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Interested committees:

Title: BS EN IEC 61373 Railway applications - Rolling stock equipment - Shock and vibration tests

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Introduction

This draft standard is based on national and international discussions. Your comments on this draft are invited and will assist in the preparation of the consequent standard.

For international standards, comments will be reviewed by the relevant UK national committee before sending the consensus UK vote and comments to the international committee, which will then decide appropriate action. If the international standard is approved, it is usual for the text to be published as a British Standard.

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Submission of Comments

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Template for comments and secretariat observations

Date: xx/xx/20xx	Document: ISO/DIS xxxx
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1	2	(3)	4	5	(6)	7
MB	Clause No./ Subclause No./Annex (e.g. 3.1)	Paragraph/Figure/ Table/Note	Type of comment	Commend (justification for change) by the MB	Proposed change by the MB	Secretariat observations on each comment submitted
	3.1	Definition 1	ed	Definition is ambiguous and needs clarifying.	Amend to read '...so that the mains connector to which no connection...'	
	6.4	Paragraph 2	te	The use of the UV photometer as an alternative cannot be supported as serious problems have been encountered in its use in the UK.	Delete reference to UV photometer.	

COMMITTEE DRAFT FOR VOTE (CDV)

PROJECT NUMBER: IEC 61373 ED3	
DATE OF CIRCULATION: 2023-12-01	CLOSING DATE FOR VOTING: 2024-02-23
SUPERSEDES DOCUMENTS: 9/2862/CD, 9/2896A/CC	

IEC TC 9 : ELECTRICAL EQUIPMENT AND SYSTEMS FOR RAILWAYS	
SECRETARIAT: France	SECRETARY: Mr Denis MIGLIANICO
OF INTEREST TO THE FOLLOWING COMMITTEES:	PROPOSED HORIZONTAL STANDARD: ☐ Other TC/SCs are requested to indicate their interest, if any, in this CDV to the secretary.
FUNCTIONS CONCERNED: ☐ EMC ☐ ENVIRONMENT ☐ QUALITY ASSURANCE ☐ SAFETY	
☒ SUBMITTED FOR CENELEC PARALLEL VOTING Attention IEC-CENELEC parallel voting The attention of IEC National Committees, members of CENELEC, is drawn to the fact that this Committee Draft for Vote (CDV) is submitted for parallel voting. The CENELEC members are invited to vote through the CENELEC online voting system.	☐ NOT SUBMITTED FOR CENELEC PARALLEL VOTING

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TITLE: Railway applications – Rolling stock equipment – Shock and vibration tests

PROPOSED STABILITY DATE: 2027

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

**RAILWAY APPLICATIONS –
ROLLING STOCK EQUIPMENT –
SHOCK AND VIBRATION TESTS****FOREWORD**

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

This third edition cancels and replaces the second edition, issued in 2010 and constitutes a technical revision.

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

- consideration of specific ASD spectra from onboard measurements and certification limited to the specific case;
- exclusion from the scope of applicability of traction motors and any substructure not equipped with electrical/electronic/pneumatic device;
- clarification for order of testing and typical test sequence, taking into account the possibility of simultaneous multi-axis testing;
- recommendation and guidance for removing resilient mounts of the equipment (if located between the equipment and the main structure) during the long-life test;
- qualification of the fixture device used to attach the equipment to the test bench;
- guidance for using a measuring point as a possibility to assess mechanical integrity;
- 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;
- duration of long-life test can be set from 5 hours to 100 hours per axis, with corresponding acceleration ratio (default value) indicated in a table;
- clarification of the concept of structural integrity;
- description of test exemption cases, subassembly tests, and finite element analysis for structural parts of equipment (new Annex E);
- the lowest frequency f_1 of ASD spectra is fixed at 5 Hz whatever the mass of the equipment for Categories 1 and 2;
- update of ASD spectra for functional random vibration test: Table 1, Table 2, Table 3, Table 4, Table A.2 and Figure 5, Figure 6, Figure 7, Figure 9;

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

FDIS	Report on voting

Full information on the voting for the approval of this document 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.

1 INTRODUCTION

2 This document covers the requirements for random vibration and shock testing items of
3 pneumatic, electrical and electronic equipment/components (hereinafter only referred to as
4 equipment) to be fitted on to railway vehicles. Random vibration and shock (as test method or
5 as numerical simulation) is the only method to be used for equipment/component approval.

