EXPOSURE TO THE HAND-ARM TRANSMITTED VIBRATION AT USING PNEUMATIC SANDING MACHINE

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Abstract
According to some recent data approximately 1.5 to 2 million workers in the USA, 1.6 millions in GB and several millions in EU are exposed to vibration. Therefore protection against vibration gains more and more attention. In 2002 the Directive /44/EC –On the Minimum Health and Safety Reqiurements regarding to Exposure of Workers to the Risk Arising from Physical Agents: Vibration – was issued. It set limits for the worker's exposure to hand-transmitted vibration to 2,5 m/s^2 (action value), i.e. 5 m/s^2 (upper limit value). Written into laws the Directive became obligatory for all EU member-states. The whole-body vibration limits are set at 0,5 m/s^2 , i.e. at 1,15 m/s^2. As generally known, the pneumatic hand-tools are one of the most dangerous sources of hand-transmitted vibration. In the last few years only in GB there have been some 140.000 miners with signs of VWF (Vibration White Finger desease) who were paid nearly 3, 000,000,000£. Indemnity (Griffin, 1996). The measurement results and vibration acceleration analyses confirm that the risk of permanent health damage to persons operating hand sanding machines is quite real. As a matter of fact, this investigation work was initiated because of health damages observed with sanding machines operators in the woodworking and wood processing plants in Croatia. Daily exposure should be strictly limited in accordance with the recommended exposure times.

Key words: daily exposure limits, health risk, permanent health damage, vibration acceleration analysis.

Classification JEL: Z13 Economic Sociology

1. Introduction

The paper reports and analyzes results of vibration measurements carried out on hand sanding machines. Vibration levels were measured on the front and rear handles of the FESTO LRB-W1 and LRB-T1 hand sanding machines and at two points on the holding handle of the FESTO RTL-F1 hand sanding machine. The measured levels of the weighted vibration accelerations were compared to the daily exposure limits according to ISO 5349-1:2001 and ISO/TC 108/SC4/14. Daily exposures for each type of sanding machine were determined according to the same standards.

Sanding machines of various forms, sizes and ways of coupling the hand-arm system of the machine are sometimes used in wood machining and in machining of welding joints and other metal surfaces. Many workers use such sanding machines over a full working day, others do so only occasionally. Intensive vibration can be transmitted to the hands and arms of the operators causing various patterns of diseases (Šestan, 1984, Goglia et. al., 1995). To protect workers against serious health impairment caused by vibration, the levels of hand-transmitted vibration were measured at the joinery in Lokve and at the Integrated Woodworking Plant in Delnice (DIP-Delnice) in Croatia. The paper reports on the results of these measurements and their analyses.

2. Method and equipment

Vibration levels were measured on two types of hand sanding machines commonly used in woodworking. Basic technical characteristics of the hand sanding machines type ***A*** were:

- compressed-air motor,
- motor rotation frequency 7000 min^{-1} at an air pressure of 5-6 bar,
- displacement 4 mm,
- number of operation cycles 14000 min^{-1},

- air consumption 0.36 m^3/min,
- sanding area 115 x 225 mm^2,
- weight 2.7 kg

Basic technical characteristics of the hand sanding machines type ***B*** were:

- compressed-air motor,
- motor rotation frequency 5600 min^{-1} at an air pressure of 5 bar,
- displacement 5 mm,
- number of operation cycles 11200 min^{-1},
- air consumption 0.25 m^3/min,
- sanding area 95 x 175 mm^2,
- weight 1.8 kg

The 120 grain size abrasive paper was used on the sanding machines during testing.

3. Testing plan and testing conditions

The vibration measurements on the hand sanding machine handles were carried out according to the International Standard ISO 5349-1:2001 in normal working conditions. On the hand sanding machines type ***A*** were hand sanding machine measurements were made on both, the front and the rear handle, at idling and at sanding. On the hand sanding machines type ***B*** measurements were also made on both, the front and the rear handle, but only at sanding, and finally, on the hand sanding machines type ***C*** measurements were made at two points on the handle, as this machine type is only single-handled. All three types of machines are shown in Figure 1. In accordance with the recommendations of the ISO 5349-1:2001 the vibrations were measured simultaneously in all three axes of the coordinate system and tape-recorded. The directions of the axes are shown in Figure 2.

