IEC 61373

Edition 2.0 2010-05

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Railway applications – Rolling stock equipment – Shock and vibration tests

Applications ferroviaires – Matériel roulant – Essais de chocs et vibrations

IEC 61373:2010

IEC Central Office
3, rue de Varembé
CH-1211 Geneva 20
Switzerland
Email: inmail@iec.ch
Web: www.iec.ch

About the IEC

The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

About IEC publications

The technical content of IEC publications is kept under constant review by the IEC. Please make sure that you have the latest edition, a corrigenda or an amendment might have been published.

- Catalogue of IEC publications: www.iec.ch/searchpub

The IEC on-line Catalogue enables you to search by a variety of criteria (reference number, text, technical committee,…). It also gives information on projects, withdrawn and replaced publications.

- IEC Just Published: www.iec.ch/online_news/justpub

Stay up to date on all new IEC publications. Just Published details twice a month all new publications released. Available on-line and also by email.

- Electropedia: www.electropedia.org

The world's leading online dictionary of electronic and electrical terms containing more than 20 000 terms and definitions in English and French, with equivalent terms in additional languages. Also known as the International Electrotechnical Vocabulary online.

- Customer Service Centre: www.iec.ch/webstore/custserv

If you wish to give us your feedback on this publication or need further assistance, please visit the Customer Service Centre FAQ or contact us:
Email: csc@iec.ch
Tel.: +41 22 919 02 11
Fax: +41 22 919 03 00

A propos de la CEI

La Commission Electrotechnique Internationale (CEI) est la première organisation mondiale qui élabore et publie des normes internationales pour tout ce qui a trait à l'électricité, à l'électronique et aux technologies apparentées.

A propos des publications CEI

Le contenu technique des publications de la CEI est constamment revu. Veuillez vous assurer que vous possédez l'édition la plus récente, un corrigendum ou amendement peut avoir été publié.

- Catalogue des publications de la CEI: www.iec.ch/searchpub/cur_fut-f.htm

Le Catalogue en-ligne de la CEI vous permet d'effectuer des recherches en utilisant différents critères (numéro de référence, texte, comité d'études,…). Il donne aussi des informations sur les projets et les publications retirées ou remplacées.

- Just Published CEI: www.iec.ch/online_news/justpub

Restez informé sur les nouvelles publications de la CEI. Just Published détaille deux fois par mois les nouvelles publications parues. Disponible en-ligne et aussi par email.

- Electropedia: www.electropedia.org

Le premier dictionnaire en ligne au monde de termes électroniques et électriques. Il contient plus de 20 000 termes et définitions en anglais et en français, ainsi que les termes équivalents dans les langues additionnelles. Egalement appelé Vocabulaire Electrotechnique International en ligne.

- Service Clients: www.iec.ch/webstore/custserv/custserv_entry-f.htm

Si vous désirez nous donner des commentaires sur cette publication ou si vous avez des questions, visitez le FAQ du Service clients ou contactez-nous:
Email: csc@iec.ch
Tél.: +41 22 919 02 11
Fax: +41 22 919 03 00

IEC 61373

Edition 2.0 2010-05

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Railway applications – Rolling stock equipment – Shock and vibration tests

Applications ferroviaires – Matériel roulant – Essais de chocs et vibrations

INTERNATIONAL ELECTROTECHNICAL COMMISSION

COMMISSION ELECTROTECHNIQUE INTERNATIONALE

PRICE CODE
CODE PRIX V

ICS 45.060

ISBN 978-2-88910-944-9

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

RAILWAY APPLICATIONS – ROLLING STOCK EQUIPMENT – SHOCK AND VIBRATION TESTS

FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.

6) All users should ensure that they have the latest edition of this publication.
7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

International Standard IEC 61373 has been prepared by IEC technical committee 9: Electrical equipment and systems for railways.

This second edition cancels and replaces the first edition, issued in 1999 and constitutes a technical revision.

The main technical changes with regard to the previous edition are as follows:

- change of the method to calculate the acceleration ratio which has to be applied to the functional ASD value to obtain the simulated long-life ASD value;
- addition of the notion of partially certified against this standard;
- suppression of Annex B of the first edition due to the new method to calculate the acceleration ratio;
- addition of guidance for calculating the functional RMS value from service data or the RMS value from ASD levels of Figures 2 to 5.

The text of this standard is based on the following documents:

FDIS	Report on voting
9/1386/FDIS	9/1397/RVD

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

The contents of the corrigendum of October 2011 have been included in this copy.

INTRODUCTION

This standard covers the requirements for random vibration and shock testing items of pneumatic, electrical and electronic equipment/components (hereinafter 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. The test levels to be applied to the equipment 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 test certification 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 equipment 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 (increase of the frequency);

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 exist and may be used with prior agreement between the manufacturer and the customer. In such cases test certification against this standard will not apply. Where service information is available tests can be performed using the method outlined in Annex A. If the levels are lower than those quoted in this standard, equipment is partially certified against this standard (only for service conditions giving functional test values lower than or equal to those specified in the test report).

