Conference "Ergonomics And Occupational Health"
Zagreb, 11th and 12th November, 1994

A part of the papers presented at the Conference "Ergonomics and Occupational Health" which was held in Zagreb on 11th and 12th November 1994 were published in Archives of Industrial Hygiene and Toxicology, Number 4, Vol 45, 1994.

As announced in that issue, the present issue of the journal has been dedicated to the other part of the Conference papers. Most of the papers deal with current topics in forestry from the point of view of ergonomic principles and health. Following the journal policy, the papers in the categories "Original Scientific Papers" and "Communications" have been published in English and all the other papers in Croatian.

In the hope that this endeavour will stimulate the implementation of current ergonomic solutions, and help improve working conditions in Croatia, and that it will also encourage further investigations in the field, we thank the authors, referees and all the others who have contributed along the process of publishing the papers.

M. ŠARIĆ
Guest Editor

Sastanak "Ergonomija u medicini rada"

Zagreb, 11. i 12. studenoga 1994.

Dio radova priopćenih na radnom sastanku "Ergonomija u medicini rada" koji je od održan u Zagrebu 11. i 12. studenoga 1994. godine, objavljen je u Arhivu za higijenu rada i toksikologiju br. 4, vol. 45, 1994.

Kao što je bilo najavljeno, u ovom broju časopisa sadržani su preostali radovi i opažanja sa Sastanka. Većina radova odnosi se na ergonomsko-zdravstvene probleme u šumarstvu. Kako je to bilo učinjeno i s radovima tiskanima u prethodnom broju Arhiva, u skladu s aktualnom koncepcijom časopisa, priopćenja koja imaju obilježja znanstvenoga rada ili kratkoga znanstvenoga priopćenja tiskana su na engleskom, a ostala na hrvatskom jeziku.

Na kraju ovog pothvata koji će, nadamo se, biti poticaj unapređenju primjene suvremenih ergonomskih rješenja i poboljšanju uvjeta rada u nas, kao i nastavku i intenziviranju potrebnih istraživanja na ovom području, želimo zahvaliti autorima objavljenih priloga, recenzentima i svima onima koji su pridonijeli da ovi radovi budu redigirani i tiskani.

M. Šarić
Gost urednik

CONFERENCE "ERGONOMICS AND OCCUPATIONAL HEALTH", Zagreb, 11th and 12th November, 1994
Arh hig rada toksikol 1995;46:5–13

ORIGINAL SCIENTIFIC PAPER
UDC 613.644:331:674

NOISE AND VIBRATION LOAD OF LUMBERMEN

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At eight lumbering sites in Slovenia the noise load of lumbermen working with new and used motor saws was investigated by noise measurements at the ear level. A major contribution to the noise load (L_{eqv} = 96–100 dB(A) came from motor saw operations such as limbing. Lumbermen are overloaded with interrupted noise for 25 per cent of their working time. The noise produced by a used motor saw exceeds the noise coming from a new one by 0.7 dB(A). Results of a pilot research into the lumbermen's vibration load generated by Husqvarna 266 and 254 motor saws are also presented. The measurements involved three cutting sites and four lumbermen for six days. The vibration load during the working hours ranged between 6.6 and 10.8 m/s^{-2}. Owing to the fact that vibrations are interrupted and the exposure does not last throughout the working day, the vibration load does not reach a level which would be detrimental to lumbermen's health.

Key terms:
motor saw testing, occupational exposure, working conditions

The power saws that are used in the lumbering industry produce noise, vibrations and exhaust gases. Data about their harmful effects on the working environment are plentiful. The noise and vibration levels emitted by motor saws have been widely investigated. To prevent occupational health impairment and to secure the workers' safety it is necessary to know to which noise and vibration loads they are exposed while performing certain jobs or using certain methods of work. Obviously the loads depend on working conditions, technology and organization of work. In the attempt to estimate at least approximate loads of lumbermen we have undertaken an investigation of the noise and vibration load that are due to the cutting method currently used in Slovenia. The Husqvarna motor saw was the most often used motor saw in our research.

