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**Rolling stock equipment—Shock
and vibration tests**

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Contents

	Page
Introduction.....	1
1 Scope.....	1
2 Normative references	4
3 Terms and definitions	5
4 Classification of tests	5
5 Order of testing.....	6
6 Reference information required by the test house	6
6.1 Method of mounting and orientation of equipment under test	6
6.2 Reference and control points	7
6.3 Mechanical state and functioning during test	8
6.4 Reproducibility for random vibration tests	8
6.5 Measuring tolerances	9
6.6 Recovery	9
7 Initial measurements and preconditioning.....	9
8 Random vibration test conditions	10
8.1 Test severity and frequency range.....	10
8.2 Duration of functional vibration tests	10
8.3 Functioning during test	11
9 Simulated long life testing at increased random vibration levels	11
9.1 Test severity and frequency range.....	11
9.2 Duration of accelerated vibration tests	11
10 Shock testing conditions	12
10.1 Pulse shape and tolerance.....	12
10.2 Velocity changes	12
10.3 Mounting.....	12
10.4 Repetition rate	12
10.5 Test severity, pulse shape and direction	12
10.6 Number of shocks	12
10.7 Functioning during test	13
11 Transportation and handling.....	13
12 Final measurements.....	13
13 Acceptance criteria	13
14 Report	13

15	Attestation of testing	14
16	Disposal	14
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	21
Annex B (informative)	Guidance for deriving design levels from random vibration test data	28
Annex C (informative)	Figure identifying general location of equipment on railway vehicles and their resulting test category	35
Annex D (informative)	Example of a type test attestation	36
Annex JA (normative)	Vibration test method for railway rolling stock equipment not specified in IEC 61373	37
Annex JB (normative)	Shock resistance test method for railway rolling stock equipment not specified in IEC 61373	44
Annex JC (informative)	Referential information for understanding of random vibration test and for selecting test machine	47
Annex JD (informative)	Comparison table between JIS and corresponding International Standard	61

Foreword

This translation has been made based on the original Japanese Industrial Standard revised by the Minister of Land, Infrastructure, Transport and Tourism through deliberations at the Japanese Industrial Standards Committee as the result of proposal for revision of Japanese Industrial Standard submitted by Japan Association of Rolling Stock Industries (JARI)/Japanese Standards Association (JSA) with the draft being attached, based on the provision of Article 12 Clause 1 of the Industrial Standardization Law applicable to the case of revision by the provision of Article 14.

Consequently **JIS E 4031** : 1994 is replaced with this Standard. Also **JIS E 4032** : 1994 is withdrawn and replaced with this Standard.

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Attention is drawn to the possibility that some parts of this Standard may conflict with a patent right, application for a patent after opening to the public, utility model right or application for registration of utility model after opening to the public which have technical properties. The relevant Minister and the Japanese Industrial Standards Committee are not responsible for identifying the patent right, application for a patent after opening to the public, utility model right or application for registration of utility model after opening to the public which have the said technical properties.

Rolling stock equipment—Shock and vibration tests

Introduction

This Japanese Industrial Standard has been prepared based on the first edition of **IEC 61373** published in 1999, adopting entirely the corresponding parts without any modification of technical contents, but with addition of specification items unique to JIS that are not given in the said International Standard (special provision for equipment whose mass exceeds 500 kg, explanation of ASD, use of official seal designating the conduct of the test). Further, for aiding the conduct of the random vibration test, which has never been specified in any other **JIS** of rolling stock equipment before, the related information for understanding the test and selecting the tester for it is given in Annex JC.

In any future use of this Standard, its body text, and Annex A to Annex D should be preferentially applied for the purpose of achieving conformance to the International Standard.

The portions with continuous sidelines or dotted underlines are the matters in which the contents of the corresponding International Standard have been modified. A list of modifications with explanations is given in Annex JD.

1 Scope

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 and 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.

This 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 (hereafter referred to as “the interested parties”). 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.

