe gear, suspension components and mechanical parts designed to transmit forces and/or torque, which may be subjected to tests in accordance with their special requirements, applicable to their use on railway vehicles. In all such cases the tests carried out should be dealt with by separate agreement at the tender stage;
- c) equipment intended for use in special operational environments as specified by the customer.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this International Standard. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this International Standard 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 ISO and IEC maintain registers of currently valid International Standards.

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

IEC 60068-2-47:1982, *Basic 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: Test methods – Test Fh: Vibration, broadband random (digital control) and guidance*

3 Definitions

For the purpose of this standard the definitions given in IEC 60068-2-64 apply.

4 General

This standard is intended to highlight any weakness/error which may result in problems as a consequence of operation under environments where vibration and shock are known to occur in service on a railway vehicle. This is not intended to represent a full life test. However, the test conditions are sufficient to provide some reasonable degree of confidence that the equipment will survive the specified life under service conditions.

Compliance with this standard is achieved providing no mechanical damage or deterioration in performance occurs as a result of these tests.

The test levels quoted in this standard have been derived from environmental test data, as referred to in annex A. This information was submitted by organizations responsible for collecting environmental vibration levels under service conditions.

The following tests are mandatory for compliance with this standard:

Functional random test levels

These are the minimum test levels to be applied in order to demonstrate that the equipment under test is capable of functioning when subjected to conditions which are likely to occur in service, on railway vehicles.

The degree of functioning shall be agreed between the manufacturer and the end user prior to tests commencing (see 6.3.2). Functional test requirements are detailed in clause 8.

The functional tests are not intended to be a full performance evaluation under simulated service conditions.

Simulated long life test levels

This test is aimed at establishing the mechanical integrity of the equipment at increased service levels. It is not necessary to demonstrate ability to function under these conditions. Simulated long life testing requirements are detailed in clauses 9 and 10.

Shock testing

Shock testing is aimed at simulating rare service events. It is not necessary to demonstrate functionality during this test. It will however be necessary to demonstrate that no change in operational state occurs, and that no mechanical movement or damage takes place. These points shall be clearly demonstrated in the final test report.

5 Order of testing

A possible order of testing is as follows:

Vertical, transverse and longitudinal simulated long life testing by increased random vibration; followed by vertical, transverse and longitudinal shock testing; followed by transportation and handling (when identified/agreed) and finally by vertical, transverse and longitudinal functional random testing.

NOTE – Transportation and handling tests are not a requirement of this standard, and are therefore not included in this standard.

The order of testing may be altered to minimize re-jigging. The order of testing shall be recorded in the report. Performance tests in accordance with 6.3.3 shall be undertaken before and after simulated long life testing, during which time transfer functions will be taken for comparison purposes in order to establish if any changes have taken place as a result of the simulated long life testing.

The orientation and direction of excitation shall be stated in the test specification and included in the report.

6 Reference information required by the test house

NOTE 1 – Additional general information can be found in IEC 60068-2-64.

NOTE 2 – For general mounting of components refer to IEC 60068-2-47.

6.1 Method of mounting and orientation of equipment under test

The equipment under test shall be mechanically connected to the test machine by its normal means of attachment, including any resilient mount, either directly or by means of a fixture.

As the method of mounting can significantly influence the results obtained, the actual method of mounting shall be clearly identified in the test report.

Unless otherwise agreed it is preferred that the equipment shall be tested in its normal working orientation with no special precautions taken for the effects of magnetic interference, heat or any other factors, upon the operation and performance of the equipment under test.

Wherever possible, the fixture shall not have a resonance within the test frequency range. When resonances are unavoidable, the influence of the resonance on the performance of the equipment under test shall be studied and identified in the report.

6.2 Reference and control points

The test requirements are confirmed by measurements made at a reference point and, in certain cases, at control points, related to the fixing points of the equipment.

In the case of large numbers of small items of equipment mounted on to one fixture, the reference and/or the control points may be related to the fixture rather than to the fixing points of the equipment under test provided the lowest resonant frequency of the loaded fixture is above the upper test frequency limit.

6.2.1 Fixing point

A fixing point is a part of the equipment under test in contact with the fixture or vibration testing surface at a point where the equipment is normally fastened in service. If a part of the mounting structure is used as the fixture, the fixing points shall be taken as those of the mounting structure and not of the equipment under test.

6.2.2 Control point

A control point is normally a fixing point. It shall be as close as possible to the fixing point and in any case shall be rigidly connected to the fixing point. If four or less fixing points exist, each one is defined as a control point. The vibration at these points shall not fall below the specified minimum limits. All control points shall be identified in the test report. In the case of small items of equipment where the size, weight and complexity of the mechanical structure do not merit multipoint control, the report shall identify how many control points were used and their locations.

6.2.3 Reference point

The reference point is the single point from which the reference signal is obtained in order to confirm the test requirements, and is taken to represent the motion of the equipment under test. It may be a control point or a fictitious point created by manual or automatic processing of the signals from the control points.

