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ANALYSIS OF NOISE LEVEL AFFECTING MACHINE OPERATORS DURING TIMBER HARVESTING IN POLAND

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Abstract: *The main aim of the research was a machinery operator's noise level assessment in the timber harvesting process. Tests were carried out with sampling and dosimetrical methods during wood harvesting for the machine and manual levels. As a result of the research it was stated that for the harvester and forwarder operator the noise level was the lowest (69 – 75 dB(A)). Higher values (80 – 86 dB(A)) were found during wood skidding with the LKT 81 Turbo skidder and also with other machinery and equipment combined with different class farm tractors. For chain saws and brush chippers the values of the noise level considerably exceeded the threshold limit value (TLV, 85 dB(A)).*

1. Introduction

Privatisation of forest services in Poland was initiated in the 1990s. The former employees of the State Forests were then starting their own enterprises in the form of self-employed, one-man businesses. Initially the range of services offered included specialist harvesting and skidding tasks performed with the use of chain saws, farm tractors or specialist LKT 81 skidders obtained from units of the State Forests. Increasing requirements of the market, of occupational safety, of environmental protection and the growing pressure of the society significantly affected a change in the scope of these enterprises' activity. Recently there have appeared service enterprises with a varied service profile, often using technologically advanced machinery and tools. The effectiveness of the jobs performed has increased. The working conditions of machinery operators have changed as well.

Undoubtedly, increased exposure of operators to noise is a negative effect. Very often the impact of noise leads to permanent reduction of the hearing threshold and, consequently, even to total deafness. Moreover, due to the existence of neural connections between the hearing tract and the cortex, hearing stimuli act on the central nervous system, and *via* this system – on the functions of many internal organs. Prolonged action of this stressor results in decreasing immunity to the harmful action of other factors (Engel et al., 1997). These are conditions for the development of hypertension, peptic ulcer disease, neuroses, etc. For this reason, analysis of the level of acoustic exposure should continue to be the subject of ergonomic research.

2. Research aim and scope

The aim of the present research was to determine the level of daily exposure of machine and tool operators in the timber harvesting process. The scope of the research included the determination of acoustic exposure during the performing of late thinnings (the manual-machine technology) and of timber harvesting at clear cutting (the machine technology) in coniferous stands.

3. Methods

Measurements were taken using the direct method according to the instructions of the Polish Standard PN-ISO 1999: 2000 with the use of the Sonopan DM-50 noise dosimeter. The intensity of noise in the forwarder or harvester cabin was determined by means of the Brüel & Kjaer sonometer, type 2230, using the sampling method consisting in recording the values at equal time intervals. The microphone of the measurement apparatus was placed 10 cm away from the operator's right ear. The data obtained allowed for calculating the value of the equal sound level $L_{A,eq,Te}$ (formulas 1 and 2).

$$L_{A,eq,Te} = 10\log\left[\frac{1}{T_e}\int_{t_1}^{t_2}\frac{p_A^2(t)}{p_0^2}dt\right] \quad \text{dB(A)} \quad (1)$$

$$L_{A,eq,T_e} = 10\lg\left[\frac{1}{T_e}\sum_{i=1}^{n}\left(T_i * 10^{0,1L_{A,eq,T_i}}\right)\right] \quad \text{dB(A)} \quad (2)$$

Where: $T_e=t_2 - t_1$ – measurement time; $p_A(t)$ – temporary value of acoustic pressure corrected according to the characteristics of frequency A in *Pa*; p_0^2 – value of pressure of reference equal to 20 μPa; L_{Ai} – equivalent noise level present in a time period T_i, dB(A); T_i – period of action of noise L_{Ai}, s

In further computations, the daily exposure to noise $L_{EX,8h}$ (formula 3) was determined. The period of the action of noise on the operator was determined on the basis of chronometric research.

$$L_{EX,8h} = L_{A,Te} + 10\log\frac{T_e}{8h} \quad \text{dB(A)} \quad (3)$$

4. Research results and discussion

The research conducted allowed for the conclusion that the lowest values of the level of daily exposure occurred during timber harvesting by means of multifunctional machines (TJ 1270B, TJ 1010B) and half-suspended logging by means of the LKT 81 skidder (Table 1). The values of $L_{AEX,8h}$ ranged between 68 and 79 dB(A). Acoustic stimuli below 80 dB(A) on these sites indicate a lack of the harmful effect of noise on the hearing organs (Engel et al., 1997). Still, it must be remembered that during the operation of the LKT 81 Turbo skidder with the operator's cabin open the noise exceeds the admissible value of 85 dB(A) (Sowa and Leszczyński, 1999).

