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Raven hrupa v delovnem okolju ob upoštevanju različnih poprav

Considering Various Corrections of Noise Level in the Workplace Environment

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Podani so rezultati raziskave, s katero smo naredili primerjavo med ravnmi hrupa v delovnem okolju ob upoštevanju različnih poprav (impulzne, kakor to določa nova slovenska zakonodaja, in tonske, kakor je podana v standardu ISO 9612) in tudi brez njih. Meritve smo opravili v treh podjetjih kovinskopredelovalne industrije.

Analiza je bila opravljena z namenom, da bi videli, kakšen je dejanski vpliv posamezne poprave na dnevno izpostavljenost delavca hrupu (predvsem tonske poprave, ki je nova zakonodaja ne predvideva).

Rezultati so pokazali, da gre za statistično pomembno razliko z veliko stopnjo zaupanja med posameznimi popravami.

(Ključne besede: ravni hrupa, poprave tonske, poprave impulzne, analize frekvenčne)

In this paper research results are presented that compare the noise levels in the workplace and consider different corrections (impulse as envisaged by the new Slovenian legislation and tone correction as given in the ISO 9612 standard) or the absence of corrections. The measurements were taken in three metalworking companies.

The analyses were performed to determine the influence of a single correction on a worker's daily exposure to noise (especially tone correction, which is not mentioned by the new legislation).

The results show a statistically important difference, with a high level of reliability between the single corrections.

(Keywords: noise level, tone corrections, impulse corrections, frequency analysis)

0 UVOD

Izpostavljenost dovolj visokim ravnem hrupa ima lahko za posledico, med drugim, okvaro sluha. Dodatni negativni vpliv pa imata še impulzivni značaj hrupa in navzočnost izrazitih tonov ([1] do [3] in [5]).

Za impulziven hrup je značilna visoka vrednost, ki traja kratek čas. Človeško uho ni zmožno slediti spremembam hrupa, ki so krajše od 100 ms. Zaradi počasnejšega odziva ušesa pa vpliv na poškodbe sluha ni zmanjšan.

Poudarjeni toni so nevarni predvsem zato, ker stalno delujejo na točno določeno frekvenčno področje v ušesu.

Pri meritvah lahko upoštevamo impulzivnost in poudarjene tone v obliki dodatnih popravnih faktorjev.

Po stari slovenski zakonodaji [8] se je hrup s poudarjenimi toni ali izrazitimi impulzi ocenjeval za 5 dB strožje, pri čemer pa ni bilo izrecno definirano, kaj

0 INTRODUCTION

Exposure to relatively high levels of noise can, amongst other things, result in hearing defects. The nature of the impulsive noise and the presence of pronounced tones represent additional negative influences ([1] to [3] and [5]).

Impulsive noise is characterised by a high value over a short period of time. The human ear cannot follow noise changes that occur over less than 100 ms; however, this slow response of the ear does not result in a lowering of the hearing impairment.

Pronounced tones are dangerous because they are constantly acting over a certain frequency range in the human ear.

In these measurements the impulsiveness and pronounced tones in the form of additional corrective factors can be taken into consideration.

According to the previous Slovenian legislation [8], noise with pronounced tones or explicit impulses was classified as being for 5 dB higher; however, poudarjeni toni ali impulzi so, torej stvar posamezne presoje (v praksi zanemarjeno).

Nova slovenska zakonodaja [6] se je naslonila na standard ISO 9612 [5]. Ta podaja kot možen način upoštevanja impulzivnosti hrupa t.i. *impulzno popravo* K_I, kar je prevzela tudi naša zakonodaja, ni pa prevzela upoštevanja prisotnosti izrazitih tonov (t. i. *tonska poprava* K_T), kar prav tako navaja omenjeni standard.

