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EXPOSURE OF TIMBER TRUCK DRIVERS TO WHOLE-BODY VIBRATION AND NOISE

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ABSTRACT

The research focused on the exposure of timber truck drivers to whole-body vibration and noise. Sixteen timber trucks were chosen as the objects of the study. Vibration was recorded simultaneously from the seat and from the floor of the truck cabin, next to the seat fastening. Also, vibration was measured from the seat of the timber crane. The weighted one-third octave spectra of vibration were analyzed according to the 2002/44/EC "vibration directive" and the ISO 2631 (1997) standard. Seat vibration of the trucks exceeded the daily exposure action value of 0.5 m/s^2 in 63% of the cases. In the vertical direction, the seat vibration was the most powerful at frequencies between 1 and 12.5 Hz, and in the longitudinal and transverse directions at frequencies below 5 Hz. In the seats of the timber cranes, vibration exceeded the daily exposure limit value of 1.15 m/s^2 in some cases. The noise exposure of the drivers was below 80 dB(A), and inside the cabin of the truck, noise was the most powerful at frequencies between 63 and 2000 Hz.

1. INTRODUCTION

For most road, off-road, rail and air vehicles, the vibration acceleration spectra are complex but often include one or two principal components in the range of 0.5−5.0 Hz. Vehicle seating tends to amplify the vibration at some frequencies in the range of 1−5 Hz, depending on seat characteristics [1]. Whole-body vibration is a well-known risk factor when considering degeneration of the lumbar spine and chronic back disorders. However, the mechanism causing these degenerative changes remains obscure.

European Union Member States were to bring into force the 2002/44/EC "vibration directive" of the European Parliament no later than 6 July 2005. However, Member States may apply for a transitional period of up to five years for equipment given to workers before 6 July 2007. For whole-body vibration, the daily exposure limit value mentioned in the directive, standardized to an eight-hour reference period, is 1.15 m/s^2, or at the choice of the Member State concerned, a vibration dose value of 21 m/s$^{1.75}$. The daily exposure action value standardized to an eight-hour reference period is 0.5 m/s^2, or at the choice of the Member

State concerned, a vibration dose value of 9.1 $m/s^{1.75}$ [2]. Workers' exposure to whole-body vibration is to be measured according to the standard ISO 2631 (1997) [3].

In Finland, there are some 900 timber truck companies and 3,500 drivers. The purpose of the study was to measure the exposure of drivers to whole-body vibration and noise.

2. MATERIALS AND METHODS

Sixteen timber trucks and timber cranes of different ages and manufacturers were chosen as the objects of the study. Examples of the timber trucks with and without the crane cabin are presented in Figures 1 and 2.

Figure 1. Timber truck with a crane cabin.

Figure 2. Timber truck without a crane cabin.

2.1 Vibration

Vibration was recorded simultaneously along three mutually perpendicular axes (x, y and z directions) both from the seat and from the cabin floor of the timber truck, next to the seat fastening. The triaxial seat accelerometer Dytran 5313A was used for the seat measurements, and the triaxial B&K 4321 accelerometer was used for the floor measurements; the accelerometer was mounted on the floor using a magnet. The vibration signals were amplified with HVM 100 vibration meters (Larson Davis).

Floor and seat vibration were recorded with a Sony PC 208 digital cassette recorder. From the samples, the weighted RMS acceleration was analyzed in the one-third octave bands with a B&K 3560 C analyzer. The weighted RMS acceleration a_w is defined as

$$a_w = \left\{ \frac{1}{T} \int_0^T [a_w(t)]^2 \, dt \right\}^{\frac{1}{2}} \tag{1}$$

2.2 Noise

Noise inside the cabin was recorded with a B&K 2231 noise level meter and a Sony TCD-D8 tape recorder. The recordings were analyzed in the one-third octave bands with a B&K 2133 analyzer. Drivers' exposure to noise was measured with a CEL 360 noise dose meter.

3. RESULTS

3.1 Vibration

The frequency weighted vibration a_w multiplied by factor k according to ISO 2631 standard (1997) is presented in Tables 1-3: x designates the fore-and-aft direction, y designates the side-to-side direction, and z designates the vertical direction.

The weighted vibration spectra measured from the seats and from the floor of the timber truck cabin are presented in Figure 3.

Table 1. Weighted vibration during main road driving.

