Acoustic Levels in the Wood Processing Industry in Northeast Italy

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Abstract

Acoustic pollution regulations, recently modified, are characterized by some important innovations on the prevention of a risk factor which is well known as the first cause of occupational disease in Italy and the second in Europe. The sector of wood processing is one of the most concerned by such a problem. The data collected by the Agencies in charge of this issue do confirm that timber processing accounts for a high risk activity in terms of hazard occurrence. The timber processing sector relies on a variety of processing plants and production lines which are characterized by a high level of process automation. In Northeast, the productive compartment of the wood working presents many issues in term of occupational safety and health. This sector represents a crucial role in Italian economy; in fact, Northeast Italy plays an important role in the supply of primary and secondary wood products. The exposure to the acoustic levels is one of the principal risks for workers. The acoustic survey was carried out under full and normal operating conditions of the industries. The examined industries do not always comply with the ergonomics and safety standards established by law for an acoustic comfort meeting workers' needs. Such interventions take into account the change of the lay-out of the production cycle, the reduction of acoustic emissions directly at their sources, an effective organization of work and a greater awareness towards the use of personal protection devices.

Keywords: acoustic pollution, noise reduction, wood processing, Northeast Italy

Introduction

The timber processing sector relies on a variety of processing plants and production lines which are characterized by a high level of process automation. In spite of this, many businesses, also due to the low added value of their finished products, still make use of obsolete machines and processing lines which, while still assuring a good operation and production efficiency, are by now inadequate to comply with the new requirements in terms of workers' health and safety. The data collected by the Agencies in charge of this issue do confirm that timber processing accounts for a high risk activity in terms of hazard occurrence (INAIL, Italian Workers' Compensation Authority, 2008). This is also ascribable to the fact that the production chain in question still includes many hand-made processing phases, which imply direct exposure of workers to work environment risk factors (equipment, machines and materials). This exposure results from a closer and more continuous contact with dangerous equipment and environment compared to other sectors (Table 1). In Northeast, the productive compartment of the wood working presents many issues in term of occupational safety and health. The exposure to high acoustic level is one of the principal risks for workers.
On the technical level, the cycle of the factories manufacture, which gets inspiration from the hand-crafted tradition, is today nearly wholly mechanized. The good levels of productivity achieved, must not allow to under estimate the risks for the health of the workers who work in

these factories. In particular, the process of mechanization of the manufacture processes has led to an increase of the noise sources and, as a result, of an increase of the percentage of workers exposed to this risk. Not by chance, in the wood macrosector, the majority of recognized cases of hypacusia and deafness take place in furniture factories; still, the index of frequency is not particularly high (Verdel *et al.*, 2001, Zimbalatti *et al.*, 2008).

Table 1. Activity sectors. Occupational hazard.

Sector of economic activity	**Index of frequency** (*)				
	Temporary disability	Permanent disability	Death rate	Total	Index number
Metal processing	65.79	2.47	0.08	68.34	191.2
Non-metallic minerals	63.86	2.64	0.12	66.61	186.4
Timber processing	**58.51**	**4.13**	**0.06**	**62.70**	**175.4**
Construction	54.43	4.10	0.19	58.72	164.3
Industry and Services (combined)	34.19	1.49	0.06	35.74	100.0

(*) Accidents indemnified per 1,000 covered by INAIL (Italian Workers' Compensation Authority)

The study has been conducted in Trento, one of the most important Italian regions in terms of timber production with an annual amount of processed timber of 631.458 m^3, i.e. 33% of the total amount of timber processed in Northeast Italy (ISTAT, 2008). Given the great economic importance of the Trento wood sector and in view of the problems related to the work conditions of this sector, it has been decided to start from the acoustic survey (on the basis of the laws currently in force) correlated to the production processes considered to be a representative sample of the entire regional sector (Proto *et al.*, 2009).
Timber processing encompasses a number of different kinds of processes which are almost always characterized by an elevated level of automation. In spite of this, many businesses, also because of the low added value of the finished product, still rely on obsolete equipment and machines which, while still keeping a pretty good level of productivity, are likely to create many problems and jeopardize both the safety and the health of the workers (Zimbalatti *et al.*, 2005, Giametta *et al.*, 2007).