NOISE LOAD

Methods

The noise load to which lumbermen are exposed has been investigated at eight lumbering sites in different areas of Slovenia (Table 1). The trees were cut in sortiments or in double length of logs by the Swedish method (rikleo), with a different grade of cutting order. Many data about noise levels emitted by motor saws are available (1–4). Investigations of worker's noise load are generally rare. Those that have been undertaken have been carried out in different forest management conditions and with different working methods (5, 6). In our investigation the lumbermen mostly used the Husqvarna motor saw, type 226 (Table 1).

Table 1 *Cutting sites and motor saws*

Forest area	Forest	Motor saw type	Motor saw age		Output in recorded time		Products
			1st day	2nd day	1st day m^3	2nd day m^3	
Kras	Bukovje	Husq. 266 SE	7–8 years	1 month	7. 53	10.47	multiple length
mixed	Snežnik	Husq. 266 SE	6 years	1 month	9.39	5.85	multiple length
forest	Vrhnika	Husq. 266 SE	7 months	7 years	16.51	14.10	double length
Alps	Preddvor	Jonsered 630	1.5 year	6 years	6.62	8.77	sortiments
spruce	Pokljuka	Husq. 266 SG	3 years	1 year	5.75	5.55	double length
forest	Vitanje	Husq. 254 SG(XP)	4 years	1 year	9.56	11.10	multiple length
Beech	Idrija	Husq. 266 SE(SG)	1.5 year	6 years	21.45	13.43	sort. and longw.
forest	Litija	Husq. 61 FF(266)	2 months	5 years	12.60	10.35	sortiment

The intensity of the noise at the worker's ear level caused by the cross cutting was greatly different from the levels measured during the testing of new motor saws because of different adjustment of carburators and different duration of the motor saw use. Different types of new motor saws produced noise levels from 102 to 104 dB(A) during cutting in the test procedure. The saws in our investigation generated a noise level from 100 to 109 dB(A) – only exceptionally the level was 96 dB(A) (Table 2).

The noise load of lumbermen was established by means of measurements of the noise level near lumbermen's ears (7) – twice daily for about 48 minutes at each cutting site. On one day out of two the noise level of a relatively new motor saw was measured and on the other day an identical measurement was done for a used motor saw of the same type. At 30-second intervals five different noise characteristics were recorded by the Brüel et Kjaer instrument 2231. The details of the lumberman's work were recorded by a video-camera and the dominant task in each 30-second interval was established. During the recording of noise load the work output was also noted. Details of the cutting site, working method, lumberman and his equipment were registered.

Table 2 *Noise of motor saws in the testing procedure*

Forest	Motor saw type	Noise level in testing in institutes dB(A)			Noise level at cutting sites					
					New motor saws			Older motor saws		
		Idling	Cutting	Racing	Idling	Cutting	Racing	Idling	Cutting	Racing
Bukovje	Husq 266				72.4	103.9	101.1	77.6	102.7	100.1
Snežnik	Husq 266	78	102	104	85.1	105.6	112.8	86.7	108.3	108.9
Vrhnika	Husq 266				80.5	101.9	107.5	78.2	104.3	105.6
Preddvor	Jonsereds	76	103	105	79.6	105.0	111.5	75.8	105.6	112.3
Pokljuka	Husq 266				75.0	104.6	108.5	75.3	104.4	106.6
Vitanje	Husq 254	76	102	103	81.3	99.6	106.8	76.8	101.1	103.3
Idrija	Husq 266				80.6	102.3	108.3	76.7	105.4	109.9
Litija	Husq 61		102	105	80.9	95.9	102.5	74.1	97.4	100.0

RESULTS AND DISCUSSION

The noise level during the work with a motor saw oscillated from values under 50 dB(A) to the maximum levels of 111–122 dB(A). There were brief peaks over 125 dB(A). The worker's load during (recorded) working time was 96–104 dB(A). The average equivalent noise level was about 100 dB(A) (Table 3) and greatly varied from task to task. During motor saw operation i.e. during felling, limbing and crosscutting the average noise load was 100–103 dB(A).

