COMMITTEE OF EXPERTS ON THE TRANSPORT OF DANGEROUS GOODS AND ON THE GLOBALLY HARMONIZED SYSTEM OF CLASSIFICATION AND LABELLING OF CHEMICALS

Sub-Committee of Experts on the
Transport of Dangerous Goods

Thirtieth session
Geneva, 4-12 (a.m.) December 2006
Item 10 of the provisional agenda

ANY OTHER BUSINESS

NOTE ON THE WORK OF WORKING GROUP ISO/TC122/SC3/WG 7 "RANDOM VIBRATION TEST"

Transmitted by the International Standards Organization (ISO)

The Technical Committee ISO/TC122 "packaging" and Its Sub-Committee 3 "Performance requirements and tests for means of packaging, packages and unit loads" met in Atlanta from25 to 27 October".

On that occasion there was a meeting of the Working Group ISO/TC122/SC3/WG 7 "Random vibration". A main subject was the discussion on the periodical review of ISO 13335:2001: *"Packaging -- Complete,filledtransport packages and unit loads -- Vertical random vibration tests"*

ISO 13335:2001 specifies a method to carry out vertical random test on a complete, filled transport package or unit load using random excitation. It contains an informative annex which gives an indicative power spectral density which can be used to simulate generic (mainly road) transport, when experimental recordings are not available. It does not attempt to address the correlation between transport distance and test time.

Two proposals were made to revise this standard by the addition of further informative annexes, one from Japan and one from CEN. Each of them proposes a vibration spectrum derived from measurements of actual transport loads. Although both proposals were felt to be valuable contributions, at the Atlanta meeting the Working Group did not feel it could commit itself to an immediate revision. For the time being the standard has been confirmed, but the WG will continue to consider the subject and may in the future decide to incorporate one or both of them in the standard.

Brief summaries of proposals are available in attached mail from the ISO/TC122/SC3 Secretary.

The UN Subcommittee of Experts on the Transport of Dangerous Goods is hereby invited to take note of the above. Interested members might contact the ISO/TC122/SC3 Secretary, Mr. Mick Maghar for additional information.

* * *

Date: 17 November 2006

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Dear Mr Abram

I would like to draw the attention of the UN Sub-Committee of Experts on the Transport of Dangerous Goods to a project which is currently under consideration in ISO/TC 122/SC 3, *Packaging – Test methods*.

ISO 13355 2001: *Packaging — Complete, filled transport packages and unit loads — Vertical random vibration test* specifies a method to carry out a vertical random vibration test on a complete, filled transport package or unit load using random excitation. It contains an informative annex which gives an indicative power spectral density which can be used to simulate generic (mainly road) transport, when experimental recordings are not available. It does not attempt to address the correlation between transport distance and test time.

Two proposals have been made to revise this standard by the addition of further informative annexes, one from Japan and one from CEN. Each of them proposes a vibration spectrum derived from measurements of actual transport loads. Although both proposals were felt to be valuable contributions, at a recent meeting the Working Group did not feel it could commit itself to an immediate revision. For the time being the standard has been confirmed, but the WG will continue to consider the subject and may in the future decide to incorporate one or both of them into the standard.

I enclose brief summaries of both proposals.

Yours sincerely

M. Maghar

M Maghar
Secretary ISO/TC 122/SC 3

CEN/TC 261
Packaging

Subcommittee 5
Primary and transport packaging

Working Group 14
Test methods

Proposal concerning ISO 13355

Adding an Annex

by Ulrich Braunmiller

Proposal: Add the following annex to ISO 13355

Annex B
(informative)

Table B.1 gives test duration and power spectral density of the vibration derived of measured data of western European transports. This is a multilevel test where all three levels are performed in sequence of any succession. The test in table B.1 is giving an adequate test for a 12 hours transport on road. To reduce testing time the levels could be increased by multiplying the values of all power spectral densities with factors according to table B.2.

Table B.1: Vibration spectrum for road transport

	Power Spectral Density		
Frequency in Hz	**Level 1 in g^2/Hz**	**Level 2 in g^2/Hz**	**Level 3 in g^2/Hz**
3	0,001920	0,003780	0,006000
5	0,003200	0,006300	0,010000
11			0,010000
24	0,000500	0,000960	
38	0,000052	0,000100	
48			0,000300
61	0,000044	0,000087	
71			0,000300
80			0,000150
98	0,000014	0,000028	
200	0,000014	0,000028	0,000150
time [h:min:s]	07:12:00	03:36:00	01:12:00
Percent of test time	***60***	***30***	***10***
3-200 Hz a_{RMS}/g	*0,181*	*0,253*	*0,415*
5-200 Hz a_{RMS}/g	*0,167*	*0,233*	*0,395*

**Note: Peak to peak displacement may exceed 1 inch by testing with low frequencies.
A frequency range from 5 to 200 Hz may be sufficient for a testing of small items**

Table B.2: Factors to increase the vibration level and reduce the test time, basis is a 12 hour transport

Test time T_2 in hours : minutes	**Level increase factor I**
0:30	1,89
1:00	1,64
2:00	1,43
3:00	1,32
4:00	1,25
6:00	1,15
9:00	1,06
12:00	1,00

Note: The minimum testing duration per relevant axis should be 30 minutes

Motivation and Background

1 Basis of the proposal are the results of the EU Project SRETS (Source Reduction by European Testing Schedules)

In a joint research project of ten partners mechanical-dynamical transportation loads were measured. Measurements took place in UK, Spain, Portugal and Germany on different vehicles and roads. Of this measured data vibration spectra were calculated. Evaluations of these spectra took place by vibrating four products. For each product type and probability of damage due to transport vibration was known. The test spectra reproduced both well.