Materials and methods

The sector of wood transformation is traditionally marked by high levels of exposure to noise, due to a series of attendant circumstances, such as the use of facilities with high acoustic power in often narrow work environments. Starting from these considerations, the Mechanical Section of the D*i*STA*f*A of the Mediterranean University of Reggio Calabria, in collaboration with the Trees and Timber Institute, has carried out a survey about acoustic levels in the wood processing industry in Northeast Italy.

The legislation reference

The legislation about noise pollution has been recently changed. The D. Lgs. 195/2006, in fact, has changed the D. Lgs. 626/94. The title has been replaced by the Title V-bis, which regards the rules for the accomplishment of the "Protection from Physical Agents" at work. In particular, it has received and accomplished the European Directive 2003/10/CE on the workers' exposure to noise, and it has introduced a series of articles which define the minimum requirements for health and safety with regard to exposure to noise. First of all, the limit of daily exposition to noise decreases from 90 to 87 dB(A); this limit considers also the noise reduction produced by the personal protective equipment (PPE) worn by workers. Moreover, the peak level of impulsive noise is measured by the weight curve C, instead of the linear system. The maximum value of exposure to noise beyond whom it is obligatory to signal and/or to define the borders of the area, decreases from 90 to 85 dB(A); finally, the evaluation of noise considers also the possible interactions with vibrations or hearing toxic substances (Casini S., 2006). The new legislation defines, coherently with what said before, two values of reference: the **maximum value of exposure**, that is the level it is not possible to exceed, and the **action values**, lower and higher, that have to be considered by the employer to take specific protection measures for workers; in particular, if the lower value is exceeded, activities of "information, formation and PPE supply" must be carried out; if the higher value is exceeded, actions of "information, training and PPE supply with the obligation of use" are needed (Table 2).

Instrumentation and test parameters

The researches have been carried out with the use of a precision integrator phonometer Delta Ohm HD 9020. This instrument is set every year at the laboratory S.I.T.; before and after each daily series of measurements, the calibration has been controlled by a calibrator Delta Ohm HD 9101. The collected data have been transferred through a serial cable to a laptop to be processed successively. The modalities of measurement and the methodology of research include the arrangement of the instrument, through a special tripod and a bracket with a feeler, at the height of the operator's ear, and at such a distance from his head, so as to reduce, as much as possible, the effects of diffraction and the distance of the measured value. The tests, have been carried out during full activity and normal operating conditions of the industries and, after evaluating the workers' residence time in their work stations, the level of daily personal exposure has been calculated ($L_{EX,\ 8h}$).
The knowledge for each worker of the level of exposure and the value of peak acoustic pressure makes possible to verify the respect of the limit values established in the art. 49-quater of D.Lgs. 195/06, to decide the prevention and protection measures to be taken. Moreover, it is very useful to estimate also the uncertainty related to the level of daily personal exposure, to define if a specific limit of exposure is, or can be exceeded.

$$\text{Level of daily personal exposure} = L_{EX,8h} = L_{Aeq,Te} + 10 \log \left(\frac{T_e}{T_0}\right) \quad \text{(dB(A))}$$

$$\text{where: } L_{Aeq,Te} = 10 \log \left\{ \frac{1}{Te} \int_0^{Te} \left[\frac{P_A(t)}{P_0}\right]^2 dt \right\} \qquad (1)$$

T_e = daily period of a worker's personal exposure to noise;
T_o = 8 hours;
P_A = instantaneous acoustic pressure (weighting scale A), in Pa;
P_0 = 20 μPa.

Table 2. Main differences between the old and the new legislation

Estimated provisions	D.Lgs. 277/1991	D.Lgs. 195/2006
Periodicity for noise evaluation	No	4 years
Interaction with vibrations and hearing toxic substances	No	Yes
Areas to be signaled/boundaries to be defined	≥ 90 dB(A)	≥ 85 dB(A)
Measure of peak level	dB(lin)	dB(C)
Lower value of action	85 dB(A)	80 dB(A)
Higher value of action	90 dB(A)	85 dB(A)
Maximum limit of exposure	90 dB(A)	87 dB(A)
Training for the use of PPE	≥ 85 dB(A)	≥ 80 dB(A)
Register of statements	Yes	No