For random vibration if a fictitious point is used, the spectrum of the reference signal is defined as the arithmetic mean at each frequency of the acceleration spectral density (ASD) values of the signals from all control points. In this case, the total r.m.s. value of the reference signal is equivalent to the root mean square of the r.m.s. values of the signals from the control points.

$$\text{Total r.m.s. value of the reference point} = \sqrt{\frac{\sum_{i=1}^{i=n_c} (r.m.s.i)^2}{n_c}}$$

where n_c is the number of control points.

The report shall state the point used and how it was chosen. It is recommended that for large and/or complex equipment a fictitious point is used.

NOTE – Automatic processing of the signals from the control points using a scanning technique to create the fictitious point is permitted for confirmation of the total r.m.s. acceleration. However, it is not permitted for confirmation of the ASD level without correcting for such sources of error as analyzer bandwidth, sampling time etc.

6.2.4 Response point (measuring points)

A response point is a specific location on the equipment under test at which data is gathered for the purpose of examining the vibration response characteristics of the equipment. This is done before commencing the tests detailed in this standard (see clause 7).

6.3 Mechanical state and functioning during test

6.3.1 Mechanical state

If the equipment under test has more than one mechanical condition in which it could remain for long periods when fitted to a railway vehicle, two mechanical states shall be selected for test purposes. At least one of the worst states shall be selected (for example, in the case of a contactor, the mechanical state which affords the least clamping pressure).

When more than one state exists, the equipment under test shall spend equal time in both states selected during vibration and shock testing; the levels of which are as specified in clauses 8 and 10 respectively.

6.3.2 Functional tests

If required, the functional tests shall be specified by the manufacturer and agreed between manufacturer and customer prior to commencement of the tests. They shall be carried out during the vibration tests at the levels stated in clause 8 of this standard.

Functional tests are aimed to verify the operational capability and are not to be confused with performance tests. They are only intended to demonstrate a degree of confidence that the equipment under test will perform in service.

NOTE 1 – Functional tests will not be conducted during shock testing unless previously agreed between the manufacturer and end user.

NOTE 2 – In the case where the functional tests are modified, then these have to be detailed in the report.

6.3.3 Performance tests

Performance tests shall be carried out prior to commencing, and on completion of all the tests specified. The performance test specification shall be defined by the manufacturer and shall include tolerance limits.

6.4 Reproducibility for random vibration tests

Random vibration signals are not repeatable in the time domain; no two similar length time samples from a random signal generator can be overlain and shown to be identical. Nevertheless it is possible to make statements about the similarity of two random signals and set tolerance bands on their characteristics. It is necessary to define a random signal in a way that ensures that, should the test be repeated at a later date, by a different test house or on a different item of equipment, then the excitation is of a similar severity. It should be noted that all the following tolerance boundaries include instrumentation errors but exclude other errors, specifically random (statistical) errors and bias errors. The measurements are taken at the control/reference point(s).

6.4.1 Acceleration spectral density (ASD)

The ASD shall be within ± 3 dB (range $\frac{1}{2} \times \text{ASD}$ to $2 \times \text{ASD}$) of the specified ASD levels as shown in the appropriate figures 1 to 4. The initial and final slope should not be less than those shown in figures 1 to 4.

6.4.2 Root mean square value (r.m.s.)

The r.m.s. of the acceleration at the reference point over the defined frequency range shall be that specified in figures 1 to 4 $\pm 10\%$.

NOTE – With respect to the low frequency content it may be difficult to obtain ± 3 dB. In such cases it is only important for the test value to be noted in the report.

6.4.3 Probability density function (PDF)

Unless otherwise stated, for each response point the time series of the measured acceleration(s) shall have a distribution with a PDF which is approximately Gaussian and a crest factor (ratio of the peak to r.m.s. values) of at least 2,5.

NOTE – Figure 5 shows the tolerance bands of the cumulative PDF.

6.4.4 Duration

The total duration of exposure to the prescribed random vibration in each axis shall not be less than that specified (see 8.2 and 9.2).

6.5 Measuring tolerances

The vibration tolerances shall conform to 4.3 of IEC 60068-2-64.

6.6 Recovery

The initial and final measurements shall be taken under the same conditions (for example, temperature). If necessary a period of time after testing and before the final measurements shall be allowed, in order to enable the equipment under test to attain the same conditions as existed for the initial measurements.

7 Initial measurements and preconditioning

Before commencing any testing, the equipment shall be subjected to a performance test according to 6.3.3. Where the nature of such testing is outside the physical capability of the test house, the tests shall be conducted by the manufacturer who shall provide a statement that the item under test conformed with the performance tests prior to the vibration and shock testing identified in this standard. It is the responsibility of the manufacturer to define the location of the response points which shall be clearly identified in the report.

Transfer functions shall be calculated from the random signals taken from the reference point and response points, which shall be defined by the manufacturer. Where panels are removed for examination or instrumentation, they shall be replaced during the testing.

The transfer functions shall be taken under the test conditions specified in clause 8 for categories 2 and 3 equipment and in clause 9 for category 1 equipment.

The measurement shall aim to achieve a coherence of at least 0,9. If this is not possible, a minimum of 120 spectral averages (or 240 statistical degrees of freedom for linear averaging) shall be taken with 0 % overlap.