Table: Data of the joint research project

Source Reduction by European Testing Schedules (SRETS)	
Final Report	
1. February 1996 - 31. January 1999	
Contract N° SMT4-CT95-2005 (DG 12 - RSMT)	
Project partner:	
Fraunhofer-Institut Chemische Technologie (Co-ordinator)	D
Pira International	UK
Packforsk - Swedish Packaging Research Institute	S
Fraunhofer-Institut Materialfluß und Logistik	D
Laboratoire National D´Essais	F
Beratung, Forschung, Systemplanung, Verpackung e.V.	D
Robert Bosch GmbH	D
Tetra Pak Carton Systems (Tetra Pak - Alfa Laval Materials)	I, S
J&B Scotland LTD	UK
Hunting Engineering Ltd	UK

Printed versions of the reports are available as
- BCR information, Project reports, Report EUR 19090, ISBN 92-828-7624-1 (black and white version)
- Packforsk report No 189, ISSN 1402-5809 (coloured version)

The report is also available as a download by CEEES on
- www.ceees.org under www.ceees.org/pdf/srets.pdf

2 Results of the SRETS project modified by CEN TC261/SC 5/WG 14

Basis see www.ceees.org/pdf/srets.pdf
A three level test is proposed, no fixed sequence of the levels
Test time: based on a 12 hour real time transport
Frequency ranges: 3 to 200 Hz

Test Without time compression

Total Testing Time [h:min]:		12:00	h
Frequency in Hz	v_1 in g²/Hz	v_2 in g²/Hz	v_3 in g²/Hz
3	0,001920	0,003780	0,006000
5	**0,003200**	**0,006300**	**0,010000**
11			**0,010000**
24	**0,000500**	**0,000960**	
38	**0,000052**	**0,000100**	
48			**0,000300**
61	**0,000044**	**0,000087**	
71			**0,000300**
80			**0,000150**
98	**0,000014**	**0,000028**	
200	**0,000014**	**0,000028**	**0,000150**

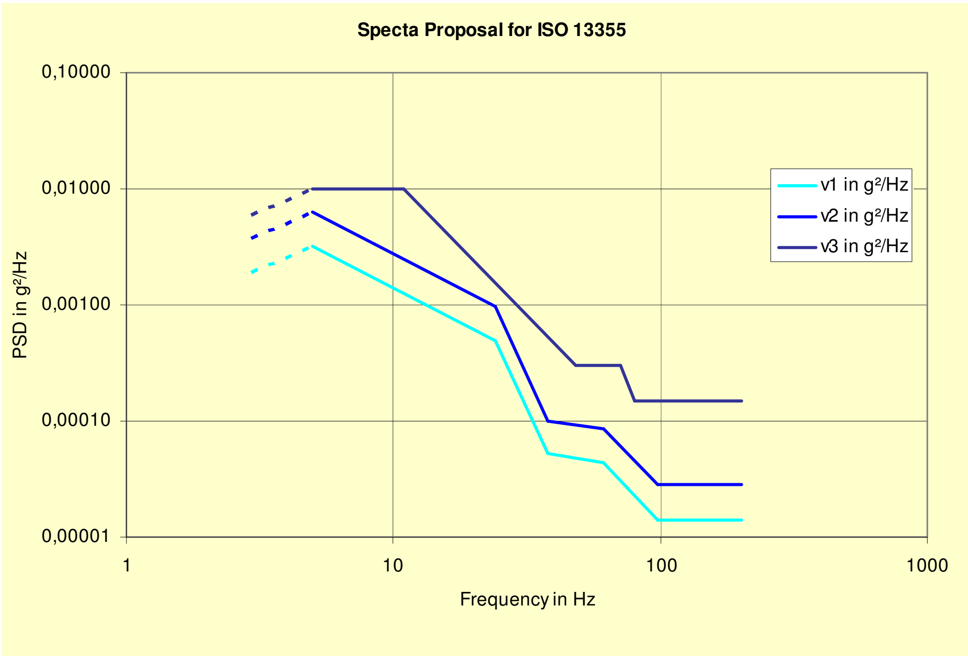
time	[h:min:s]	07:12:00	03:36:00	01:12:00
3-200 Hz	*a_{RMS} / g*	*0,18*	*0,25*	*0,41*
	v / m/s	*0,14*	*0,19*	*0,27*
	d / mm(pp)	*13,5*	*19,0*	*24,4*
5-200 Hz	*a_{RMS} / g*	*0,17*	*0,23*	*0,395*
	v / m/s	*0,09*	*0,13*	*0,202*
	d / mm(pp)	*5,8*	*8,1*	*11,3*

v_1, v_2, v_3: Vibrations Levels, Power Spectral Density in g²/Hz

a_{RMS}: Root mean square value of the acceleration in g

v: Velocity in m/s

d: Displacement (peak to peak) in mm



The requirements of a 1 inch shaker can be met if the frequency range is reduced to 5 to 200 Hz

3 Time compression

A method for calculating accelerated test times can be used, but shorter times would be less accurate and a 30 minute test should be the lowest limit for the test time.