When the mass of equipment to be tested (hereafter to be referred to as “equipment under test”) exceeds 500 kg, the test only for the parts constructing the equipment may be applied. In the case of large mass equipment, whether the vibration and shock tests are required or not shall be decided upon agreement between the interested parties. When the vibration and shock tests are not performed, the manufacturer may prove the resistance of the equipment against shock and vibration by calculation.

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 the 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 of metal spring 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. When testing a rotary machine such as a traction motor, it is preferable to perform the test with the machine rotating;
- c) equipment intended for use in special operational environments as specified by the customer.

NOTE 1 This Standard consists of both the test method of **IEC 61373**, which is given in the text, and the test method of the previous **JIS**, which is given in Annex JA and Annex JB, so that the selection is possible.

This Standard is constructed as such because **IEC 61373 : 1999** and the previous **JIS E 4031 : 1994**, though both are the specification of the

vibration test method for railway rolling stock, were considerably different from each other in the test concept or the procedures and in drafting a new **JIS** standard, it was considered that complete conformance of **JIS** to the **IEC 61373 : 1999** involves factors that would require a lot of time to adapt to such as insufficiency of conforming test facilities in Japan and the lack of measure to shorten the test duration (alternative classification) which was possible in the previous **JIS E 4031 : 1994**. Further, the accumulation of data obtained according to the test procedure of the previous **JIS E 4031 : 1994** is sufficient and thus the validity of the test procedure is well established in Japan, and one-way conformance to the **IEC** standard was anticipated to cause confusion among users.

However, it should also be considered that, among the fields of aircraft, automobile and railways, the aircraft and automobile fields in Japan have already adopted the random vibration testing, except for the last remaining sine-wave vibration test in the railways standard. For this reason, in use of this Standard, the specification in the text and those in Annex A to Annex D are to be adopted preferentially for the purpose of achieving conformance to the International Standard.

NOTE 2 The International Standard corresponding to this Standard and the symbol of degree of correspondence are as follows.

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

The symbols which denote the degree of correspondence in the contents between **JIS** and the corresponding International Standard are **IDT** (identical), **MOD** (modified) and **NEQ** (not equivalent) according to **ISO/IEC Guide 21**.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this Standard. For standards with the indication of the year, the edition of the indicated year shall be applied and not any revisions (including amendments) made thereafter. For those without, the most recent edition of the standard (including amendments) shall be applied.

JIS C 60068-2-27 : 1995 *Basic environmental testing procedures. Part 2: Tests. Test Ea and guidance: Shock*

NOTE : Corresponding International Standard: **IEC 60068-2-27 : 1987** *Environmental testing. Part 2: Tests. Test Ea and guidance: Shock* (IDT)

JIS C 60068-2-47 : 2004 *Environmental testing—Part 2-47: Test methods—Mounting of components, equipment and other articles for vibration, impact and similar dynamic tests*

NOTE : Corresponding International Standard: **IEC 60068-2-47 : 1999** *Environmental testing—Part 2-47: Test methods—Mounting of components, equipment and other articles for vibration, impact and similar dynamic tests* (IDT)

JIS C 60068-2-64 : 1997 *Environmental testing—Part 2: Test methods—Test Fh: Vibration, broad-band random (digital control) and guidance*

NOTE : Corresponding International Standard: IEC 60068-2-64 : 1993 *Environmental testing—Part 2: Test methods—Test Fh: Vibration, broad-band random (digital control) and guidance* (IDT)

JIS E 4001 *Railway rolling stock—Vocabulary*

NOTE : Corresponding International Standard: IEC 60050-811 *International Electrotechnical Vocabulary (IEV)—Chapter 811: Electric traction* (MOD)

3 Terms and definitions

For the purpose of this Standard the terms and definitions given in **JIS C 60068-2-64** and **JIS E 4001** apply.

4 Classification of tests

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 service 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:

a) 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 interested parties 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.

b) Simulated long life test levels

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

c) 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.

The requirements of shock testing shall be as specified in clause **10**.