V pričujoči raziskavi smo zato izvedli primerjavo med vrednostmi hrupa, ki jih dobimo z upoštevanjem posameznih poprav in brez njih. Zanimal nas je vpliv upoštevanja poprav na skupno (dnevno) izpostavljenost delavca hrupu in ne le pri posameznem opravilu. To se zdi primerno, ker je osnovni kriterij pri zaščiti delavca pred hrupom ([5], [6] in [9]) dnevna izpostavljenost hrupu $L_{EX,8h}$.

there was no explicit definition of what the pronounced tones or impulses were, this was a matter of subjective estimation and was often neglected in practise.

The new Slovenian legislation [6] is based on the ISO 9612 standard [5]. This standard states the possibility of considering noise impulsiveness e.g. *impulse correction* K_I, which has been incorporated into our new legislation but has not taken over the consideration of any pronounced tones' presence (e.g. *tonality correction* K_T), which is, however, stated in the above-mentioned standard.

Our research compares the noise values obtained when considering single corrections with those that do not consider them. We were also interested in the influence of cumulative (daily) noise exposure when considering the correction. This seems reasonable since the workers' daily noise exposure, $L_{EX,8h}$, is the basic criterion when protecting the worker from noise ([5], [6] and [9]).

1 MATERIALI IN METODE

1.1 Opis merilnih mest

Pri izvajanju meritev smo se omejili na kovinsko predelovalno industrijo. Meritve smo izvedli v treh slovenskih podjetjih.

- PODJETJE A

Poglavitna dejavnost podjetja je izdelava namenskih orodij. V proizvodnji se v glavnem uporabljajo obdelovalni stroji (struženje, frezanje, razrez ipd.)

Dodatna dejavnost podjetja je kovanje polizdelkov in energijska oskrba drugih industrijskih obratov (kotlarna, kompresorska postaja)

- PODJETJE B

Glavna dejavnost podjetja je izdelava večje opreme s področja toplotne tehnike. V proizvodnji se v glavnem uporabljajo metode razreza in spajanja kovin

- PODJETJE C

Glavna dejavnost podjetja je izdelava namenskih nadgradenj na vozilih. V proizvodnji se v glavnem uporabljajo kleparski in ključavničarski postopki.

1.2 Opis postopka merjenja

Uporabili smo merilni instrument podjetja Bruel&Kjaer, s serijsko številko 2201657 in območjem merjenja 50 do 120 dB, ki izpolnjuje določila tehničnih specifikacij po IEC 225, IEC 651 in IEC 804.

• Določitev ravni hrupa

Meritve smo izvedli v skladu s standardom SIST ISO 9612.

Merilni mikrofon postavimo na delavčevo mesto in v višini njegovega ušesa 0,2 m od njega. Mikrofon mora biti obrnjen proti viru ropota. Med mikrofonom in virom ropota ne sme biti ovir.

1 MATERIALS AND METHODS

1.1 Description of the places were the measurements were taken

The measurements were restricted to the metalworking industry. These measurements were performed in three Slovenian companies.

- COMPANY A

The company produces tools. The production involves the use of machines (milling, turning, cutting, etc.)

Other processes include the forging of semi-manufactured products and the supply of energy to other areas (boiler house, compressor unit/station).

- COMPANY B

The company produces large equipment for power techniques/technology. The production involves cutting and joining metod parts.

- COMPANY C

The company produces special purpose upgrading on vehicles. The production involves plumbing and locksmithing processes.

1.2 Description of the measuring procedure

A Bruel&Kjaer measuring instrument, with the serial no. 2201657 and range 50 to 120 dB which meets the IEC 225, IEC 651 and IEC 804 technical specification regulations, was used.

• Determination of the noise level

The measurements were performed in accordance with the SIST ISO 9612 standard.

The measuring microphone was set up in the workplace at ear level, 0.2 m from the ear. The microphone had to face the noise source. There must be no hindrance between the microphone and the noise source.

Čas merjenja mora biti dovolj dolg, da odčitek ustrezne ravni hrupa niha za manj ko 0,5 dB. Čas merjenja ne sme biti krajši od 15 s. Pri izrazitem periodičnem hrupu je potrebno zajeti vsaj eno periodo.

Kadar delavec spreminja lokacijo delovnega mesta med delavnikom, meritve izvajamo na vseh značilnih lokacijah, pri čemer upoštevamo čas, ki ga porabi na enem delovnem mestu.