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

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

13 Engineering judgement and experience are required in the execution and interpretation of this
14 document.

15 This document is suitable for design and validation purposes; however, it does not exclude the
16 use of other development tools (such as sine sweep), which may be used to ensure a
17 predetermined degree of mechanical and operational confidence. The test levels to be applied
18 to the equipment under test are dictated only by its location on the train (i.e. axle, bogie or
19 body-mounted).

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

24 The procedures and requirements defined in this document do not substitute or overrule any
25 structural assessment required from other structural requirement standards. This document is
26 not intended to be used as a proof of fatigue strength.

27 NOTE European Standards EN 12663 and EN 13749 are examples of such structural requirement standards.

28

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 document 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 document 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 document, equipment is partially certified against this document (only for service conditions giving functional test values lower than or equal to those specified in the test report).

Whilst this document 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 document shall be resulting from an agreement between supplier and customer, based on customized spectra resulting from onboard measurements. Certification according to this document is reached but limited to the specific case.

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 document 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 document 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.

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

76 **Category 2** Bogie mounted

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

79 **Category 3** Axle mounted

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

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

85 The cost of testing is influenced by the weight, shape and complexity of the equipment under
86 test. Consequently, the supplier may at the tender stage propose a more cost-effective method
87 of demonstrating compliance with the requirements of this document. Where alternative
88 methods are agreed, it will be the responsibility of the supplier to demonstrate to the customer
89 or its representative that the objective of this document has been met. If an alternative method
90 of evaluation is agreed, then the equipment tested cannot be certified against the requirements
91 of this document.

92 This document is intended to evaluate equipment which is attached to the main structure of the
93 vehicle (and/or components mounted thereon). It is not intended to test equipment which forms
94 part of the main structure. Main structure in the sense of this document means car body, bogie
95 and axle.

96 The following items are out of scope of this document:

- 97 - Traction motors for railway vehicles;
- 98 - Any mechanical substructure not equipped with electrical/electronic/pneumatic component.

99 There are a number of cases where additional or special vibration tests may be requested by
100 the customer, cases where additional or special vibration tests may be requested by the
101 customer, which are not specified in this document, for example:

- 102 a) equipment mounted on, or linked to, items which are known to produce defined frequency
103 excitation;
- 104 b) equipment such as traction motors, pantographs, shoe gear, or suspension components
105 which may be subjected to tests in accordance with their special requirements, applicable
106 to their use on railway vehicles. In all such cases the tests carried out should be dealt with
107 by separate agreement at the tender stage;
- 108 c) equipment intended for use in special operational environments as specified by the
109 customer;
- 110 d) transportation and handling tests.

111

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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, definitions, symbols and abbreviated terms

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60068-2-64, ISO 3534-1 and the following apply. ISO and IEC maintain terminology databases for use in standardization at the following addresses:

- ISO Online browsing platform: available at <https://www.iso.org/obp>

- IEC Electropedia: available at <http://www.electropedia.org/>

3.1.1 random vibration

vibration the instantaneous value of which cannot be precisely predicted for any given instant of time

3.1.2 Gaussian distribution

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

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

where:

σ is the RMS value;

x is the instantaneous value;

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

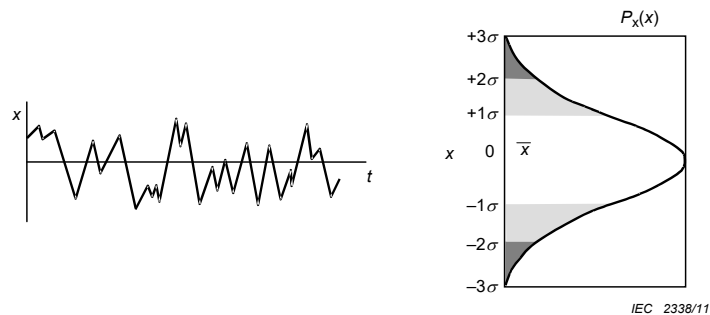


Figure 1 – Gaussian distribution

NOTE According to Figure 1, the probability that the instantaneous acceleration value is between $\pm a$ 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.

3.1.3 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 bandwidth, in the limit as the bandwidth approaches zero and the averaging time approaches infinity

3.1.4 component

<in a cubicle> pneumatic, electrical, or electronic part located inside a cubicle.

3.1.5 cubicle

self-contained item of equipment, comprising structure, mechanical parts and mounted components.