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 on the test levels at the tender stage. It is recommended that the frequency spectra and the shock duration/amplitude be determined using the guidelines in Annex A. Equipment tested at levels lower than those quoted in this standard cannot be fully 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. However multi-axis testing may be used with prior agreement between the manufacturer and the customer.

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 1 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 2 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 equipment 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 equipment 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. Main structure in the sense of this standard means car body, bogie and axle. 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, shoegear, or suspension components 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 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 60068-2-27:2008, *Environmental testing – Part 2-27: Tests – Test Ea and guidance: Shock*

IEC 60068-2-47:2005, *Environmental testing – Part 2-47: Tests – Mounting of specimens for vibration, impact and similar dynamic tests*

IEC 60068-2-64:2008, *Environmental testing – Part 2-64: Tests – Test Fh: Vibration, broadband random and guidance*

ISO 3534-1:2006, *Statistics – Vocabulary and symbols – Part 1: Probability and general statistical terms*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60068-2-64 and in ISO 3534-1 apply as well as the following.

3.1
random vibrations
a vibration the instantaneous value of which cannot be precisely predicted for any given instant of time

3.2
Gaussian distribution ; normal distribution
a Gaussian, or normal, distribution has a probability density function equal to (see Figure 1):

$$P_x(x) = \frac{1}{\sigma\sqrt{2.\pi}} \cdot e^{\frac{-(x-\bar{x})^2}{2.\sigma^2}}$$

where:

σ is the r.m.s value;

x is the instantaneous value;

$\bar{x}$ is the mean value of x.

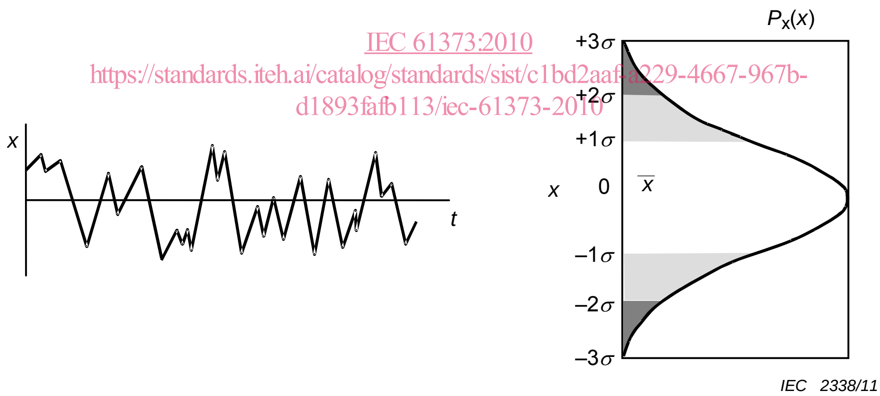

Figure 1 – Gaussian distribution

NOTE According to Figure 1, the probability that the instantaneous acceleration value is between ± a is equal to the zone under the probability density curve $P_x(x)$. This means that the instantaneous acceleration value between:

- 0 and 1σ represents 68,26 % of the time,
- 1σ and 2σ represents 27,18 % of the time,
- 2σ and 3σ represents 4,30 % of the time.

3.3
Acceleration Spectral Density
ASD
mean-square value of that part of an acceleration signal passed by a narrow-band filter of a centre frequency, per unit bandwith, in the limit as the bandwith approaches zero and the averaging time approaches infinity

3.4
components
pneumatic, electrical, or electronic parts located inside a cubicle

3.5
cubicle
whole equipment, including mechanical parts and especially the structure, (e.g. converter, inverter, etc.) composed of mounted components

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 if the criteria in Clause 13 are met.

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: The functional random test levels 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: 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 Clause 9.

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, that there is no visual deformation and that mechanical integrity has not changed. These points shall be clearly demonstrated in the final test report. Shock testing requirements are detailed in Clause 10.

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 shall 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 devices of attachment, including any resilient mount, either directly or by utilising 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 against 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 check points

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

In the case of large numbers of small items of equipment mounted on one fixture, the reference and/or check 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 higher than 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.

6.2.2 Check point

A check point shall be as close as possible to a fixing point and in any case shall be rigidly connected to it. If four or less fixing points exist, each one is defined as a check point. The vibration at these points shall not fall below the specified minimum limits. All check 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 checking, the report shall identify how many check 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 check point or a fictitious point created by manual or automatic processing of the signals from the check 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 check 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 check points.

Total r.m.s. value of the reference point = $\sqrt{\dfrac{\Sigma_{i=1}^{i=n_c}(r.m.s._i)^2}{n_c}}$

where n_c is the number of check 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 check 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 Measuring point

A measuring 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. A measuring point is defined 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, 9 and 10.

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 at verifying 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, this has to be detailed in the report.

6.3.3 Performance tests

Performance tests shall be carried out prior to commencement, and upon 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 overlaid 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 which ensures that should the test be repeated at a later date, by a different test house or on a different item of equipment, 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 check/reference point(s).

6.4.1 Acceleration spectral density (ASD)

The ASD shall be within ±3 dB (range ½ × ASD to 2 × ASD) of the specified ASD levels as shown in the appropriate Figures 2 to 5. The initial and final slope should not be less than those shown in Figures 2 to 5.

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 2 to 5 ± 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 measuring 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 6 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).