V primerih, ko se raven hrupa v delovnem prostoru spreminja povsem naključno, npr. kleparska delavnica, izvajamo meritve naključno in v dovolj velikih časovnih obdobjih, tako da so rezultati med seboj neodvisni. Običajno vzamemo najmanj pet meritev in na podlagi tega določimo ocenjeno raven hrupa (enačba 4).

• Frekvenčna analiza

Na delovnih mestih smo izvedli dodatno še terčno frekvenčno analizo hrupa z namenom, da bi ocenili navzočnost poudarjenih tonov.

Frekvenčne analize smo izvedli v skladu s standardom SIST ISO 9612. Rezultat analize je na zaslonu instrumenta izrisan kot palični diagram.

1.3 Vrednotenje rezultatov meritev

• Določitev ravni hrupa z impulzno popravo

Impulzno popravo upoštevamo v skladu z novo slovensko zakonodajo, torej tako da izmerjeni ustrezni ravni hrupa prištejemo razliko med ravnijo, merjeno z dinamiko *I* (Impulse), in ravnijo, merjeno z dinamiko *F* (Fast). Če je razlika manjša od 2 dB, se zanemari, če pa je večja od 6 dB, se prišteje le 6 dB.

Na delovnih mestih smo ocenjevali hrup med celotnim delavnikom. Ostali smo pri sistemu označevanja (določevanja) ustrezne ravni L_{Aeq}, namesto dnevne izpostavljenosti hrupa $L_{EX,8h}$ (nova zakonodaja), ker dejansko dobimo enake rezultate, če zajamemo vse ravni hrupa v dnevu (tudi obdobja relativne tišine) in iz njih izračunamo ustrezno raven L_{Aeq}, kakor če računamo $L_{EX,8h}$ ob upoštevanju časa, ko prevladuje relativna tišina.

Iz navedenih razlogov smo tudi hrup z impulzno popravo označevali z L_{AIeq}, namesto z $L_{Ar,Te}$, kakor je v novi zakonodaji, torej [6]:

The measuring time had to be sufficient to ensure that the equivalent noise level reading varied by less than 0,5 dB. The measuring time must not be shorter than 15 s. In the case of a pronounced periodic noise, at least one whole period has to be measured.

In cases where the worker changes his working place in the course of his working day, measurements are performed in all typical locations by considering the time spent in each workplace.

In cases where the noise level in the workplace changes periodically, e.g. in a plumbing workshop, measurements were performed randomly in time intervals large enough to ensure independent, relevant results. Usually, five measurements were taken to define the estimated noise level (Equation 4).

• Frequency analysis

An additional third-octave band-frequency noise-level analysis was performed in the workplaces with the aim of evaluating the presence of pronounced tones.

The frequency analyses were performed in accordance with the SIST ISO 9612 standard. On the instrument's monitor, the analysis result is shown as a bar chart.

1.3 Evaluation of the results

• Determination of the noise level by means of impulse correction

Impulse correction is taken into account in accordance with the new Slovenian legislation, which means that the difference between the level measured by the dynamic *I* (Impulse) and the level measured by the dynamic *F* (Fast) is added to the measured equivalent noise level. If the difference is less than 2 dB it is ignored. In cases where the difference is more than 6 dB, only 6 dB are added.

In the workplaces the noise was evaluated throughout the working day. We used the marking system for equivalent level, $L_{AEq,}$ instead of the daily noise exposure, $L_{EX,8h}$ (new legislation), because we actually obtain the same results when we consider all the noise levels over the whole day (even the periods of relative silence) and calculate the equivalent level, L_{Aeq}, or when we calculate $L_{EX,8h}$ considering the period of relative silence.