5 Order of testing

A possible order of testing is as follows:

- a) Performance test (see **6.3.3**)
- b) Transfer functions test (vertical, longitudinal and transverse)
- c) Simulated long life test (vertical, longitudinal and transverse)
- d) Shock test (vertical, longitudinal and transverse)
- e) Transportation and handling test (vertical, longitudinal and transverse)
- f) Functional vibration test (vertical, longitudinal and transverse)
- g) Transfer functions test (vertical, longitudinal and transverse)
- h) Performance test (see **6.3.3**)

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. The test of time transfer functions will be taken before and after the testing 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

For general mounting of components, refer to **JIS C 60068-2-47**. Additional general information can be founded in **JIS C 60068-2-64**.

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 referred 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 rms value of the reference signal is equivalent to the root mean square of the rms values of the signals from the control points.

$$\text{Total rms value of the reference point} = \sqrt{\frac{\sum_{i=1}^{i=n_c} (rms_i)^2}{n_c}}$$

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 rms 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 to 10 respectively.

6.3.2 Functional tests

If required, the functional tests shall be specified by the manufacturer and agreed between interested parties 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 interested parties.

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 $1/2 \times \text{ASD}$ 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.

NOTE : ASD (Acceleration Spectral Density) can be also called Acceleration PSD (Acceleration Power Spectral Density). In this Standard, ASD is consistently used.

6.4.2 Root mean square value (rms)

The rms of the acceleration at the reference point over the defined frequency range shall be that specified in figures 1 to 4 ± 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 rms 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 to JIS C 60068-2-64.

6.6 Recovery

The initial and final measurements specified in clause 5 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.

8 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. When the application orientation of equipment is unclear or unknown then the test shall be carried out in the three planes with the rms value given for the vertical plane.

Table 1 Test severity and frequency range for functional random vibration tests

Category		Orientation	RMS m/s ²	Frequency range (see figure)
1 Body mounted	Class A	Vertical	0.75	1
		Transverse	0.37	
		Longitudinal	0.50	
	Class B	Vertical	1.00	2
	Transverse	0.45		
	Longitudinal	0.70		
2 Bogie mounted		Vertical	5.4	3
		Transverse	4.7	
		Longitudinal	2.5	
3 Axle mounted		Vertical	38	4
		Transverse	34	
		Longitudinal	17	
NOTE : These test values are intended to represent typical service values as highlighted in Annex A, and are the minimal test levels to be applied to the equipment under test. Where actual measured data exists the functional vibration test conditions listed below may be increased by using the method shown in Annex A.				

8.2 Duration of functional vibration tests

The duration of the functional vibration test shall be sufficient to allow all the specified functions to be completed.

NOTE 1 The object of this test is to demonstrate that the equipment under test is unaffected by the applied test levels which are representative of those expected in service.

NOTE 2 It is envisaged that these tests would not normally take less than 10 min.

8.3 Functioning during test

The functional tests agreed between the interested parties (see 6.3.2) shall be carried out during functional random vibration testing.

9 Simulated long life testing at increased random vibration levels

9.1 Test severity and frequency range

When the application orientation of equipment is unclear or unknown then the equipment shall be subjected to the vertical test levels of table 2 in all three planes.

Table 2 Test severity and frequency range of simulated long life test

Category		Orientation	RMS 5 h test period m/s ²	Frequency range (see figure)
1 Body mounted	Class A	Vertical	5.90	1
		Transverse	2.90	
		Longitudinal	3.90	
	Class B	Vertical	7.90	2
		Transverse	3.50	
		Longitudinal	5.50	
2 Bogie mounted		Vertical	42.5	3
		Transverse	37.0	
		Longitudinal	20.0	
3 Axle mounted		Vertical	300	4
		Transverse	270	
		Longitudinal	135	

9.2 Duration of accelerated vibration tests

All categories of equipment shall be subjected to a total conditioning time of 15 h. This shall normally be divided into periods of 5 h conditioning in each of three mutually perpendicular axes. If during the course of testing over heating of equipment is felt to be a problem, (i.e. vibration of rubber parts, etc.) it is permissible to stop the tests for a period of time in order to allow the equipment to recover. However, it must be noted that the total duration of 5 h vibration shall be achieved. If tests are stopped then this shall be stated in the report.