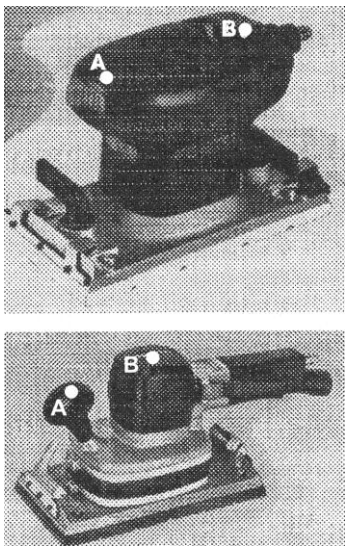

Figure 1: Three tested types of the hand sanding machines
Source: own photos

The tape-recorded measurement results were analyzed at the Department for Mechanical Engineering of the Faculty of Forestry, University of Zagreb. The following equipment was used for the vibration measurements and for data analyses: a Brüel & Kjaer accelerometer (type 4374) which was mounted on a 3-axial holder designed at the Faculty of Forestry, Zagreb, Brüel &

Kjaer amplifiers type 2635, Brüel & Kjaer tape recorders type 7003 and a Brüel & Kjaer frequency analyzer type 2132. The measurement results were analyzed using the software developed at the Faculty of Forestry in Zagreb.

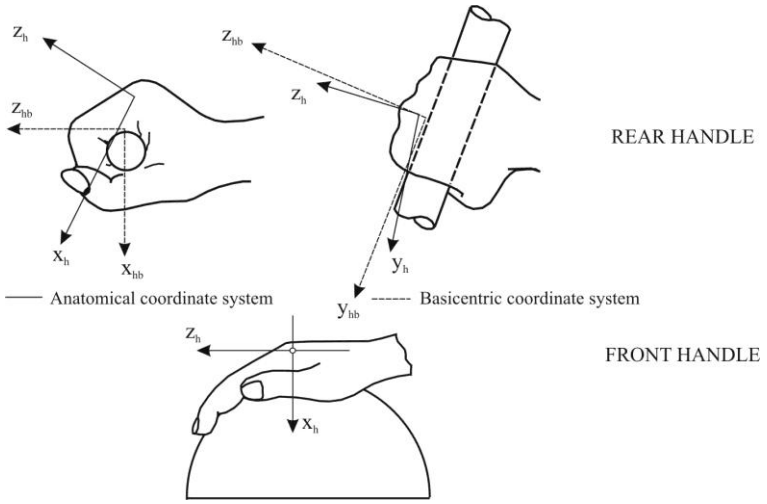

Figure 2: Coordinate system for the hand at measuring vibrations on rear and front handles
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4. Results of measuring

Measurements were carried out simultaneously in all three axes of the coordinate system. The frequency weighted acceleration levels for all three axes of the front and rear handles of the hand sanding machines type ***A*** at idling are given in Table 1. Table 1 also shows the weighted acceleration sum (**A(8)** values). The acceleration measured in each of the three axes was analyzed in one-third octave bands (Figure 3).

Table 1: Weighted acceleration level and equivalent vibration sum A(8) for the hand sanding machines type ***A*** *at idling, m/s*^{2}

Handle	**Axe**	**Measurement No.**						**Mean value**	**A(8)**
		1	**2**	**3**	**4**	**5**	**6**		
Front	x	5.4	5.1	5.1	5.0	5.2	4.8	5.1	**7.4**
	y	2.4	2.2	2.2	2.3	2.9	2.3	2.4	
	z	5.0	4.6	4.6	4.6	4.5	5.4	4.8	
Rear	x	2.1	1.8	1.7	1.4	1.3	1.7	1.7	**3.2**
	y	3.0	2.4	2.4	2.4	2.3	2.0	2.4	
	z	1.4	1.1	1.2	1.2	1.2	1.2	1.2	