A time compression is also possible by using the Miner-Palmgren hypothesis. Using the value 5 for the k-factor is proposed

Formula for test time reduction: $\frac{T_{real}}{T_{test}} = \left(\frac{a_{RMS\,test}}{a_{RMS\,real}}\right)^{2\cdot k} = \left(\frac{PSD_{test}}{PSD_{real}}\right)^{k}$

a_{RMS}: RMS Value of Acceleration in g or in m/s²
PSD: Break Point in Power Spectral Density in g²/Hz or in (m/s²)²/Hz
T_{real}: Time for transport
T_{test}: Time for test

Objective: 30 min of testing
Power Spectral Density increase by $(24)^{0,2}$ = 1,8882

Objective: 60 min of testing
Power Spectral Density increase by $(12)^{0,2}$ = 1,6438

The general increase of the power spectral density is $\left(\frac{T_{real}}{T_{test}}\right)^{\frac{1}{k}}$

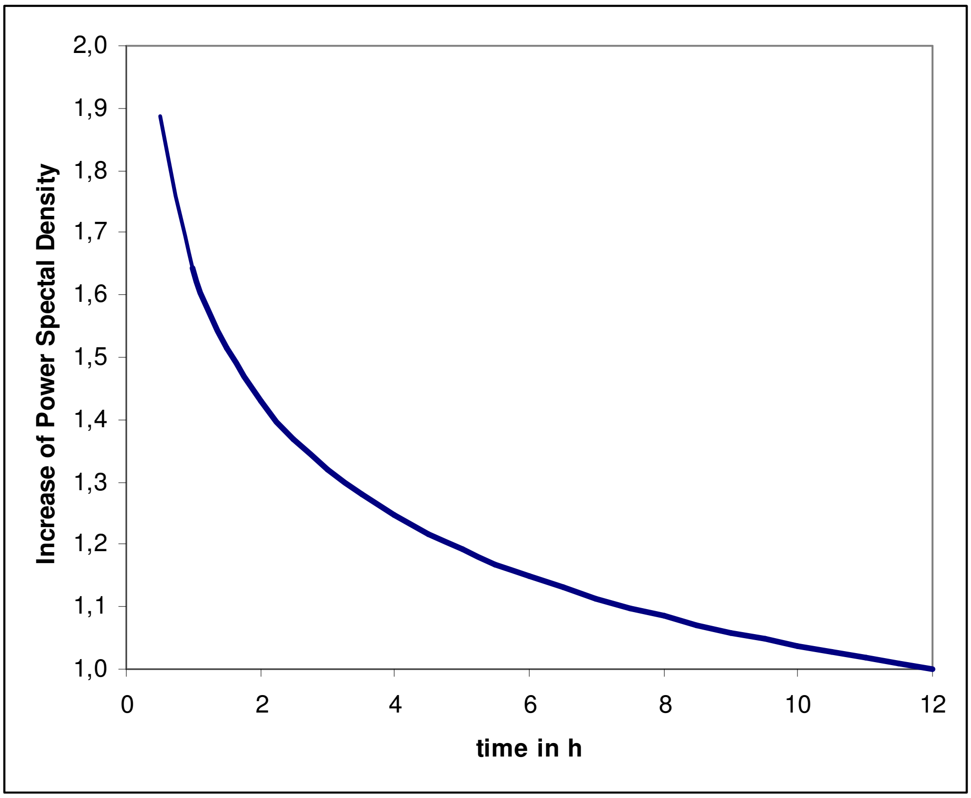


Figure: General increase of the power spectral density if T_{real} = 12 h and k=5

4 Example 30 Minutes Test

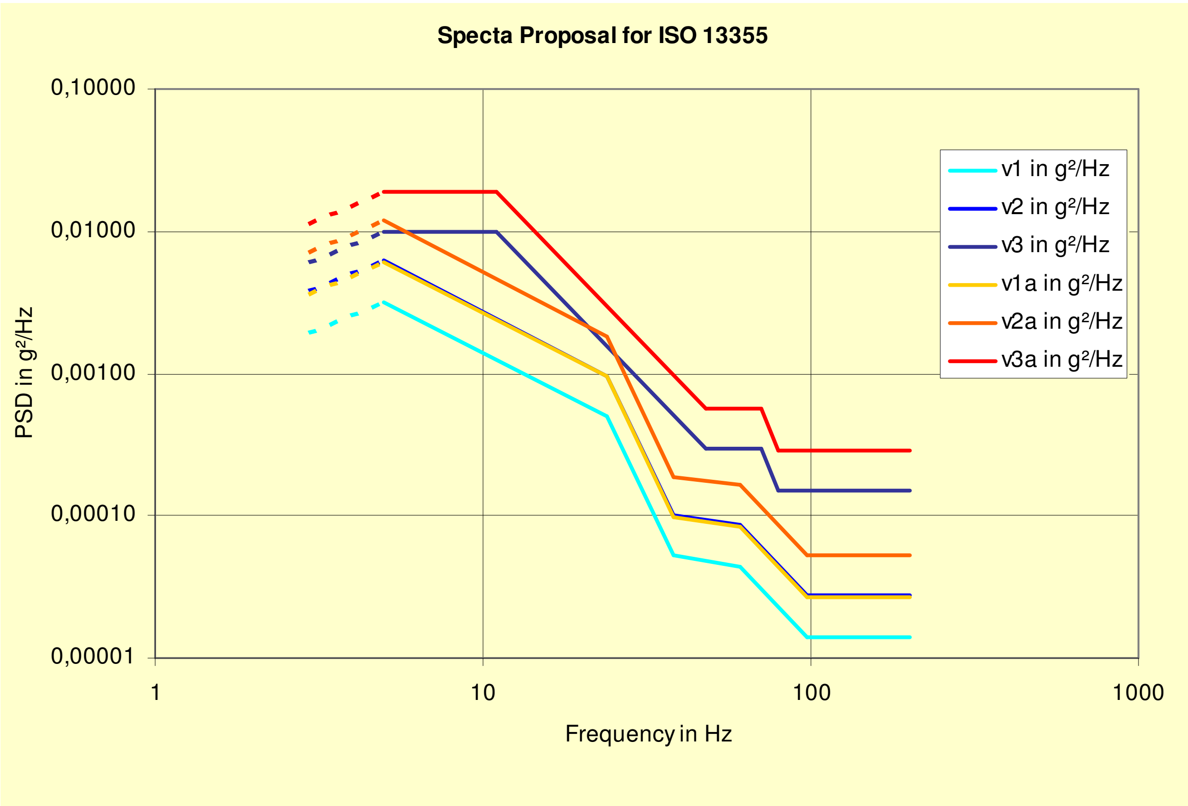
	Acc. Testing Time [h:min]:		**0:30**	h
	Frequency in Hz	v_{1a} in g²/Hz	v_{2a} in g²/Hz	v_{3a} in g²/Hz
	3	0,003625	0,007137	0,011329
	5	**0,006042**	**0,011896**	**0,018882**
	11			**0,018882**
	24	**0,000944**	**0,001813**	
	38	**0,000098**	**0,000189**	
	48			**0,000566**
	61	**0,000083**	**0,000164**	
	71			**0,000566**
	80			**0,000283**
	98	**0,000026**	**0,000053**	
	200	**0,000026**	**0,000053**	**0,000283**
time	[h:min:s]	00:18:00	00:09:00	00:03:00
3-200 Hz	*a_{eff} / g*	*0,25*	*0,35*	*0,57*
	v / m/s	*0,19*	*0,26*	*0,37*
	d / mm(pp)	*18,6*	*26,1*	*33,6*
5-200 Hz	*a_{eff} / g*	*0,23*	*0,32*	*0,54*
	v / m/s	*0,13*	*0,18*	*0,28*
	d / mm(pp)	*7,9*	*11,1*	*15,5*