Timber truck	Seat [m/s^2]			Floor [m/s^2]		
	1,4 a_{wx}	1,4 a_{wy}	a_{wz}	1,4 a_{wx}	1,4 a_{wy}	a_{wz}
1	0,22	0,27	0,45	0,20	0,21	0,37
2	0,30	0,20	0,75	0,16	0,19	0,56
3	0,33	0,32	0,60	0,25	0,25	0,53
4	0,48	0,58	0,71	0,27	0,35	0,54
5	0,29	0,33	0,75	0,29	0,25	0,54
6	0,14	0,18	0,44	0,14	0,19	0,36
7	0,16	0,22	0,35	0,13	0,17	0,29
8	0,30	0,34	0,61	0,22	0,24	0,48
9	0,16	0,50	0,38	0,15	0,14	0,28
10	0,25	0,30	0,41	0,21	0,23	0,42
11	0,18	0,25	0,35	0,17	0,33	0,39
12	0,13	0,23	0,37	0,18	0,16	0,32
13	0,33	0,28	0,50	0,26	0,22	0,47
14	0,19	0,51	0,46	0,23	0,34	0,38
15	0,72	0,16	0,52	0,38	0,32	0,44
16	0,39	0,37	0,63	0,26	0,33	0,55

Table 2. Weighted vibration during forest road driving.

Timber truck	Seat [m/s^2]			Floor [m/s^2]		
	1,4 a_{wx}	1,4 a_{wy}	a_{wz}	1,4 a_{wx}	1,4 a_{wy}	a_{wz}
1	0,39	0,76	0,64	0,29	0,51	0,59
2	0,49	0,43	0,83	0,79	0,52	0,65
3	0,36	0,67	0,71	0,30	0,51	0,62
4	0,48	0,58	0,71	0,36	0,55	0,76
5	0,24	0,26	0,43	0,19	0,19	0,33
6	0,35	0,25	0,35	0,14	0,19	0,36
7	0,25	0,34	0,58	0,21	0,26	0,50
8	0,30	0,48	0,58	0,23	0,34	0,48
9	0,22	0,40	0,41	0,20	0,29	0,40
10	0,37	0,68	0,54	0,31	0,48	0,53
11	0,25	0,40	0,42	0,25	0,50	0,63
12	0,31	0,34	0,30	0,17	0,23	0,25
13	0,28	0,34	0,41	0,24	0,45	0,39
14	0,43	0,70	0,52	0,40	0,78	0,59
15	0,75	0,87	0,94	0,58	0,62	0,76
16	0,41	0,68	0,81	0,35	0,55	0,78

Table 3. Weighted seat vibration during loading.

Measure-ment	1,4 a_{wx}	1,4a_{wy}	a_{wz}
1	0,59	0,47	0,43
2	0,86	0,52	0,40
3	1,22	0,56	1,08
4	0,85	0,55	0,61
5	1,01	0,43	0,40
6	0,67	0,41	0,36
7	1,25	0,48	0,46
8	1,13	0,40	0,44
9	0,70	0,60	0,54
10	0,42	0,40	0,31
11	0,57	0,44	0,40
12	0,59	0,39	0,34
13	0,90	0,69	0,50
14	0,59	0,60	0,33
15	0,89	0,64	0,75
16	0,73	0,51	0,49