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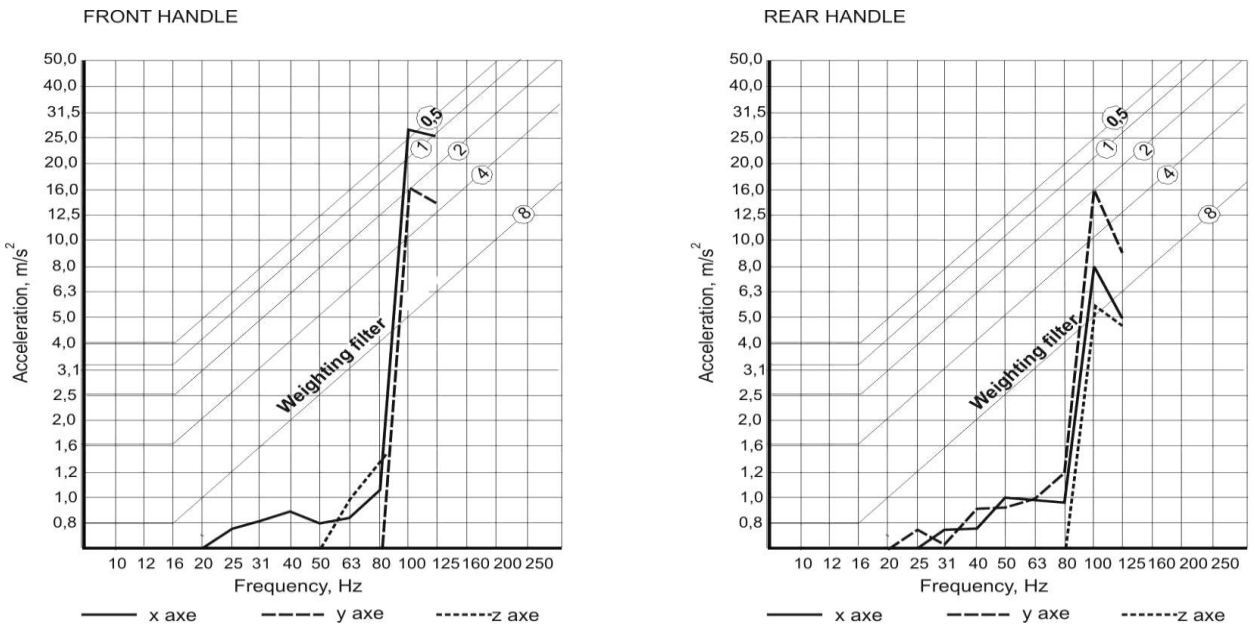

*Figure 3: Acceleration analyzed in one-third octave bands on the front and on the rear handles hand sanding machines type **A** at idling*

Source: own

If the maximum values of the weighted accelerations in the individual axes on the front and rear handles measured at idling are substituted into the dose-effect diagram in accordance with the ISO 5349-1:2001 as shown in Figure 4, it can be presumed that the measured vibration acceleration level on the front handle will cause permanent damage in 10% of the operators after just five years of exposure time.

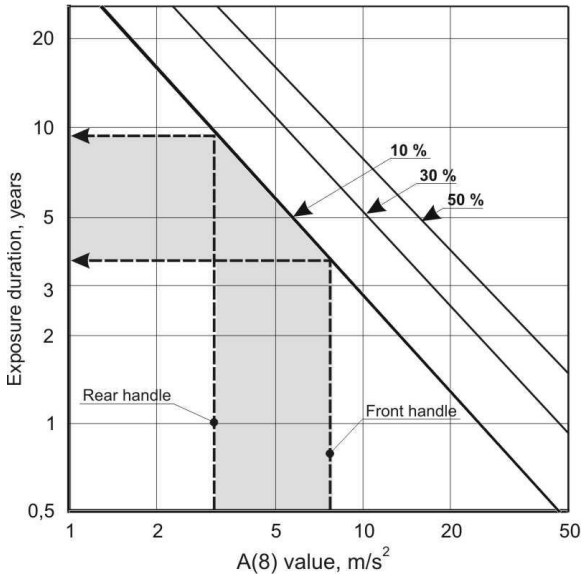

*Figure 4: Probability of permanent health-damage to the operator of the hand sanding machines type **A** at idling*

Source: own

The frequency weighted acceleration level for all the three axes of the front and rear handles of the hand sanding machines type ***A*** at sanding are shown in Table 2. The accelerations measured in the three axes were analyzed in one-third octave bands (Figure 5).