v_{1a}, v_{2a}, v_{3a}: Vibrations Levels, Power Spectral Density in g²/Hz

a_{RMS}: Root mean square value of the acceleration in g

v: Velocity in m/s

d: Displacement (peak to peak) in mm



Picture: 30 Minutes Test compared to real time test

5 Example 60 Minutes Test

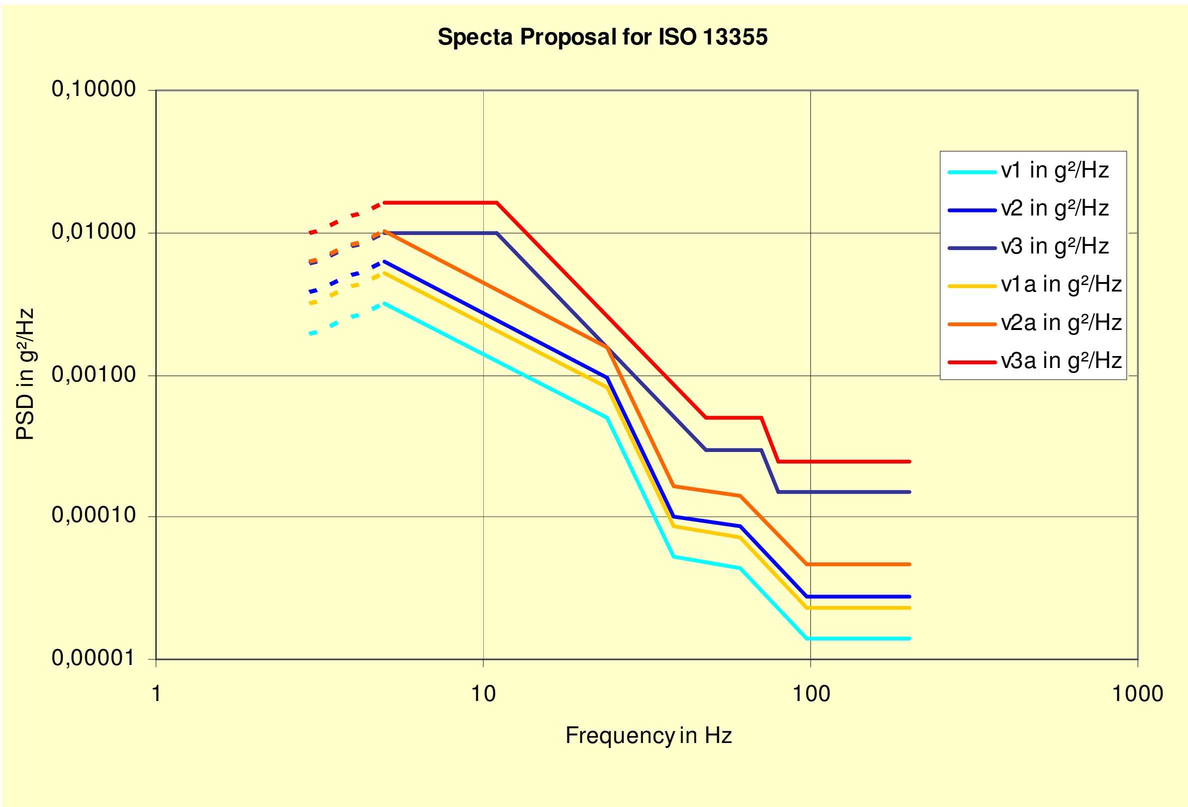
	Acc. Testing Time [h:min]:		1:00	h
	Frequency in Hz	v_{1a} in g²/Hz	v_{2a} in g²/Hz	v_{3a} in g²/Hz
	3	0,003156	0,006213	0,009863
	5	**0,005260**	**0,010356**	**0,016438**
	11			**0,016438**
	24	**0,000822**	**0,001578**	
	38	**0,000085**	**0,000164**	
	48			**0,000493**
	61	**0,000072**	**0,000143**	
	71			**0,000493**
	80			**0,000247**
	98	**0,000023**	**0,000046**	
	200	**0,000023**	**0,000046**	**0,000247**
time	[h:min:s]	00:36:00	00:18:00	00:06:00
3-200 Hz	*a_{eff} / g*	*0,23*	*0,32*	*0,53*
	v / m/s	*0,17*	*0,24*	*0,34*
	d / mm(pp)	*17,4*	*24,4*	*31,3*
5-200 Hz	*a_{eff} / g*	*0,21*	*0,30*	*0,51*
	v / m/s	*0,12*	*0,17*	*0,26*
	d / mm(pp)	*7,4*	*10,4*	*14,5*