For the reasons given the noise using impulse correction is marked as L_{AIeq} instead of $L_{ar,Te}$ as, stated in the new legislation [6]:

$$L_{AIeq} = 10\log\left(\frac{1}{T_e}\sum_{i=1}^{n} T_i 10^{0.1\left(L_{Aeq,T_i}+K_{Ii}\right)}\right) \qquad (1),$$

kjer so:

$L_{Aeq,Ti}$ - ustrezna zvezna *A*-vrednotena raven hrupa med časovnim obdobjem T_i,

K_{Ii} - impulzna poprava med časovnim obdobjem T_i,

T_e - trajanje izpostavljenosti hrupu.

where:

$L_{Aeq,Ti}$ represents the equivalent A evaluated noise level during the time interval T_i

K_{Ii} represents the impulsive correction during time interval T_i

T_e represents the duration of the noise exposure.

• Določitev ravni hrupa z impulzno in tonsko popravo

Če pri terčni frekvenčni analizi ugotovimo, da raven pri določeni frekvenci za več ko 5dB presega ravni najbližjih sosednjih frekvenc (levo in desno), potem govorimo o poudarjenih tonih. V tem primeru predlaga standard ISO 9612 dodatni koeficient K_T. Vrednost $K_T = 5$. Raven hrupa z impulzno in tonsko popravo - L_{AITeq} izračunamo [5]:

• Determination of the noise level by means of impulse and tone correction

In this case the third-octave band-frequency analysis shows that the level at a certain frequency exceeds the closest neighbouring frequencies (to the left and to the right) by more than 5 dB, a case of pronounced tones is encountered. In such a case the ISO 9612 standard suggests an additional coefficient K_T. The value of $K_T = 5$. The noise level with the impulse and tone correction, L_{AITeq}, is calculated as [5]:

$$L_{AITeq} = 10\log\left(\frac{1}{T_e}\sum_{i=1}^{n} T_i 10^{0.1\left(L_{Aeq,T_i}+K_{Ii}+K_{Ti}\right)}\right) \quad (2),$$

kjer je:
K_{Ti} - tonska poprava med časovnim obdobjem T_i.

where:
K_{Ti} represents the tone correction during the time interval T_i

• Določitev ravni hrupa brez poprav [5]

• Determination of the noise level without correction [5]

$$L_{Aeq} = 10\log\left(\frac{1}{T_e}\sum_{i=1}^{n} T_i 10^{0.1 L_{Aeq,T_i}}\right) \quad (3).$$

• Določitev ravni hrupa, ki se naključno spreminja

V primerih, ko se raven hrupa v delovnem prostoru spreminja povsem naključno – npr. kleparska delavnica, standard ISO 9612 predlaga za določitev ocenjene ravni hrupa naslednji postopek.

Meritve, da bi določili zanesljivosti, si morajo slediti v dovolj velikih časovnih obdobjih, da so rezultati med seboj neodvisni.

Pri n-kratnem številu neodvisnih vzorcev L_i določimo ocenjeno raven z naslednjo zvezo [5]:

• Determination of the periodically changing noise level

In cases when the noise level changes periodically, e.g. in a plumbing workshop, the ISO 9612 standard suggests the following procedure for determining the estimated noise level.

To ensure independent results, measurements aiming at reliability determination have to follow in large enough time intervals.

In n-time the number of independent samples, L_i, the estimated level is determined as follows [5]:

$$L_{Aeq} = \overline{L} + 0{,}115 s^2 \quad (4),$$

kjer je:

where:

$$\overline{L} = \frac{1}{n}\sum_{i=1}^{n} L_i$$

aritmetično povprečje izmerjenih ravni v decibelih in

is the arithmetic mean of the measured levels in decibels and

$$s = \sqrt{\frac{\sum_{i=1}^{n}(L_i - \overline{L})^2}{n-1}}$$

standardni odmik v decibelih.

is the standard deviation in decibels.

1.4 Obdelava rezultatov - testiranje razlike med dvema aritmetičnima povprečjema

Ker smo opazovali iste vzorce v dveh različnih okoliščinah, je šlo za odvisne vzorce. Pri vsakem od opazovanih enot imamo dvojico podatkov, tako da izvedemo *preskus dvojic*, s katerim preskušamo razliko med aritmetičnima povprečjema.