Reduction of personal protective equipment

The new legislation imposes the employer, in case of exposure beyond the maximum value of 87 dB(A), to check the efficiency of the devices of hearing individual protection. So, during the tests in the different factories, the indications given by the D.M. 02/05/01 which fix the standards for the identification and the use of hearing protection devices through the reception of the rule UNI-EN 458 (Table 3), have been applied.
The action level (L_{act} - 85 dB) is the value beyond whom the employer make sure all workers wear PPE when noise levels are over 85 dB(A). In case the valuation points out an insufficient protection, it is necessary to use another kind of hearing protector with a higher reduction. On the contrary, if the valuation reveals that the protection effect is too high, it is necessary to use a different PPE with a lower reduction: we know indeed that hyperprotection can cause feelings of isolation and difficulty to perceive sounds. So it is necessary to make sure that the protection offered by the PPE stays in the limits of acceptance according to table 2. To verify the suitability of a PPE there are several methods based on the level of knowledge of the peculiarities of the environment noise and the values of acoustic reduction provided by the constructor of the device, together with the mark CE.
The method used in this research for the evaluation of the efficiency of PPE, is the system of simplified reduction of noise level - SNR (Simplified Noise Reduction) - that uses the equivalent level of acoustic noise pressure according to curve C. Successively, the equivalent level for each worn device (L'_{Aeq}) has been compared to the action level to evaluate the suitability of the hearing protector itself.

$$\text{Real level at the ear} = L'_{Aeq} = L_{Ceq} - SNR \qquad (2)$$

where:
L_{Ceq} = Equivalent level of acoustic noise pressure according to weighting scale C;
SNR = Value of acoustic reduction per octave band of a hearing protector.

Table 3. Evaluation of acoustic reduction

Real level at the ear	L'_{Aeq} dB	Evaluation of protection
Higher than L_{act}	80	Insufficient
Between L_{act} and L_{act} - 5	80 - 75	Acceptable
Between L_{act} - 5 and L_{act} - 10	75 - 70	Good
Between L_{act} - 10 and L_{act} - 15	70 - 65	Acceptable
Lower than L_{act} - 15	65	Too high (*Hyperprotection*)

Examined factories and production cycles

The sawmills under study had an average annual production of 3.700 m³ wood products. The timber usually process comes from the provincial area (68%), from the other provinces of the Trento Region (20%), and from both national and international markets (12%). In particular, all the sawmills studied use to buy long stems which are then cut in to sawlogs by means of cross-cutting. Softwood sawlogs have an average length of about 4 m, whereas hardwood sawlogs are on average 3 m long. The wood products fall within three categories: carpentry and construction materials, semi-finished products to be additionally processed and products for packing, boxing and shipment.

Table 4. Peculiarities of the examined sawmills

	Number of workers	**Timber volume** (m³/year)	**Species of wood**	**Products**	**Workforce** (days/year)
A	5	2.600	Chestnut, beech,	Carpentry and packing timber	215
B	6	4.800	Spruce	Trusses, semi-finished products	240
C	5	3.500	Spruce, beech	Semi-finished and capentry timber	230

Results

In tables 5, 6 and 7 you can see the results of measurements and the processing activities carried out in each sawmill in the different work stations. The machines working wood through the shaving removal by tools, disks or rolling knives at a high speed, give out high acoustic levels, especially if they are not well used and repaired. In no station the value of L_{peak}(C) came out higher or equal to135 db(C), so the verification of the respect of the action values and the exposure limits has been carried out exclusively on the base of the values of the daily personal exposure $L_{EX,8h}$. In particular, in the three sawmills the equivalent levels of the multiblade saw are equal and sometimes higher to 85dB(A). As a result, the values of the daily personal exposure in a period of eight hours are different in the three examined