Note 1 to entry examples include converter, inverter, battery box.

3.1.6 acceleration ratio

coefficient applied to the functional ASD value to obtain the simulated long-life ASD value.

3.1.7 weakest point

structural area which provides the lowest margin of safety under fatigue loads.

3.2 Symbols and abbreviated terms

PCM Pulse Code Modulation

DAT Digital Audio Tape

FM Frequency Modulation

DR Digital Recorder

ADC Analog to Digital Converter

FEA Finite Element Analysis

PDF Probability Density Function

171 RH Relative Humidity

172 **4 General**

173 This document is intended to highlight any weakness/error which may result in problems as a
174 consequence of operation under environments where vibration and shock are known to occur
175 in service on a railway vehicle. This is not intended to represent a full life test. However, the
176 test conditions are sufficient to provide some reasonable degree of confidence (depending on
177 hypothesis of fatigue strength parameters) that the equipment will survive the specified lifetime
178 under service conditions.

179 Compliance with this document is achieved if the criteria in Clause 13 are met.

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

183 The following tests are mandatory for compliance with this document:

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.

184

185 **5 Order of testing**

186 Testing in the vertical, transverse and longitudinal axes may be performed in any order. A
187 possible sequence of testing is shown in Figure 2 for single axis test bench:

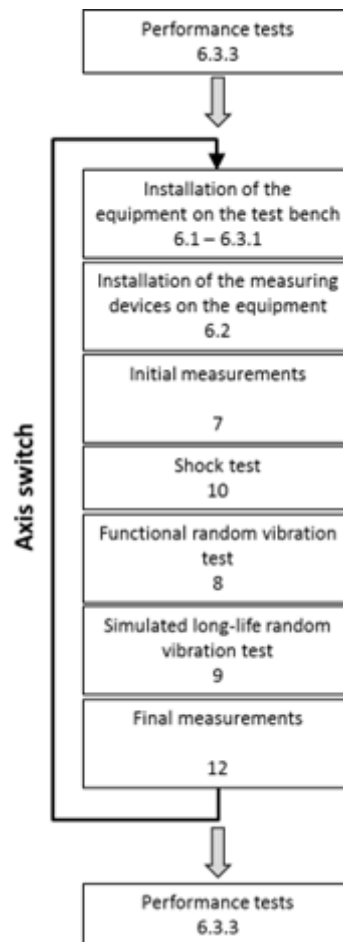


Figure 2 – Test sequence

It is allowed to change the order of testing to reduce the effort for axis permutation.

It is allowed to permute shock test, functional random vibration test and simulated long-life vibration test from the order suggested in the sequence above.

The order of testing shall be recorded in the report. Performance tests in accordance with 6.3.3 shall be undertaken in accordance with Figure 2.

For structural parts of the equipment (if applicable), 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

6.1 General

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

6.2 Method of mounting and orientation of equipment under test

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

The equipment under test shall be mechanically connected to the test machine in a manner representative of installation on the vehicle, either directly or using a fixture. Bolts and screws shall be tightened to their nominal design torque, that shall be specified by the customer.

If resilient mounts are located at the fixing points, they can be removed from the equipment for long-life test. They shall be kept in place for functional random vibration test and shock test.

In case of removing resilient mounts from the equipment for simulated long-life test, the following shall be performed (see Figure 3):

- the transfer function of resilient mounts shall be established during functional random vibration test;
- ASD level for simulated long-life test shall include the transfer function previously established: $ASD_{\text{Long-life test}} = \text{acceleration ratio}^2 \times |H| \times ASD_{\text{functional test}}$