NOTE 1 It is not necessary for equipment to function during this test.

NOTE 2 It is possible by prior agreement to reduce the amplitude of vibration. However, it is essential that the duration of the test period be increased in accordance with the method shown in Annex A. This is not a preferred option and should be limited to Category 3 axle mounted equipment. When this method is used no attestation of testing may be issued as it is outside the scope of this recommendation.

10 Shock testing conditions

10.1 Pulse shape and tolerance

The equipment under test shall be subjected to a sequence of single half sine pulses each with a nominal duration of D and a nominal peak amplitude of A conforming to **JIS C 60068-2-27** (see figure 6 for values of D and A).

The transverse motion shall not exceed 30 % of the peak acceleration of the nominal pulse in the intended direction in accordance with **JIS C 60068-2-27**.

Figure 6 shows pulse shape and tolerance limits.

10.2 Velocity changes

The actual velocity change shall be within ± 15 % of the value corresponding to the nominal pulse shown in figure 6.

Where the velocity change is determined by integration of the actual pulse shown, it shall be evaluated over the integration time interval shown in figure 6.

10.3 Mounting

The equipment under test shall be connected to the test machine in accordance with **6.1**.

10.4 Repetition rate

In order to allow the equipment under test to recover from any resonance effects sufficient time shall be allowed to elapse between the application of shocks.

10.5 Test severity, pulse shape and direction

Values are given in table 3.

Table 3 Test severity, pulse shape and direction of shock and vibration tests

Category	Orientation	Peak acceleration $A \text{ m/s}^2$	Nominal duration $D \text{ ms}$
1 Class A and class B Body mounted	Vertical	30	30
	Transverse	30	30
	Longitudinal	50	30
2 Bogie mounted	All	300	18
3 Axle mounted	All	1 000	6
NOTE: See figure 6 for pulse shape details.			

10.6 Number of shocks

The 18 shocks (three positive and three negative in each of the three orthogonal planes) as specified in **JIS C 60068-2-27** shall be applied to the equipment. This test shall be repeated for each mechanical state as identified in **6.3.1**.

10.7 Functioning during test

It is not necessary for the equipment to operate during tests. Nevertheless some equipment may have to keep integrity of its function and that shall be verified as requested by the manufacturer or the customer in the test specification except otherwise stated in the relevant product standard.

11 Transportation and handling

Where transportation and handling tests are specifically requested by the end user, they shall be in accordance with **JIS C 60068-2-27**.

12 Final measurements

On completion of the tests, the equipment shall be subjected to a performance test according to **6.3.3**. Owing to the nature of such testing, it may be outside the capability of the test house. In such cases, the tests will be conducted by the manufacturer who shall provide a statement that the item under test conformed with the performance tests after the vibration and shock testing identified in this Standard.

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) with 0 % overlap, shall be taken.

Any changes in the transfer functions or other measurements shall be investigated and explained in the test report.

13 Acceptance criteria

On completion of all the tests the equipment shall be considered acceptable for attestation of testing when the following applies:

- a) performance according to **6.3.3** remains within the defined limits;
- b) function according to **6.3.2** remains within the defined limits;
- c) visual appearance and mechanical integrity has not changed.