These three work tasks lasted 60–83 per cent of the productive working time during our investigation, so they influenced the noise load of lumbermen

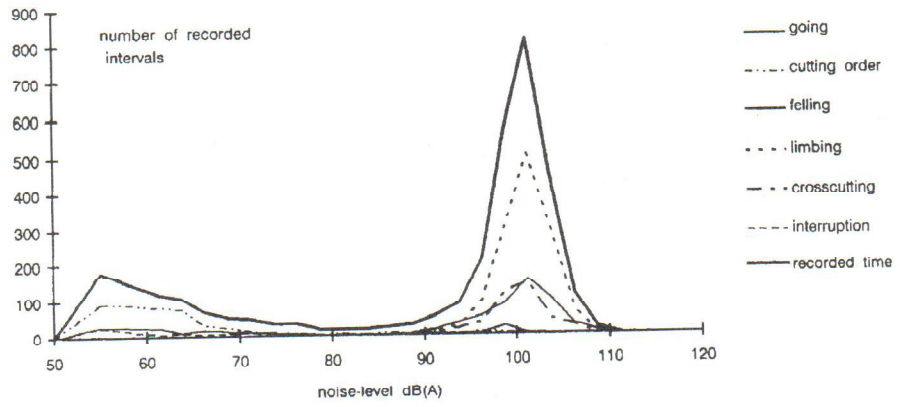

Figure 1 *Distribution of noise level*

most. From the noise level distribution in the 2.5 dB(A) classes (Figure 1) it is evident that the greatest contribution to the noise load comes from limbing, a smaller one from felling and the smallest from crosscutting. The work without a motor saw, for example maintaining the order of the cutting site reduces the lumbermen's noise load.

The differences between cutting sites were rather large, first of all because of a different mode in which work was performed. The used motor saws caused a greater noise load. Differences between forest areas in Slovenia have also been established. The greatest noise load due to the motor saw work was measured at conifers cutting on Kras, the lowest in the Alps (spruce); the noise load from beech cutting came in the middle.

Table 3 *Lumbermen's noise load by work tasks*

Work tasks	Forest area							
	Kras–mixed		Alps–spruce		Beech		Average	
	Motor saws, dB(A) – equivalent noise level							
	New	Used	New	Used	New	Used	New	Used
Going	87–94	89–92	86–94	70–93	92–94	95	92.2	92.5
Felling	101–102	99–108	99–102	98–102	100–101	100–104	102.8	101.5
Limbing	100–104	99–105	99–103	98–102	100–101	101–102	101.6	101.6
Measuring	99–100	99–106	95–100	96–100	77		99.4	102.6
Crosscutting	100–101	98–106	99–103	98–102	99–101	101–102	100.1	101.6
Turning round	92		70–96	70–90			94.0	88.8
Releasing			98–103	101			99.4	100.6
Cutting order	75–89	81–101	60–87	61–86			85.9	86.5
Maintenance of motorsaw	52–89	69–101		70	63	73	84.2	86.7
Maintenance of tools		98						
Interruptions	64–100	88–96	82–92	66–93	72–89	90–95	90.5	91.4
Recorder time	100–101	97–104	98–101	96–101	99–100	100–101		
Average	100.6	101.5	99.3	99.5	99.5	100.5	99.9	100.6
Working time 8 hours (5 hour productive time)	98.6	99.5	97.3	97.5	97.5	98.5	97.9	98.6

The lumbermen's noise load during work is evidently connected with the noise level during cutting in motor saw testing. The correlations between the noise level at testing and the noise load during motor saw operation throughout the productive time are statistically significant but not strong. There are many other influences of working conditions and working methods on the noise load. The correlations are linear (Figure 2). If the producers lowered the noise level under 100 dB(A), the noise load during productive time would not be lower than