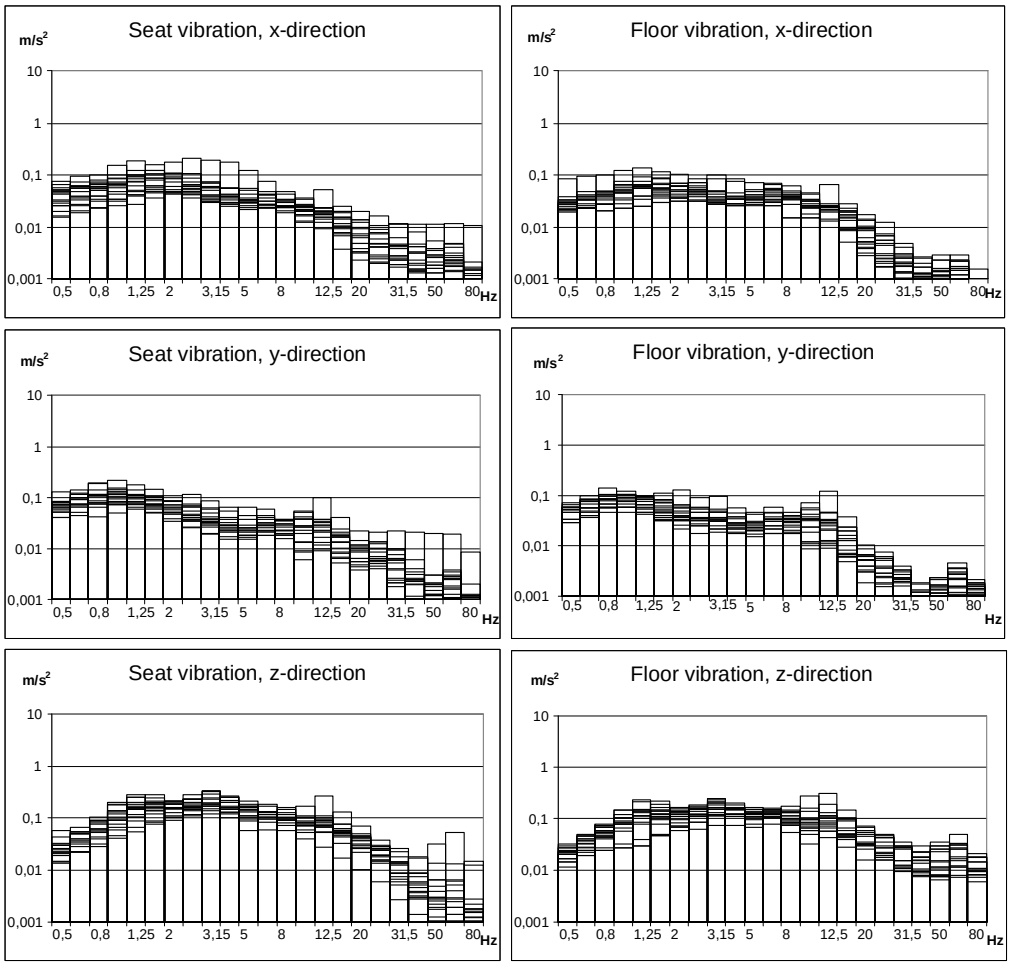

Figure 3. The weighted vibration spectra measured from the seats and from the floors of the timber truck cabins (n=16).

3.2. Noise

Noise spectra inside timber trucks' cabins are presented in Figure 4.

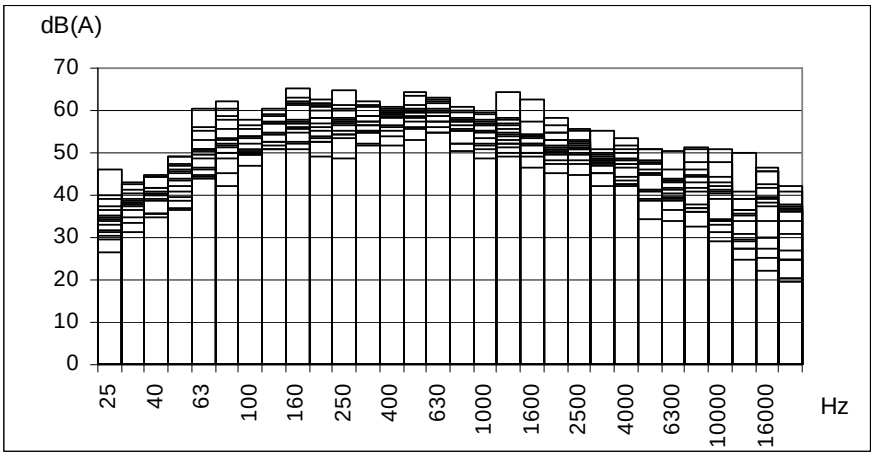

Figure 4. A-weighted noise spectra inside timber trucks' cabin during driving (n=16).

The noise inside the timber trucks' cabins varied between 63 and 72 dB(A). Drivers' noise exposure outside the timber trucks' cabins is presented in Table 4.

Table 4. Noise exposure of drivers when working outside the timber truck cabins and in the timber cranes.

Timber truck	L_{Aeq} dB(A)	L_{Cpeak} dB(C)
1	80	140
2	79	126
3	77	139
4	74	139
5	73	135
6	81	131
7	80	133
8	81	140
9	80	127
10	79	123
11	79	124
12	81	139
13	75	138
14	76	123
15	81	129
16	76	124

4. SUMMARY

RMS acceleration of vibration measured from the driver's seat exceeded the action value of 0.5 m/s^2 in 63% of the cases. In the vertical direction, the seat vibration was the most powerful at frequencies between 1 and 12.5 Hz, and in the longitudinal and transverse directions at frequencies below 5 Hz. In the seats of the timber cranes, vibration exceeded the

action value of 0.5 m/s^2 in 94% of the cases, and the exposure limit value of 1.15 m/s^2 in 13 % of the cases. The noise exposure of the drivers during working days was below 80 dB(A), and inside the cabin of the truck, noise was the most powerful at frequencies between 63 and 2000 Hz.

ACKNOWLEDGEMENT

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REFERENCES

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[2] *Directive 2002/44/EC of European Parliament and of the Council of 25 June 2002 on the minimum health and safety requirements regarding the exposure of worker to the risk arising from physical agents (vibration) (sixteenth individual Directive within the meaning of Article 16(1) of Directive 89/391/EEC).*

[3] International Organization for Standardization (ISO): *ISO 2631-1-Mechanical vibration and shock-Evaluation of human exposure to whole-body vibration-Part1 :General requirements.* Geneve: ISO, 1997. p. 31.