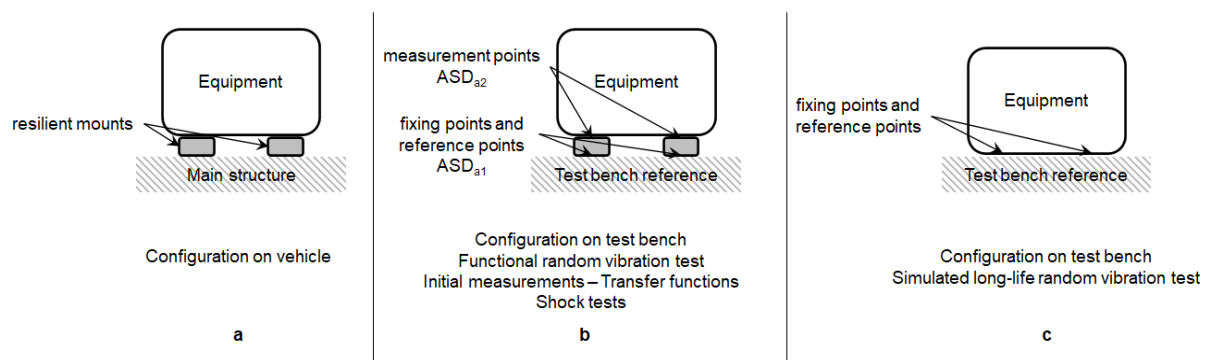


Figure 3 – Management of resilient mounts during testing

Transfer function is defined by:

$$|H| = \left| \frac{ASD_{a_2}}{ASD_{a_1}} \right|$$

Where:

ASD_{a_1} is the acceleration spectrum density of the fixing points of the functional random vibration test (b)

ASD_{a_2} is the acceleration spectrum density of the measurement points of the functional random vibration test (b)

ASD_{a_1} , ASD_{a_2} and H shall be computed between f_1 and f_2 and with a common minimum resolution Δf of 1 Hz.

The statistical error of ASD_{a_1} and ASD_{a_2} is recommended to be below 0.15, and is defined by:

$$\varepsilon = \sqrt{\frac{1}{T \cdot \Delta f}} \leq 0.15$$

Where T (s) is the duration of the signal considered for ASD computation.

Figure 4 illustrates a graphical representation of a transfer function.

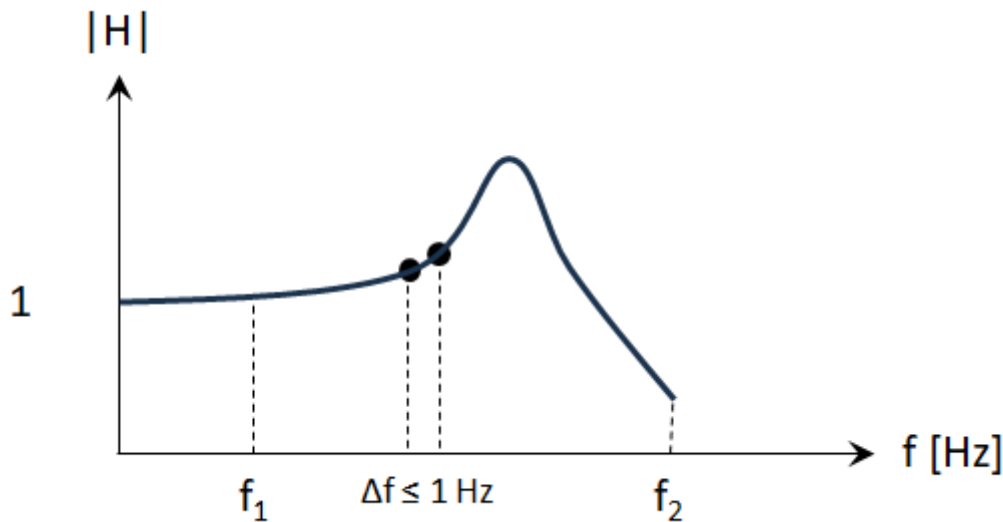


Figure 4 – Transfer function of resilient mounts

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

It is the responsibility of the user to verify that elastic mount removal does not affect the mechanical resonance frequencies and the relevant modal shapes in structural parts of the equipment.

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 device shall not have a resonance within the test frequency range.

When resonances of the fixture device are unavoidable:

- The influence of the resonance on the performance of the equipment under test shall be studied and identified in the report;
- Measurements shall be taken to ensure ASD levels conform to the standard at the reference point (see 6.2.3).

6.3 Reference and check points

6.3.1 General

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.

257 under test. In this case the lowest resonant frequency of the loaded fixture shall be higher than
258 the upper test frequency limit.

259 6.3.2 Fixing point

260 A fixing point is a part of the equipment under test in contact with the fixture or vibration testing
261 surface at a point where the equipment is normally fastened in service.

262 6.3.3 Check point

263 A check point shall be as close as possible to a fixing point and in any case shall be rigidly
264 connected to it. If no more than four fixing points exist, each one is defined as a check point. If
265 more than four fixing points exist, a minimum of four representative fixing points will be defined
266 in the relevant specification to be used as checkpoints. The vibration at these points shall not
267 fall below the specified minimum limits. All check points shall be identified in the test report. In
268 the case of small items of equipment where the size, weight and complexity of the mechanical
269 structure do not merit multipoint checking, the report shall identify how many check points were
270 used and their locations.