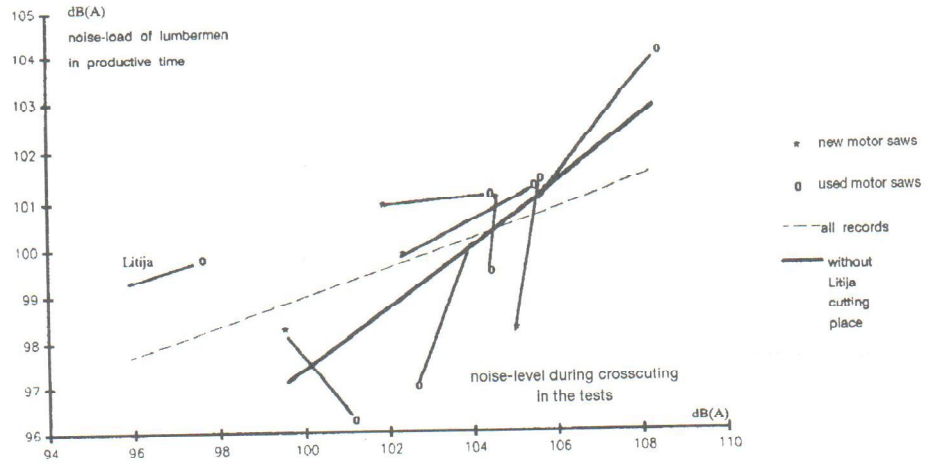

Figure 2 *Correlation between noise load during the recorded productive time and the motor saw noise level*

97 dB(A) with the currently used technology. The corresponding noise load for the entire working time with a five-hour productive time would then be 95 dB(A). This means that the noise load surpasses all allowed limits (85 dBA) (8). It is therefore essential for the lumbermen to wear hearing protection devices. For a different duration of productive time in an eight-hour working day we have calculated the noise loads between 96 and 100 dB(A) assuming that in the unproductive time the noise load does not exist. Comparison of noise level distributions in an eight-hour-long working day with the allowed noise exposure limits for the noise with interruptions (which lasts less than eight hours) also shows the lumbermen to be overloaded with the noise of 98 to 108 dB(A). The overload lasts on the average 25 per cent of the working time. It is highest at cutting of broadleaf trees and lowest at spruce cutting in the Alps. At some cutting places the noise load (with higher noise levels) surpasses the allowed limit by as much as 32 per cent of the working time (Figure 3). This is much more than was established in comparable investigations of similar working methods in the past (3, 5, 6, 9).

We could not prove a direct dependence of the noise level on motor saw's age or duration of use, although the majority (six out of eight) of the used motor saws caused greater noise level at test cutting. Also, during crosscutting, limbing and during all recorded time the noise load at five out of eight cutting sites was higher when workers used the older motor saw. The average noise load on working days with used motor saws was 0.7 dB(A) higher than the noise load with new motor saws.

Regular maintenance of the saw cutting parts, timely change of parts, use of new types of less noisy saws, more handwork e.g. maintenance of cutting order and strict observance of hearing protection could help in preventing the

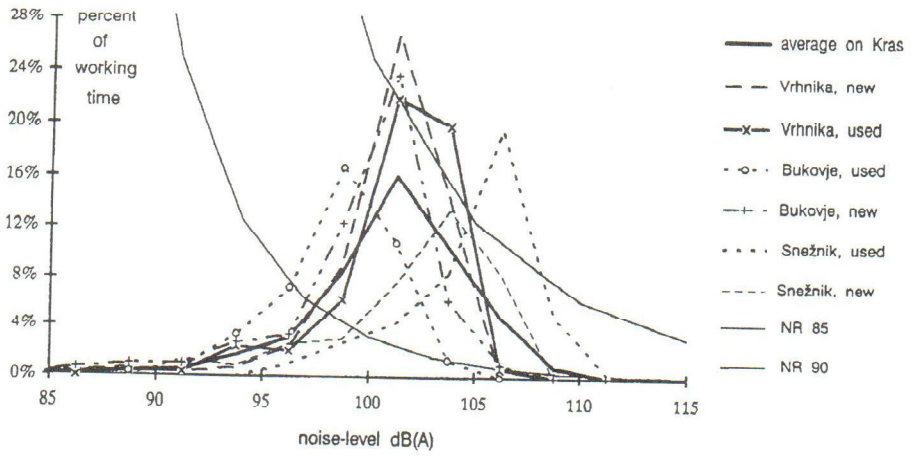

Figure 3 *Lumbermen's noise load at cutting sites in the Karst*

lumbermen from contracting an illness that may lead to a professional hearing loss as a permanent health injury.