Table 2: Weighted acceleration level and equivalent dose value A(8) for the hand sanding machines type ***A*** *measured on handles at sanding, m/s²*

Handle	**Axe**	**Measurement No.**						**Mean value**	**A(8)**
		1	**2**	**3**	**4**	**5**	**6**		
Front	x	3.5	5.4	5.5	5.8	5.6	5.8	5.3	**13.8**
	y	3.2	3.8	3.4	3.8	2.9	2.8	3.3	
	z	11.6	11.5	11.6	12.3	14.8	11.2	12.2	
Rear	x	15.9	15.6	14.9	14.8	15.0	14.8	15.2	**20.7**
	y	14.9	13.4	14.4	13.4	13.2	13.4	13.7	
	z	3.2	3.4	2.7	3.1	2.6	2.8	2.9	

Source: own

If the maximum values of the weighted accelerations in the individual axes on the front and rear handles measured at sanding are substituted into the dose-effect diagram (Figure 6), it is obvious that the measured vibration acceleration level will cause finger blanching in 10% of the operators in less than two years of exposure time.

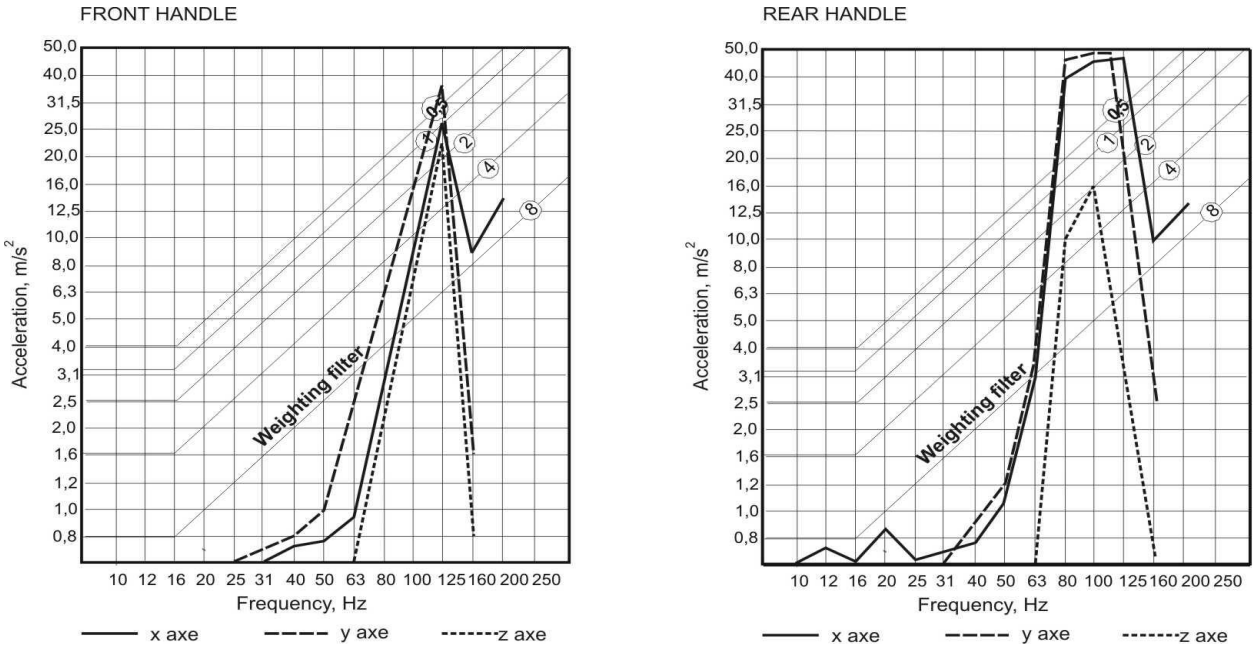

*Figure 5: Acceleration analyzed in one-third octave bands on the front and on the rear handles of the hand sanding machines type **A** at idling at sanding*