v_{1a}, v_{2a}, v_{3a}: Vibrations Levels, Power Spectral Density in g²/Hz

a_{RMS}: Root mean square value of the acceleration in g

v: Velocity in m/s

d: Displacement (peak to peak) in mm



Picture: 60 Minutes Test compared to real time test

Japanese Proposal

for ISO 13355:2001 Packaging – Complete, filled transport packages and unit loads –

Vertical random vibration test Annex (informative)

September 20, 2006
Eiichi Maezawa
Japanese representative of ISO/TC122/SC3/WG7

1. Random Vibration Test Specification to Annex of Random Vibration Test(ISO 13355)

① Random vibration test duration

Journey length (km)	Test Duration (min)
～200	15
200～500	30
500～1000	60
1000～1500	90
1500～2000	120
2000～2500	150
2500～	180

② Random vibration test PSD

Frequency (Hz)	PSD (g^2／Hz)
2	0.004
3～16	0.01
200	0.00001

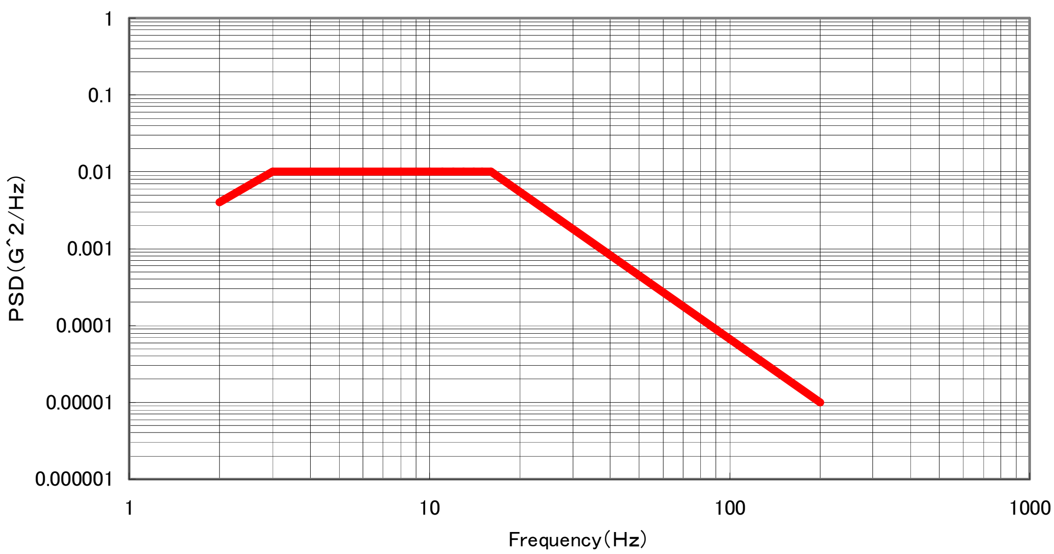


Figure 1 Test PSD Profile

2. Descriptions of the Random Vibration Test Specification proposed

2–1 Aim of design on laboratory random vibration test specification

The proposed test specifications (PSD level, frequency range, duration) are designed to simulate the capability of accumulated fatigue caused by transport vibrations.

2–2 Tailoring the transport distribution

Table 1 Transport distribution scenario（*1Unit: Journey length =1 Km ）

Transportation route	Factory	⇒	Delivery center	⇒	Distributor company	⇒	Dealer
Transportation mode	Large-sized vehicle		Large-sized vehicle		Large and medium sized vehicle		
Running road (Running speed)	Expressway (80km/hr)		Expressway (80km/hr)		General road (40km/hr and below)		
*2 Distribution ratio of vibration severity %	A: 70% B: 30%		A: 20% B: 80%		B: 97% C: 3%		

*1: The average running speed of the transport distribution scenario ≒ 80km/Hr.
Running duration = 0.75min/km.

*2: 3 groups classified by vibration severity（refer to 2-4） A: good vibration, B: usual vibration, C: bad vibration

2–3 PSD of the measured data according to table 1.

The measured vibration PSD of the transport distribution scenario (Table 1) is shown in the figure 2.

2–4 Distribution ratio of vibration severity and average PSD

The vibration severity data are classified into 3 groups (Table 2) according to the level of the PSD primary mode and distributed to the transportation routes of the transport distribution scenario (Table 3).

The average PSD of the vibration data classified into 3 groups are shown in the figure 3.