VIBRATION LOAD

In the past vibrations from motor saws caused numerous cases of vibration illness and disablement among lumbermen. Although the antivibration grips have substantially reduced the vibration level, the vibration loads of lumbermen are not negligible. In modern technology the daily time of exposure to vibration is growing because of more work with motor saw.

Methods

In our investigation the lumbermen's vibration load was established by means of measurements of vibration level on the motor saw rear handle. There the accelerations were up to three times greater than on the front handle at the test. Near the little finger of the worker's right hand a three axial accelerometer was fixed and the weighed acceleration sum was measured. The instruments recorded the average acceleration sum for half a minute or for a full minute. For each interval the predominant working task was established and so the vibration load was calculated as an effective root mean square value for each working task, for the productive and for the entire recorded time. The daily vibration load of lumbermen

was calculated under the assumption that the three daily hours of unproductive time do not cause any vibration load. Vibration levels were recorded at three cutting sites for 45–94 minutes daily on six working days for four workers.

RESULTS AND DISCUSSION

The accelerations were great during the motor saw operation. Including short interruptions they were greatest during felling (8.4–13.2 ms^{-2}), similar during limbing (8.1–13.1 ms^{-2}) and little lower during measuring and crosscutting (7.5–12.1 ms^{-2}). The weighted acceleration sum during the entire productive time amounted to 7.7–12.3 ms^{-2}, the calculated vibration load for a working day was 6.6–10.8 ms^{-2} (Table 4).

Table 4 *Lumbermen's vibration load on the motor saw rear handle*

Element of work	Motor saw					
	Husqvarna 266					Husqvarna 254
	Forest and date (weighted acceleration sum ms^{-2})					
	Glažuta				Mislinja	Gor. Grad
	8. 9. 93	15. 9. 93	23. 9. 93	30. 9. 93	9. 12. 93	4. 2. 94
Going		7.12	5.65	3.11	2.14	3.93
Felling		11.02	13.16	12.25	8.43	12.51
Releasing					6.31	
Limbing		11.02	13.14	12.50	8.12	9.22
Crosscutting		9.99	11.11	12.07	7.54	10.45
Turning round					1.89	
Maintenance				3.62		1.82
Cutting order						12.20
Productive time	8.67	10.60	12.31	11.44	7.69	9.09
Interruption	1.77	6.31	6.68	9.35		
Pause	1.77	0.90	0.59	4.50	3.70	2.44
Recorded time	7.52	9.40	11.10	10.62	7.66	8.93
Working time	7.39	7.64	10.82	9.77	6.56	7.83

The vibration load in single recorded intervals greatly oscillates: from zero to the value of 20 ms^{-2} in the working time and between 8 and 15 ms^{-2} in the productive time (Figure 4).

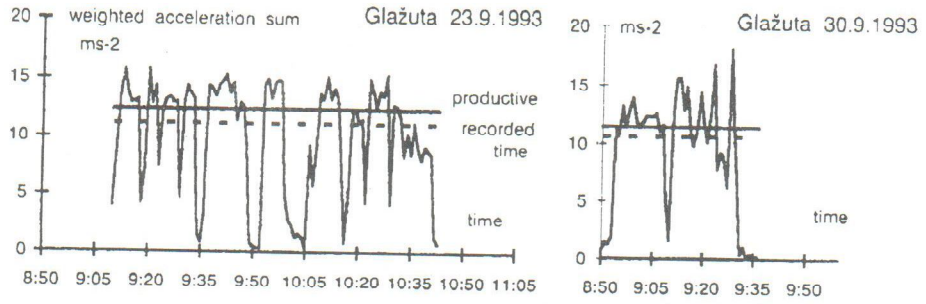

Figure 4 *Accelerations on rear handle of the Husqvarna 266 motor saw at the Glažuta cutting site*