The highest value which exceeded the admissible level of daily exposure to noise was noted for chain saw operators (Table 1). The $L_{AEX,8h}$ values obtained reached even 100 dB(A). The differentiation of the level of daily exposure observed is due to e.g. the period of exposure to noise T_e, conditioned by the technology applied and by the adopted organizational solutions. This fact is confirmed by the case of an operator's individual work, where a relatively low value of the equivalent level of noise L_{AeqTe} = 91 dB(A) was noted and the daily exposure level calculated did not exceed 90 dB(A) for the actual exposure period of 3.8 h. The highest value of the equivalent level of noise L_{AeqTe} = 104 dB(A) was noted for the operators of the Multi FKS cable winch powered by the 4.8 kW chain saw engine. However, due to the shortest period of exposure to noise (1.5 h), the value of the daily exposure level fell to 96.5 dB(A).

The results of the assessment of acoustic threat to saw operators cooperating with Niab 5-15 processor operators are also worth noting. In comparison with the traditional technology (individual felling done by saw operators), a higher risk was noted for chain saw operators, which is due to a considerably longer period of exposure to noise (6.4 h). Significant acoustic threat occurs also during the use of the Bandit 1890 HD brush chipper.

Table 1: Level of daily exposure to noise for forest machine operators

Position	L_{Aeq} dB(A)	T_e h	$L_{EX,8h}$ dB(A)
TJ 1270B harvester (123 kW)	69,00	7	68,4
TJ 1010B forwarder (82 kW)	75,00	5,2	73,1
LKT 81 Turbo skidder (72 kW)	80,01	6,8	79,3
Niab 5-15 processor aggregated with Belarus MTZ 100 tractor (75 kW)	84,9	6,4	83,9
Pronar 1025A tractor (78 kW) with Fransgard V6500 winch	85,67	5,6	84,1
Hq 357xp saw operator (3,2 kW), individual work	91,01	3,8	87,8
Bandit 1890 HD brush chipper (150 kW)	98,68	3,7	95,3
Multi FKS cable winch (4,8 kW)	103,76	1,5	96,5
Hq 357xp saw operator (3,2 kW), technology with Multi FKS cable winch	101,59	2,6	96,7
Hq 357xp saw operator (3,2 kW), technology with processor	100,91	6,4	99,9

In order to show the differentiation of acoustic threat to operators, the cumulated exposure time was presented in Figure 1 in ranges of sound intensity. The longest period of exposure to the noise of over 85 dB(A), amounting to 80% of operation time, was noted during the work of the Bandit 1890 HD brush chipper. For the chain saw operator, the period of exposure to the noise exceeding the admissible value was differentiated depending on the work technology and ranged from about 42% for individual work to 60% in the technology using the Multi FKS cable winch.

The data obtained was complemented with the values of daily exposure which occurred in forest work, obtained by other authors. Analysis of Figure 2 shows that the greatest acoustic threat in forestry is connected with the use of manual mechanical tools. Exceeding the value of admissible noise occurs also in the case of chipping timber by means of chippers, logging by means of the yarder, the Mi-8 helicopter and the Vimek forwarder.