Iz vzorčnih podatkov najprej izračunamo za vsako enoto razliko d_i, iz njih pa oceno aritmetičnega povprečja razlike:

1.4 Result processing – testing the difference between two arithmetic means

Since the same samples under two different circumstances were observed we dealt with dependent samples. In each of the observed units we have two lots of data; a *couple test* is performed in which the difference between the arithmetic means is tested.

From the sample data the d_i for each unit is calculated followed by the arithmetic mean estimation:

$$\bar{d} = \frac{1}{n}\sum_{i=1}^{n} d_i$$

in oceno variance razlik [11]:

and the variant difference estimation [11]:

$$s_d^{\ 2} = \frac{1}{n-1}\left[\sum d_i^{\ 2} - \frac{1}{n}\left(\sum_{i=1}^{n} d_i\right)^2\right]$$

n - velikost vzorca.
Standardna napaka aritmetičnega povprečja:

n - sample size.
Standard arithmetic mean error:

$$se\left(\bar{d}\right) = \frac{s_d}{\sqrt{n}}$$

Določitev faktorja *t*:

t-factor determination:

$$t = \frac{\bar{d}}{se\left(\bar{d}\right)} \qquad (5).$$

Tako izračunano vrednost Studentovega faktorja *t* primerjamo s tabeliranim. Za velikost vzorca $n = 40$ (število različnih delovnih mest, ki smo jih analizirali) sledijo pri $(n-1)$ prostostnih stopnjah $m = 39$ naslednje vrednosti *t*-faktorja glede na različne stopnje zaupanja α (preglednica 1):

Thus the calculated Student *t*-factor value is compared to the tabulated one. For a sample size of $n = 40$ (number of different analysed workplaces) the *t*-factor values regarding the different reliability level α follow in $(n-1)$ degrees of freedom $m = 39$ (Table 1).

Preglednica 1. *Vrednosti faktorja t*
Table 1. *t-factor values*

α	0,1	0,05	0,025	0,01	0,005	0,001	0,0005	0,0001
t	1,3031	1,6839	2,0211	2,4233	2,7045	3,3069	3,5510	4,0942

2 REZULTATI IZMERJENIH VREDNOSTI

Pri določitvi dnevne izpostavljenosti delavca hrupu na posameznem delovnem mestu smo njegov delavnik (7,5 ure) razdelili na tipična opravila. Merili smo raven hrupa pri posameznem opravilu in čas trajanja opravila. Po enačbah (1), (2) in (3) smo izračunali dnevno izpostavljenost.

Na delovnih mestih, kjer se hrup spreminja naključno, smo za ocenitev ravni hrupa uporabili še enačbo (4).

Malico (0,5 ure) smo zanemarili, ker ima relativna tišina zanemarljiv vpliv na osnovno ustrezno raven.

Končni rezultati ravni hrupa po posameznih delovnih mestih v podjetjih A, B in C so prikazani v preglednici 2.

Kot primer izračuna ravni hrupa je prikazano delovno mesto št. 4 – delo na računalniško krmiljenem frezalnem stroju ILR WALDRIC. Rezultati meritev po posameznih opravilih in določitev popravnih faktorjev so podani v preglednici 3.

Končni rezultati – ustrezne ravni hrupa v enem delavniku:

2 RESULTS OF THE MEASURED VALUES

When determining the worker's daily noise exposure in a particular workplace the working day (7,5 h) was divided according to the typical work operations. The noise level of the individual operation and the operation-time duration were measured. The daily exposure was calculated, based on Eqs. (1), (2) and (3).

In workplaces where the noise changes periodically, Equation (4) was additionally implemented to estimate the noise level.

The coffee break (0,5 h) was ignored because the relative silence had a negligible effect on the basic equivalent level.

The final results of noise levels in the individual workplaces in companies A, B and C are shown in Table 2.

An example of a noise-level calculation is shown for workplace No. 4 – work performed on the CNC ILR WALDRIC milling machine. The measurement results of single operations and the correction-factor determination are shown in Table 3.