The greatest contribution to the vibration load comes from vibrations during limbing because of a high vibration level and because of its long duration – 52–67 per cent of the productive time. The lumbermen's vibration load exceeded the calculated but not yet standardised limit allowed for eight-hour exposure time on most recorded days. This limit was calculated from the limits for the terc-octav bands in the ISO 5349 standard (10). For all frequencies from 6.3 to 1250 Hz the limit for one single direction is 3.919 ms^{-2}. The limit for the weighted acceleration sum is 6.788 ms^{-2}. The vibrations in one working day last shorter than eight hours and they are interrupted many times. If they do not exceed the calculated limit twice and if the motor saw work does not exceed 2–4 hours daily, the vibration load is not dangerous to the lumbermen's health. This was the case in our investigation. To diminish even more the danger of vibrations the motor saws must be regularly maintained (changing the AV mufs f.e.). To maintain the hands warm gloves must be worn. Also, prolongation of working day or longer use of motor saw is not considered wise. If these preventive measures are not observed, injuries to lumbermen's health can be expected even if modern motor saws are used.

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Sažetak

OPTEREĆENJE SJEKAČA BUKOM I VIBRACIJAMA

Na osam šumskih sječišta u Sloveniji ustanovljeno je opterećenje sjekača bukom. Sjekači su radili po jedan radni dan novom i jedan radni dan već duže vremena upotrebljavanom ali uredno održavanom motornom pilom, uglavnom iz proizvodnje Husqvarna. Opterećenje je određivano mjerenjem jačine buke svake pola minute dva puta na dan tijekom oko 48 minuta, uz praćenje radnih operacija i radnih učinaka. Na ukupno opterećenje radnika bukom (L_{ekv} = 96 – 100 dB(A) najviše je utjecala buka radnih operacija u kojima se radnici koriste motornom pilom, osobito pri kresanju grana jer je tada buka jaka i dugo traje. Opterećenje radnika bukom ovisilo je o jačini buke motorne pile na testu pri prepiljivanju. Ta je korelacija linearna ali nije tijesna, jer na opterećenje utječu i tehnologija rada i radni uvjeti i način rukovanja pojedinca motornom pilom. Kad bi proizvođači uspjeli smanjiti buku pila ispod 100 dB(A), opterećenje radnika pri sadašnjoj tehnologiji rada bilo bi u prosjeku oko odnosno ispod 97 dB(A) u produktivnom i 95 dB(A) u radnom vremenu. Naši sjekači bili su preopterećeni bukom jačine 98–108 dB(A) s prekidima u prosjeku 25% radnog vremena, a na nekim sječištima čak do 32% vremena. Pri radu starijom već upotrebljavanom motornom pilom prosječno opterećenje bukom bilo je veće za 0,7 dB(A) nego pri radu novom pilom.

Opterećenje radnika vibracijama određeno je mjerenjem ubrzanja u sva tri smjera na vodećoj ručki motorne pile u razmacima od pola ili cijele minute, tijekom 48–94 minute u radnom danu. Ukupno ubrzanje određeno je na tri radilišta u šest radnih dana za četiri sjekača. Ukupno opterećenje sjekača vibracijama u radnom vremenu iznosilo je 6,6–10.8 ms^{-2} Budući da vibracije opterećuju radnika s prekidima i njegova izloženost vibracijama ne traje duže od 2 do 4 sata na dan, opterećenja nisu tolika da bi ugrozila zdravlje većine sjekača. Vibracije za vrijeme rada motornom pilom naime nisu bile dva puta veće od granica ubrzanja, koje su dopuštene za osmosatni radni dan.

Ključne riječi:
profesionalna izloženost, radni uvjeti, testiranje motorne pile

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