Table 2: 3 group ranges of vibration severities levels

Vibration severity level		PSD（g^2/Hz）
A	Good vibration	0.005 below
B	Usual vibration	0.005–0.03
C	Bad vibration	0.03 above

Table 3: Dist. of vibration severity of transport dist. scenario

Transport vibration		Dist. ratio(%)
A	Good Vibration	30
B	Usual Vibration	69
C	Bad Vibration	1
Total		100

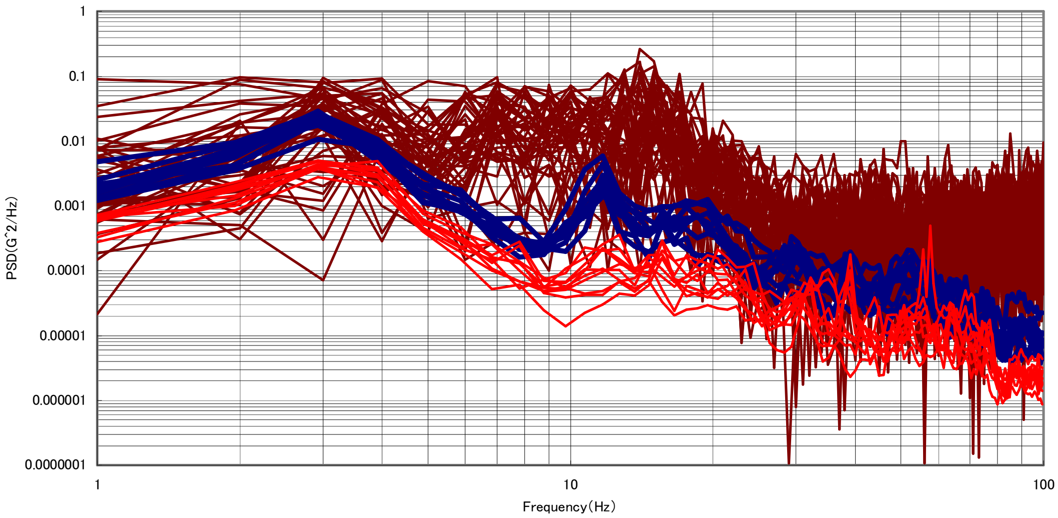


Figure 2 Transport vibration PSD

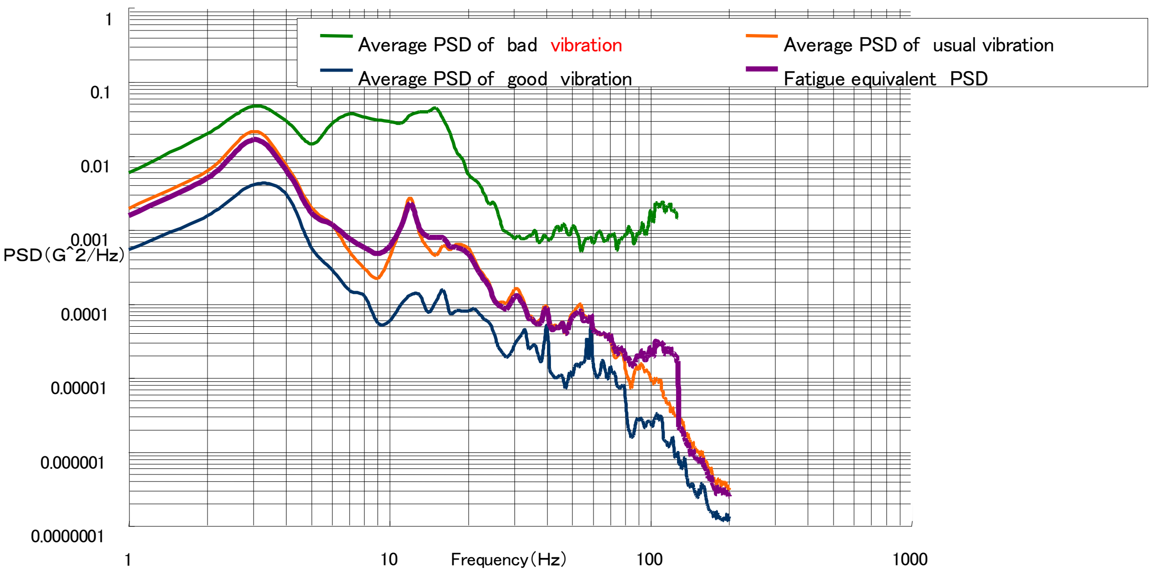


Figure 3: Average PSD of classified 3 groups and those fatigue equipollent PSD groups

2-5 Histogram with acceleration G levels and its numbers from time-history vibration