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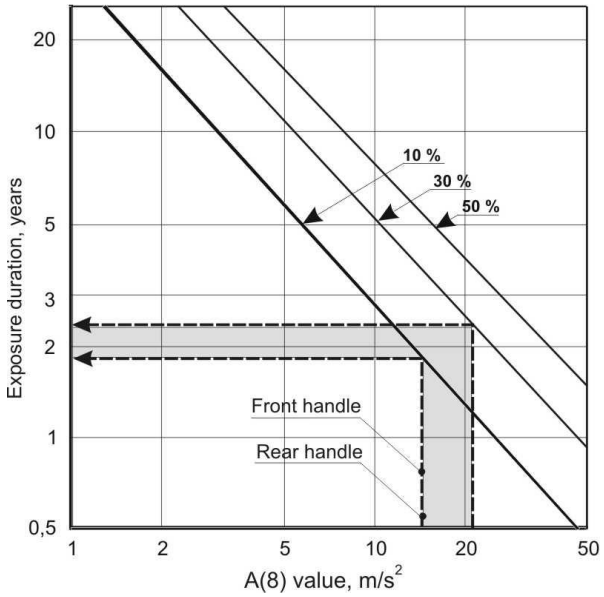

*Figure 6: Probability of permanent health-damage to the operator of the hand sanding machines type **A** at sanding*

Source: own

The hand sanding machine type ***B*** is a single-handed sanding machine and its handle can be gripped in different ways. The measurements were therefore made at two points (point ***A*** and ***B***) at the front and rear end of the handle, as shown in Figure 1. They were made only at sanding as it had been established earlier that much higher vibrations occurred at sanding than at idling.

Measurements were carried out simultaneously in all three axes of the coordinate system. Six samples were taken and mean values and A(8) values were calculated. Results are given in Table 4.

*Table 4: Weighted acceleration level and vibration equivalent total value A(8) of the hand sanding machine type **B** measured at two points on the handle at sanding, m/s^2*

Handle	**Axe**	**Measurement No.**						**Mean value**	**A(8)**
		1	**2**	**3**	**4**	**5**	**6**		
Point *A*	x	7.5	6.9	6.9	7.8	6.9	7.1	7.2	15.8
	y	10.4	9.4	9.5	8.7	8.7	7.7	8.9	
	Z	14.9	8.4	11.1	10.6	9.8	10.5	10.9	
Point *B*	x	12.7	11.9	10.6	11.7	12.3	12.2	11.6	20.1
	y	5.5	2.4	2.5	2.5	2.2	2.2	2.9	
	Z	18.6	13.6	17.0	18.5	13.4	15.9	16.2	

Source: own

The accelerations measured in each of the three axes and at the two measuring points were analyzed in one-third octave bands and are shown in Figure 7.