Final results – equivalent noise level over the whole working day:

$$\boldsymbol{L_{AIeq} = 82{,}4 \ \ \mathrm{dB}}$$
$$\boldsymbol{L_{AITeq} = 87{,}4 \ \ \mathrm{dB}}$$
$$\boldsymbol{L_{Aeq} = 80{,}5 \ \ \mathrm{dB}}$$

Preglednica 2. *Končni rezultati ravni hrupa*
Table 2. *Final results of noise level*

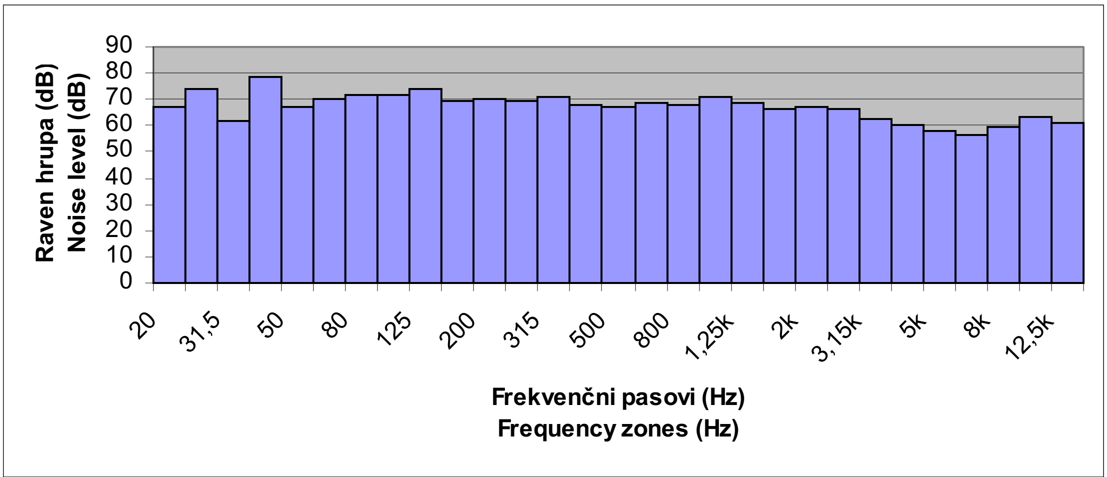
Št. Nr.	delovno mesto work place	L_{AITeq} dB	L_{AIeq} dB	L_{Aeq} dB
PODJETJE A COMPANY A				
1	struženje turning	84,3	84,3	84,3
2	frezanje miliing	86,0	86,0	84,2
3	RK/CNC Bohle	75,4	75,4	75,4
4	RK/CNC ILR Waldric	87,4	82,4	80,5
5	avtogeno rezanje oxyacetylene cutting	93,6	92,3	92,3
6	krožna žaga Ø 1000 circular saw Ø 1000	87,6	83,0	83,0
7	stiskalnica 400 t press 400 t	105,6	100,6	94,7
8	montažna dela assembly	90,7	87,0	83,0
9	varjenje welding	95,4	92,1	87,8
10	koordinatni vrtalni stroj co-ord. drilling machine	88,7	83,9	83,8
11	brušenje grinding	88,2	85,0	83,9
12	nadzor checking	69,6	69,6	67,1
13	delovodja foreman	71,2	71,2	71,2
14	konstrukcija design	48,6	48,6	48,6
15	kovaško kladivo – 20 t sledge-hammer – 20 t	112,6	107,6	101,6
16	kovaško kladivo – 3 t sledge-hammer – 3 t	108,9	103,9	97,9
17	delovodja foreman	97,2	92,3	86,9
18	kompresorist compressor-man	88,5	88,5	88,5
19	kotlarna boiler house	86,3	83,4	83,4
20	tehnik technician	73,7	68,8	68,8
PODJETJE B COMPANY B				
21	razrez pločevine sheet cutting	99,2	94,4	88,8
22	varilec - elektro obločno welder – arc welding	100,0	95,6	92,3
23	varilec - CO_2 welder – CO_2	101,6	97,1	94,9
24	viličarist fork-lift trucker	89,1	85,2	84,3
25	ličar lacquerer	84,7	84,7	84,7
26	rezalec pločevine s plazmo – I plasma sheet cutter – I	90,9	90,9	90,9
27	rezalec pločevine s plazmo – II plasma sheet cutter – II	86,3	86,3	86,2
28	prebijalni stroj punching machine	92,0	87,1	82,3
29	zahtevnejša montaža complicated assembly	73,3	73,3	71,6
30	vodja proizvodnje production manager	83,4	83,4	79,0
31	konstrukcija design	58,1	58,1	52,1
PODJETJE C COMPANY C				
32	montažno – kleparska dela z Al assembly-plumbing work with Al	105,4	98,6	95,9
33	razrez pločevine sheet cutting	99,2	94,3	88,8
34	klepar plumber	105,3	99,6	96,5
35	ključavničar locksmith	102,6	98,7	96,8
36	priprava za ličenje preparation for lacquering	88,5	83,8	83,8
37	ličar – komora lacquerer - chamber	82,4	82,4	82,4
38	strojna obdelava machining	83,7	81,1	79,9
39	obratovodja works manager	81,6	76,6	71,2
40	konstrukcija design	51,9	51,9	51,9