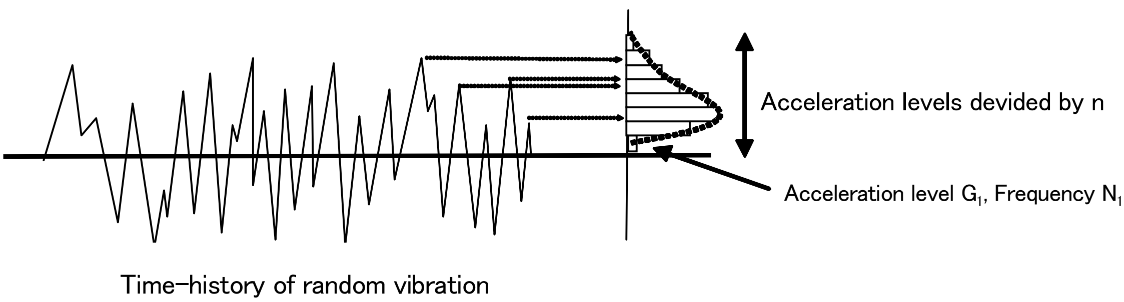


Figure 4 Distribution chart of acceleration G and its numbers

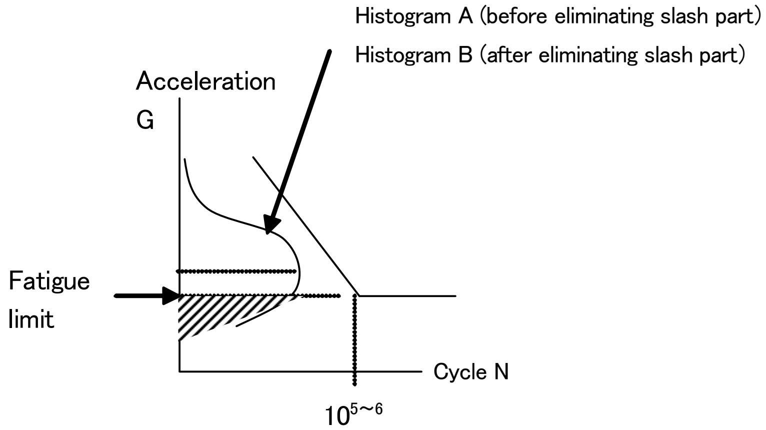


Figure 5: Random vibration histogram and fatigue limit

(1) A histogram (Histogram A) which adds the percentage of distribution ratio of vibration severity to the acceleration G level frequency histogram of the measured vibration severity data classified into 3 groups (frequency conversion by unit-length km conversion) is shown in Figure 6.

(2) Among Histogram A, a histogram (Histogram B) which eliminates small accelerations that correspond more than the fatigue limit cycle numbers (N=105～6) on the fatigue curve (SN curve) is shown in Figure 7.

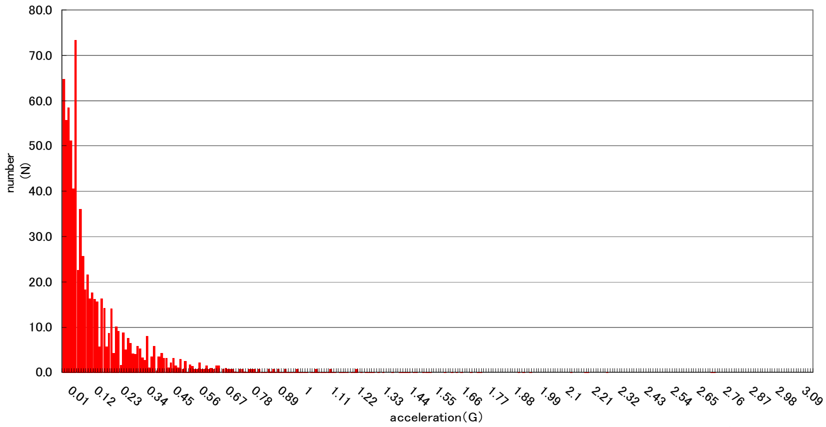


Figure 6: Histogram A (unit-length 1 Km conversion)

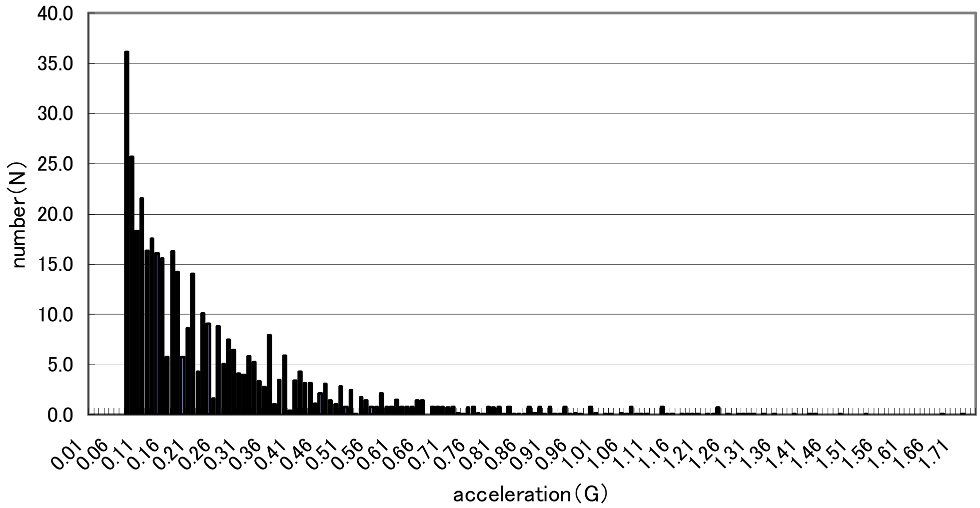


Figure 7: Histogram B (which eliminates small accelerations that correspond more than fatigue limit cycle number N=$10^{5\sim6}$ among Histogram A)

2-6 Vibration fatigue

(1) Accumulated fatigue D_a and acceleration equivalent G_{aO} of Histogram A

$$G^{\alpha}_{1} \cdot N_1 = G^{\alpha}_{a0} \cdot N_{a1}$$
$$G^{\alpha}_{2} \cdot N_2 = G^{\alpha}_{a0} \cdot N_{a2}$$
$$\vdots$$
$$G^{\alpha}_{n} \cdot N_n = G^{\alpha}_{a0} \cdot N_{an}$$

D_a = Accumulated fatigue of Histogram A
α = Index on the SN curve
(Material characteristic constant)
N_i = Total cycle number of Histogram A
G_{aO} = Acceleration equivalent of Histogram A
N_{a0} = Cycle number of G_{aO}

$$D_a = \sum_{i=1}^{n} G_i^{\alpha} \cdot N_i = G_{a0}^{\alpha} \sum_{i=1}^{n} N_{ai} \qquad (1)$$

$D_a = 42.4$

$$G_{a0} = \left(\frac{\sum G_i^{\alpha} N_{ai}}{\sum N_{a0}} \right)^{\frac{1}{\alpha}} \qquad (2)$$

$G_{aO} = 0.21$
$N_{a0} = 756$

(2) Accumulated fatigue D_b of Histogram B and cycle number N_{b0} when converging Histogram B to G_{aO}

$D_b = 22.1$
$N_{b0} = 373$

D_b = Accumulated fatigue of Histogram B
N_{b0} = Cycle number when converting Histogram B to G_{aO}

2-7 Time compression

A method for time compression can be used by the following two methods.