factories. Indeed, for the 32% of the 16 examined workers the maximum exposure value of 85dB(A) is exceeded, and the choice of PPE does not seem to be satisfying.
In sawmill A, four workers are subjected to acoustic levels higher than 85 dB(A), high action value which, not only forces workers to wear PPE, but also imposes the employer to create and apply a specific programme of technical and organizing measures to reduce this exposure. All workers have been provided with auricular insets with an arc of EAR model ReFlex, certificated according the norm EN 352-2. The test of the reduction produced by these PPE shows as the use of insets is acceptable for all other workers. They are the highest of the whole factory because of the old age of the machine, the bad conditions of maintenance and his closeness to walls (Figure 1). The sawmill, therefore, does not comply with the minimum requirements for an acoustic comfort; the overcoming of limit values found in all machines must induce the employer to reconsider the factory layout, its management and maintenance, and incidentally think about the replacement of some machines (Zimbalatti *et al.*, 2008).
In B, acoustic levels exceed 80 dB(A) and the acoustic conditions compared to the previous one are similar; in fact, the six persons work in conditions that exceed the legal limit value (Figure 1). The values of daily personal exposure, according to what has been said, are higher than legal values both for the bad conditions of maintenance. The reduction produced by earphones - EAR Ultrafit - in favour of the six workers is acceptable.
The data collected in sawmill C show quite different acoustic levels (Figure 1); there are machines with values higher than 87 dB(A), in comparison with other machines which have values around 85 dB(A). In particular, high levels have been registered near the multiblade saw and the trimmer machine. The choice of the earphone (Peltor H4A), used by this factory, appears to have good reducing levels. It could be useful, in addition, to isolate acoustically the machines with higher emission levels. It would be also necessary to draw attention on the work areas where this machines work, as they exceed of 10 dB the medium values, to warn the operator about the importance of using PPE.

Table 5. Acoustic levels in factory A

Work station	$L_{eq,i}$ (ε)	L_{peak} (dB)	Operator			
			A1	A2 – A3	A4	A5
			Residence time t_i (hours)			
1. Head Band saw	85,4 (± 0,5)	112,4		8,00		
2. Trimmer	84,9 (± 0,7)	114,1				8,00
3. Edger	82,2 (± 0,6)	108,3	3,00			
4. Multiblade saw	86,4 (± 0,8)	115,1	5,00			
5. Pit saw	86,2 (± 0,1)	116,5			8,00	
$L_{EX,8h}$ [dB(A)]			**85,3**	**85,4**	**85,7**	**84,9**
ε $L_{EX,8h}$ [dB(A)]			± 1,1	± 0,9	± 0,7	± 1,0
Level of exposure with PPE			66,0	66,0	67,0	68,0
Reduction			Acceptable	Acceptable	Acceptable	Acceptable

Table 6. Acoustic levels in factory B

Work station	$L_{eq,i}$ (ε)	L_{peak} (dB)	Operator				
			B1	B2 – B3	B4	B5	B6
			Residence time t_i (hours)				
1. Head Band saw	84,4 (± 0,9)	116,1		8,00			
2. Alternate saw	83,9 (± 0,8)	111,9					8,00
3. Multi-blade saw (A)	85,1 (± 0,5)	116,4			8,00		
4. Multi-blade saw (B)	84,7 (± 0,4)	114,1	4,00				
5. Edger	83,3 (± 0,5)	113,2	4,00				
6. Trimmer	84,6 (± 0,7)	114,1				5,00	
7. Pit saw	85,3 (± 0,5)	113,2				3,00	
$L_{EX,8h}$ [dB(A)]			**84,1**	**84,4**	**85,1**	**84,9**	**83,9**
ε $L_{EX,8h}$ [dB(A)]			± 0,8	± 1,1	± 0,9	± 0,9	± 1,1
Level of exposure with PPE			66,0	66,0	67,0	67,0	65,0
Reduction			Acceptable	Acceptable	Acceptable	Acceptable	Acceptable

Table 7. Acoustic levels in factory C

Work station	$L_{eq,i}$ (ε)	L_{peak} (dB)	Operator				
			C1	C2	C3	C4	C5
			Residence time t_i (hours)				
1. Head Band saw	84,5 (± 0,7)	115,4	6,00				
2. Trimmer	85,9 (± 1,1)	116,2		8,00			
3. Edger	85,7 (± 0,8)	117,7	2,00				
4. Multiblade saw (A)	86,7 (± 0,4)	119,3					8,00
5. Multi-blade saw (B)	87,1 (± 0,5)	120,1				8,00	
6. Pit saw	84,2 (± 0,2)	108,7			8,00		
$L_{EX,8h}$ [dB(A)]			**84,8**	**85,9**	**84,2**	**87,1**	**86,7**
ε $L_{EX,8h}$ [dB(A)]			± 1,0	± 1,3	± 0,7	± 0,9	± 0,8
Level of exposure with PPE			68,0	69,0	67,0	70,0	70,0