271 6.3.4 Reference point

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

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

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

281 where n_c is the number of check points.

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

284 Automatic processing of the signals from the check points using a scanning technique to create
285 the fictitious point is permitted for confirmation of the total RMS acceleration. However, it is not
286 permitted for confirmation of the ASD level without correcting for such sources of error as
287 analyzer bandwidth, sampling time, etc.

288 6.3.5 Measuring point

289 A measuring point is a specific location on the equipment under test at which data is gathered
290 for the purpose of examining the vibration response characteristics of the equipment. A
291 measuring point is defined before commencing the tests detailed in this document (see
292 Clause 7).

293 A measuring point is one means of checking mechanical integrity (see Clause 13). If measuring
294 points are used, there should be at least one measuring point per axis, and the axis of the
295 measuring point should be the same as the direction of excitation. Where possible, a measuring
296 point should have three axes, where one axis is oriented with the direction of excitation.

297 The location of the measuring point should be chosen in order to identify the resonant
298 frequencies of the equipment.

299 **6.4 Mechanical state and functioning during test**

300 **6.4.1 Mechanical state**

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

305 When more than one state exists, the equipment under test shall spend equal time in both
306 states selected during vibration and shock testing, the levels of which are as specified in
307 Clauses 8, 9 and 10.

308 **6.4.2 Functional tests**

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

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

315 Functional tests are not required to be conducted during shock testing unless previously agreed
316 between the manufacturer and end user.

317 In the case where the functional tests are modified, this shall be detailed in the report.

318 **6.4.3 Performance tests**

319 Performance tests shall be carried out prior to commencement, and upon completion of all the
320 tests specified. The performance test specification shall be defined by the manufacturer and
321 shall include tolerance limits.

322 **6.5 Reproducibility for random vibration tests**

323 **6.5.1 General**

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

333 **6.5.2 Acceleration spectral density (ASD)**

334 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
335 shown in the appropriate Figure 5 to Figure 9.

336 **6.5.3 Root mean square value (RMS)**

337 The RMS of the acceleration at the reference point over the defined frequency range shall be
338 that specified in Figure 5 to Figure 9 with a tolerance of ± 10 %.

339 If customized ASD levels are used under agreement between supplier and customer (see clause
340 1 of this document), the RMS of the acceleration at the reference point shall be calculated
341 accordingly.

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

344 **6.5.4 Probability density function (PDF)**

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

348 NOTE Figure 6 shows the tolerance bands of the cumulative PDF.

349 **6.5.5 Duration**

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

352 **6.6 Measuring tolerances**

353 The vibration tolerances shall conform to 4.2, 4.3, and 4.6 of IEC 60068-2-64.

354 **6.7 Recovery**

355 The initial and final measurements shall be taken under the same conditions (for example,
356 temperature). In order to enable the equipment under test to attain the same conditions as
357 existed for the initial measurements, (if necessary) a period for recovery shall be allowed after
358 testing and before the final measurements are made.

359 **7 Initial measurements and preconditioning**

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

366 For structural parts of the equipment (if applicable), transfer functions shall be calculated from
367 the random signals or sine sweep signals taken from the reference point and measuring points,
368 which shall be defined by the manufacturer. If the reference point is fictitious, the transfer
369 functions can be calculated from the closest check point.

370 Where panels are removed for examination or instrumentation, they shall be refitted during the
371 testing.

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

374 The test conditions for transfer functions shall be the same in Clause 7 and Clause 12.

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

If a sine sweep excitation is used, its amplitude should be sufficient to stimulate the lowest resonant frequency of the equipment, but not too high, to prevent equipment from damage. The sine sweep rate should be sufficiently slow to stimulate the lowest resonant frequency of the equipment. The sine sweep bandwidth shall cover the random signal bandwidth of functional vibration tests.

8 Functional random vibration test conditions

8.1 Test severity and frequency range

The equipment shall be tested with the relevant RMS value and frequency range given in Table 1 to Table 4. If the orientation of the equipment installation on the vehicle is unknown, or if the equipment can be installed in different orientations, the equipment shall be tested to the highest value in Table 1 to Table 4 for all axes. If the equipment can be installed in only two orientations, it shall be tested to the higher of the two values in Table 1 in both axes.