(1) Time compression rate K_1 by eliminating accelerations that correspond more than fatigue limit cycle numbers (N=$10^{5\sim6}$) shown in figure 5 (N = $10^{5\sim6}$)

* Time compression rate K_1 = Cycle numbers N_{b0}／Cycle numbers N_{a0}
= 0.5

(2) Time compression rate K_2 by using the fatigue curve (SN curve) of the Miner's rule

* A formula for calculating the amount of acceleration increase corresponding to a test duration.
Test intensity $G_t = G_f(T_f$: transport duration／T_t: test duration$)^{1/\alpha}$
G_f : Original intensity

* Index α on the SN curve = to apply number of 2 , $1/\alpha = 0.5$

* The value of fatigue equivalent PSD_C = 0.002 g^2/Hz (3～16Hz) is accelerated to five times.
(2.24 times of the acceleration)
Test PSD = Fatigue equivalent PSD_C X 5 = 0.01 g^2/Hz
(Time compression rate $K_2)^{\alpha} = 2.24$
Time compression rate $K_2 = T_t / T_f = 1/2.24^{\alpha}$ ≒ compressed to 1/5

(3) Total time compression rate K_3

$K_3 = K_1 \times K_2 = 0.1$

* 0.75 min/km of the running duration in the transport distribution scenario (Table 1) can be compressed to 0.075min/km

2-8 Test PSD

(1) PSD_B of Histogram B (Figure 8)

* Primary mode=3Hz (2～5Hz), Secondary mode:=12Hz(10～16Hz)

(2) PSD_C of fatigue equivalent to PSD_B (Figure 8)

* Among PSD_B, flat PSD of which fatigue equivalence is equal to that of 3～16Hz domain of the primary and secondary modes frequencies is 0.002 (g^2/Hz)

* 2Hz breakpoint = 0.0008 (g^2/Hz)

＊ 200Hz breakpoint ＝ 0.000002 (g^2/Hz)

(3) Test PSD (Figure 8)

＊ Test PSD ＝ PSD_C x 5

＊ 2Hz breakpoint ＝ 0.004 (g^2/Hz)

＊ 3～16Hz: flat PSD ＝ 0.01 (g^2/Hz)

＊ 200Hz breakpoint ＝ 0.00001 (g^2/Hz)

＊ G_{rms} of Test PSD ＝ 0.48

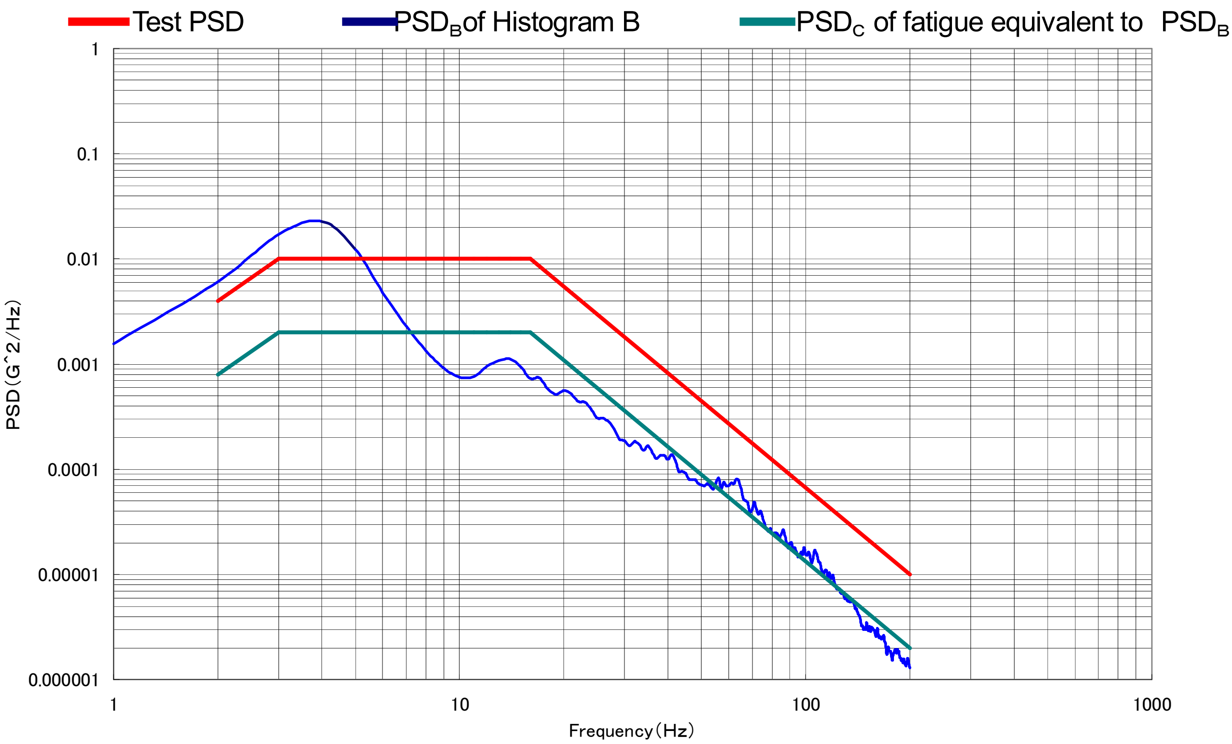


Figure 8: Test PSD

2-9 Test Duration

Journey length (km)	Test Duration (min)
～200	15
200～500	30
500～1000	60
1000～1500	90
1500～2000	120
2000～2500	150
2500～	180