Reduction	Acceptable	Acceptable	Acceptable	Good	Good

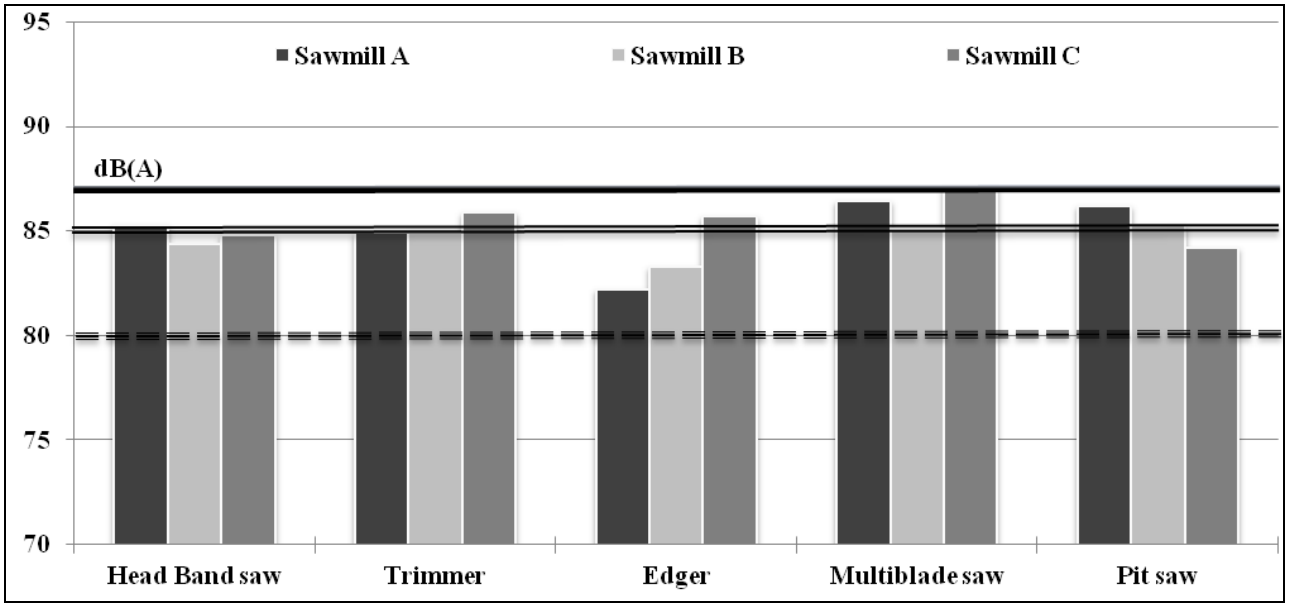

Figure 1. Equivalent levels in the examined machines

Conclusions

This study has enabled to widen our understanding of the general picture of the sector of primary timber processing whose many criticalities in terms of work safety have not only been highlighted and observed, but also analysed. The sector of primary timber processing in Trento has been found to be characterized by extremely promiscuous tasks as well as by ill-designed and managed work premises ad a lot of gaps in terms of compliance with safety and hygiene standards. On the grounds of the first results obtained it seems evident that research and personnel training efforts are essential to improve safety conditions within wood processing businesses. In the work stations where there is an equivalent acoustic level higher than 85 dB(A), it would be important to adopt specific balancing measures or precautionary interventions, and limit the access only to the employers with appropriate personal protective equipment, as well (earphones or auricular insets) (Zimbalatti *et al., 2008).*
The noise reduction, at the source or on the run, should be one of the main management programmes of this risk factor. This activity must take into account both the facilities and planning, as well as maintenance to control acoustic pollution inside factories during the cycle of wood processing. The clearing of work stations can be positively carried out by limiting the productive lines in soundproofing cabins and tunnels, and coating the plates subjected to impacts (Bianconi A., 2004). With regard to work places, there is in all three factories, a complete saturation of spaces. The acoustic field is the sum of the direct field and the one reflected by walls. To eliminate the latter, it is reasonable to put appropriate soundproofing panels hanging from the roof and applied to the factory walls. In general, the visited enterprises rely on the supply to workers of the different kinds of PPE hearing protectors in

commerce for the protection from noise. But with regard to legislation, it is important to remember that no auricular protection is valid everywhere. It is necessary to know the peculiarities of noise in the different environments where people work, to choose the right acoustic damping factor. It is also important to consider the length of stays in particularly noisy environments. In some cases, if hearing is not constantly protected, it risks permanent damages.

The authors participated equally in all the phases of the present work.

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