14 Report

Upon completion of all or part of the tests, final measurements and functional checks, the test house shall issue a comprehensive report to their customer. The report shall describe the execution of the tests and their effect on the equipment together with:

- a) the summary which shall identify changes which have occurred during the tests. Serial numbers/identification shall be quoted;
- b) details of the instrumentation and test procedures used, which shall be made available on request. They may be included in the report but this is not mandatory;

- c) methods of mounting which shall be reported as identified in **6.1**;
- d) method and order of testing used. The report shall also include figures showing the location of all control and measuring positions;
- e) functional tests carried out and values obtained pre-test and post-test;
- f) results of tests from control and reference positions, together with observations against the set objectives and acceptance criteria. The report shall contain all the control point graphs which shall be in the format of figures 1 to 6. They shall also contain the tolerance bands in order to demonstrate that the tests remained within the tolerance limits stated in this Standard;
- g) all observations done when functional test during vibration and/or function verification during shock are required.

NOTE : Where special tests have been carried out which exceed the requirements of this Standard they may be included in the report.

15 Attestation of testing

Attestation of testing shall include all of the following information:

- a) description of equipment tested;
- b) manufacturer's name;
- c) equipment type and issue/modification status;
- d) equipment serial number;
- e) test house report number;
- f) report date;
- g) product test specification.

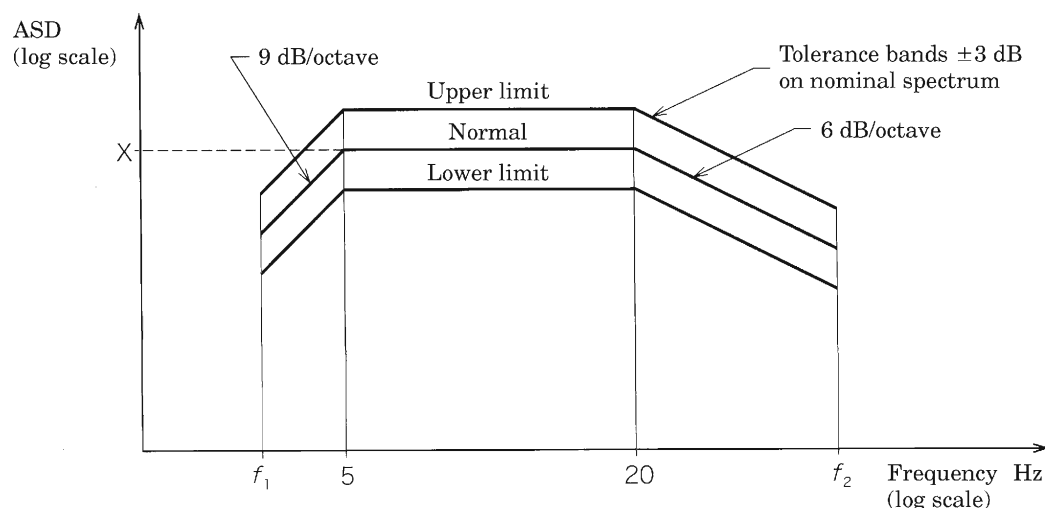
This attestation shall be signed by authorized representatives of the test house and the manufacturer or shall be stamped with an official seal.

NOTE : An example of a typical type test attestation is shown in Annex D.

16 Disposal

The equipment, having satisfied the test objects and acceptance criteria may be refurbished, to a standard agreed between the manufacturer and the end user, and placed in operational service.

For traceability purposes, it is the responsibility of the manufacturer to identify clearly all items which have been tested in accordance with this Standard.