Figure 1. Cumulated period of operators' exposure in sound intensity ranges

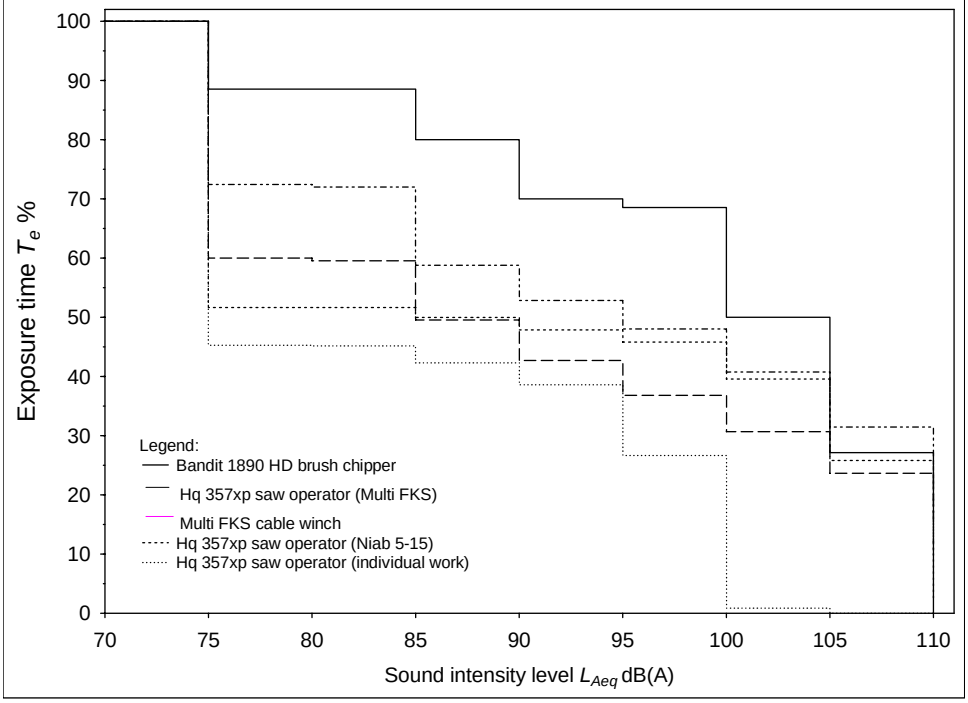
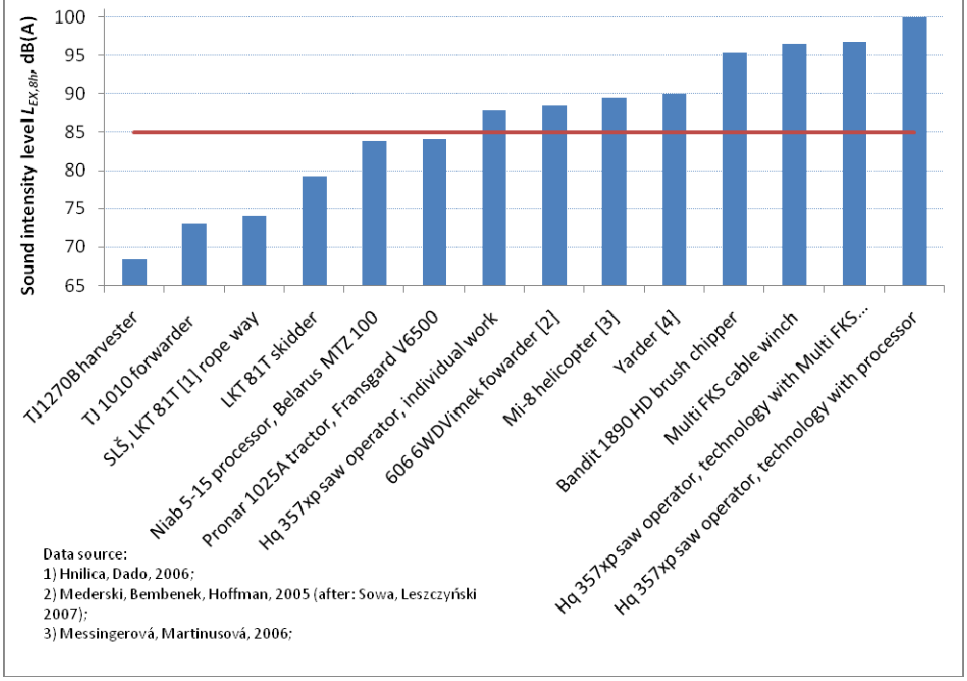


Figure 2. Level of sound intensity in forestry machine operators' work



The risk of the hearing impairment defined in the Polish Standard PN-ISO 1999: 2000 for a 50-year-old man with 30-year exposure to noise on the level of 95-100 dB is about 50%. An effective way of counteracting the negative impact of noise is to apply selective hearing protection adapted to the acoustic characteristics of the working environment (Augustyńska and Zawieski, 1999). On the basis of the formula elaborated by Else, Cempel (1989) notes that even if the periods of not using the protection are brief, its nominal effectiveness decreases. Calculations done by the authors indicate that, in the case of a saw operator equipped with the H7P3 hearing protector capable of noise reduction by 20 dB, not using protection for a period of 15 minutes results in the total noise value exceeding the admissible level (Sowa and Leszczyński, 2005).
For the operators of tractors aggregated with specialized equipment and the operators of multifunctional machines, exceeding the admissible noise value of 85 dB(A) was not noted. However, due to a frequent occurrence of more than one harmful factor in the analysed forest jobs, the national and international standards recommend lowering the admissible noise value to 80 dB(A) and shortening the working time. A decrease of the admissible value by 5 dB means that in most forest jobs the negative impact of noise must be taken into consideration.

5. Conclusions

1. The lowest level of daily exposure to noise was noted for machine timber harvesting by means of the TJ 1270B harvester and logging by means of the TJ 1010B forwarder. The L_{EX8h} values amounted to, respectively, 68 and 73 dB(A).
2. During the logging by means of the LKT 81 T skidder, the daily noise exposure level did not exceed 80 dB(A).
3. In the case of the work of the Niab 5-15 processor aggregated with the Belarus MTZ 100 tractor and logging by means of the Pronar 1025A tractor equipped with the Fransgard V6500 cable winch, the level of daily exposure to noise did not exceed the admissible value of 85 dB(A). However, the noise values of over 80 dB(A), which were noted, may negatively affect the operator's hearing.
4. The highest daily exposure level L_{AEX8h}=100 dB(A) was noted for the chain saw with a processor, which is due to a longer exposure period.
5. The differentiation of acoustic threat which occurred in a group of workers who used manual tools (the chain saw) results from the work technologies applied and from the organizational solutions adopted.
6. The differentiation of the noise threat to operators, which is related to the level of work mechanization, should serve as a recommendation of more common application of machine technologies of timber harvesting in Poland. Apart from definitely higher work efficiency, their advantage is a much lower acoustic threat to operators.

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