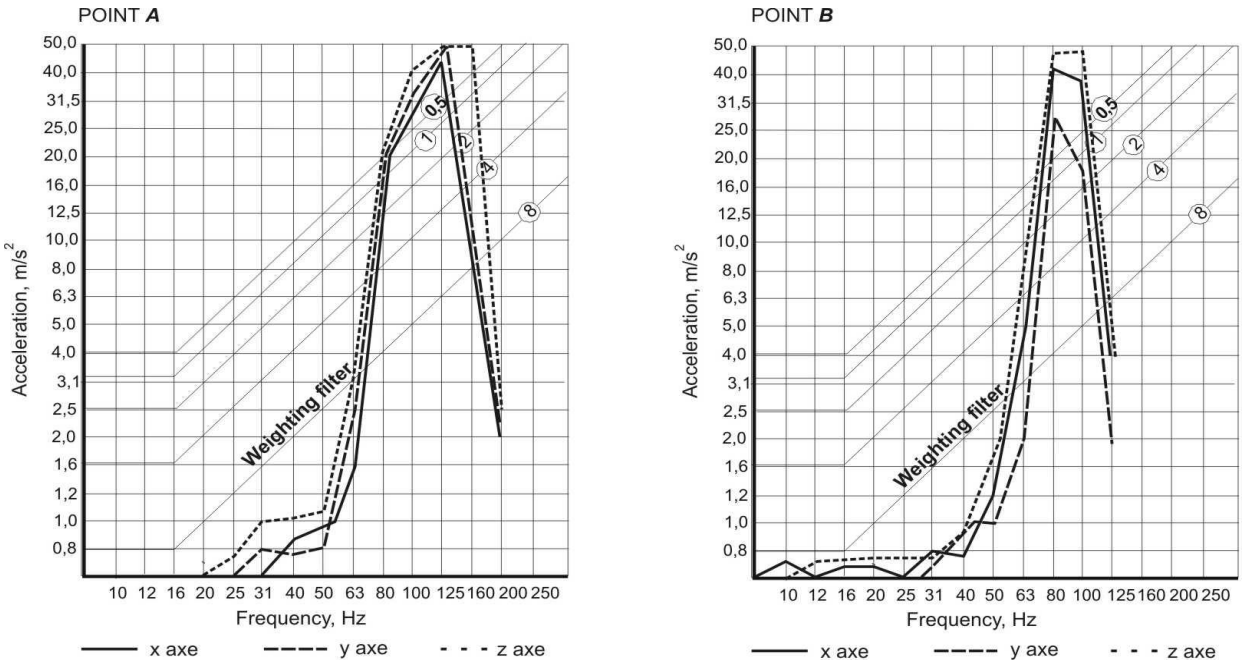

*Figure 7: Acceleration analyzed in one-third octave bands at the two measuring points on the handle of the hand sanding machine type **B** at sanding*

Source: own

The maximum value of the weighted accelerations in the individual axes was substituted into the dose-effect diagram as shown in Figure 8. It can be presumed from the diagram that the vibration acceleration level measured at sanding will cause permanent health damage in 10% of the operators in less than two years of exposure time.

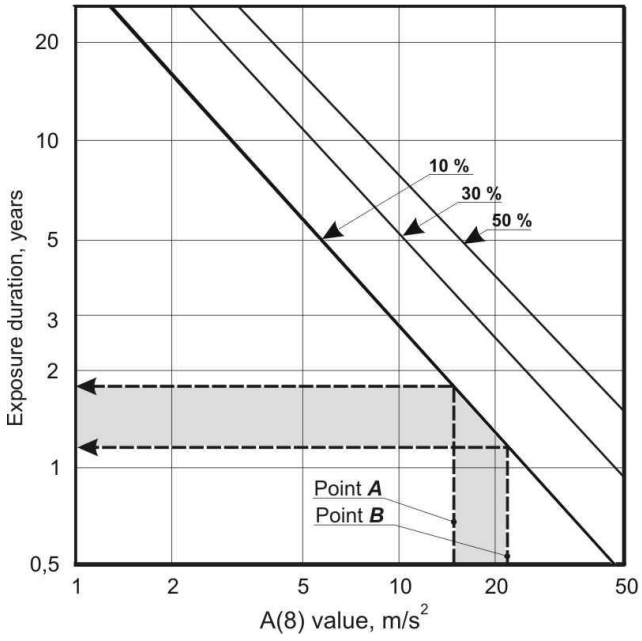

*Figure 8: Probability of permanent health damage to the operator of the hand sanding machine type **B** at sanding*

Source: own

5. Conclusions

The measurement results and vibration acceleration analyses confirm that the risk of permanent health damage to persons operating hand sanding machines is quite real. As a matter of fact, this investigation work was initiated because of health damages observed with sanding machines operators in the woodworking and wood processing plants in Croatia. Daily exposure should be strictly limited in accordance with the recommended exposure times. The efficiency of the production process should be maintained by means of work organization and work schedules should be arranged to include vibration-free periods.

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