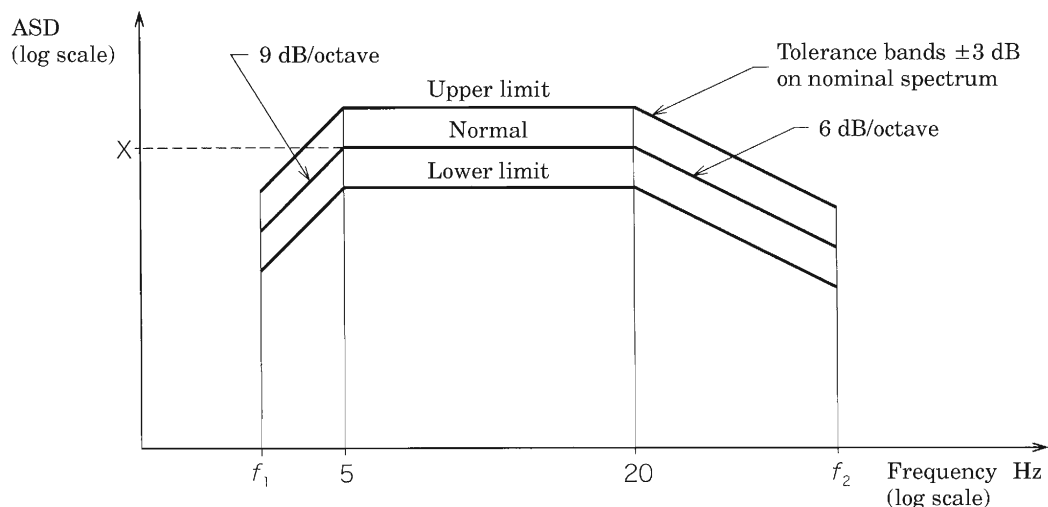


$$\begin{array}{lll}
 M < 500 \text{ kg} : & f_1 = 5 \text{ Hz} & f_2 = 150 \text{ Hz} \\
 500 \text{ kg} < M < 1\,250 \text{ kg} : & f_1 = \frac{1\,250}{M} \times 2 \text{ Hz} & f_2 = \frac{1\,250}{M} \times 60 \text{ Hz} \\
 1\,250 \text{ kg} < M : & f_1 = 2 \text{ Hz} & f_2 = 60 \text{ Hz}
 \end{array}$$

where, M : mass of equipment

	Vertical	Transverse	Longitudinal
Functional test ASD level (m/s ²) ² /Hz	0.016 4	0.004 1	0.007 3
Excitation level RMS value m/s ² 2 Hz to 150 Hz	0.75	0.37	0.50
Long life test ASD level (m/s ²) ² /Hz	1.034	0.250	0.452
Excitation level RMS value m/s ² 2 Hz to 150 Hz	5.9	2.9	3.9
NOTE 1 For items with test frequencies less than 2 Hz the rms levels will be higher than those quoted above. NOTE 2 For items with test frequencies less than 150 Hz the rms levels will be lower than those quoted above. NOTE 3 If frequencies above f_2 are known to exist they may be included, the amplitude being established by extending the 6 dB/octave decay line until it intersects the maximum frequency required. In such cases the rms levels will be increased.			

Figure 1 Category 1 – Class A – Body-mounted – ASD spectrum



$$\begin{aligned}
 M < 500 \text{ kg} : & \quad f_1 = 5 \text{ Hz} & \quad f_2 = 150 \text{ Hz} \\
 500 \text{ kg} < M < 1\,250 \text{ kg} : & \quad f_1 = \frac{1\,250}{M} \times 2 \text{ Hz} & \quad f_2 = \frac{1\,250}{M} \times 60 \text{ Hz} \\
 1\,250 \text{ kg} < M : & \quad f_1 = 2 \text{ Hz} & \quad f_2 = 60 \text{ Hz}
 \end{aligned}$$

where, M : mass of equipment

	Vertical	Transverse	Longitudinal
Functional test ASD level (m/s ²) ² /Hz	0.029 8	0.006 0	0.014 4
Excitation level RMS value m/s ² 2 Hz to 150 Hz	1.00	0.45	0.70
Long life test ASD level (m/s ²) ² /Hz	1.857	0.366	0.901
Excitation level RMS value m/s ² 2 Hz to 150 Hz	7.9	3.5	5.5
NOTE 1 For items with test frequencies less than 2 Hz the rms levels will be higher than those quoted above. NOTE 2 For items with test frequencies less than 150 Hz the rms levels will be lower than those quoted above. NOTE 3 If frequencies above f_2 are known to exist they may be included, the amplitude being established by extending the 6 dB/octave decay line until it intersects the maximum frequency required. In such cases the rms levels will be increased.			

Figure 2 Category 1 – Class B – Body-mounted – ASD spectrum