Preglednica 3. *Rezultati meritev na del. mestu št. 4 (frezanje)*
Table 3. *Measurement results for workplace No. 4 (milling)*

	Rezultati meritev Measurement results		
	grobo frezanje coarse milling	fino frezanje fine milling	priprava, preostalo preparation, other
$L_{AIeq,Ti}$ (dB)	84,5	82,4	74,3
$L_{Aeq,Ti}$ (dB)	79,7	81,6	73,1
T_i (min)	150	240	60
K_{Ii} (dB)	4,8	0	0
K_{Ti} (dB)	5	5	0
$L_{Aeq,Ti}+K_{Ii}+K_{Ti}$ (dB)	89,5	86,6	73,1
$L_{Aeq,Ti}+K_{Ii}$ (dB)	84,5	81,6	73,1

Slika 1 prikazuje rezultat frekvenčne analize pri opravilu 1 – grobo frezanje. Izrazita tona sta dva (25 Hz, 40 Hz), K_{Ti} = 5 dB. Prisoten je impulzni značaj: K_{Ii} = 4,8 dB (razvidno iz rezultatov meritev).

Figure 1 shows the frequency-analysis result for operation 1 – coarse milling. There are two pronounced tones (25 Hz, 40 Hz), K_{Ti} = 5 dB. The impulse character: K_{Ii} = 4,8 dB measurement results) is present.



Sl. 1. *DM 4, opravilo 1 (grobo frezanje)*
Fig. 1. *WP 4, operation 1 (coarse milling)*

2.1 Primerjava izmerjenih ravni hrupa

Razlike med izmerjenimi ravnmi hrupa L_{AITeq}, L_{AIeq} in L_{Aeq} zaradi različnih poprav (po posameznih delovnih mestih) so prikazane na sliki 2.

• **Primerjava L_{AITeq} in L_{Aeq}**
Izračunana vrednost faktorja *t* znaša ***t* = 7,93**.
Sklep: z veliko stopnjo zaupanja (α=0,0001) lahko trdimo, da so ravni hrupa, ki jih dobimo z upoštevanjem impulzne in tonske poprave - L_{AITeq}, statistično pomembno višje glede na ravni hrupa, ki jih dobimo brez upoštevanja poprav - L_{Aeq}.

• **Primerjava L_{AIeq} in L_{Aeq}**
Izračunana vrednost faktorja *t* znaša ***t* = 6,09**.
Sklep: z veliko stopnjo zaupanja (α=0,0001) lahko trdimo, da so ravni hrupa, ki jih dobimo z upoštevanjem impulzne poprave - L_{AIeq}, statistično pomembno višje glede na ravni hrupa, ki jih dobimo brez upoštevanja poprav - L_{Aeq}.

• **Primerjava L_{AITeq} in L_{AIeq}**
Izračunana vrednost faktorja *t* znaša ***t* = 7,48**.

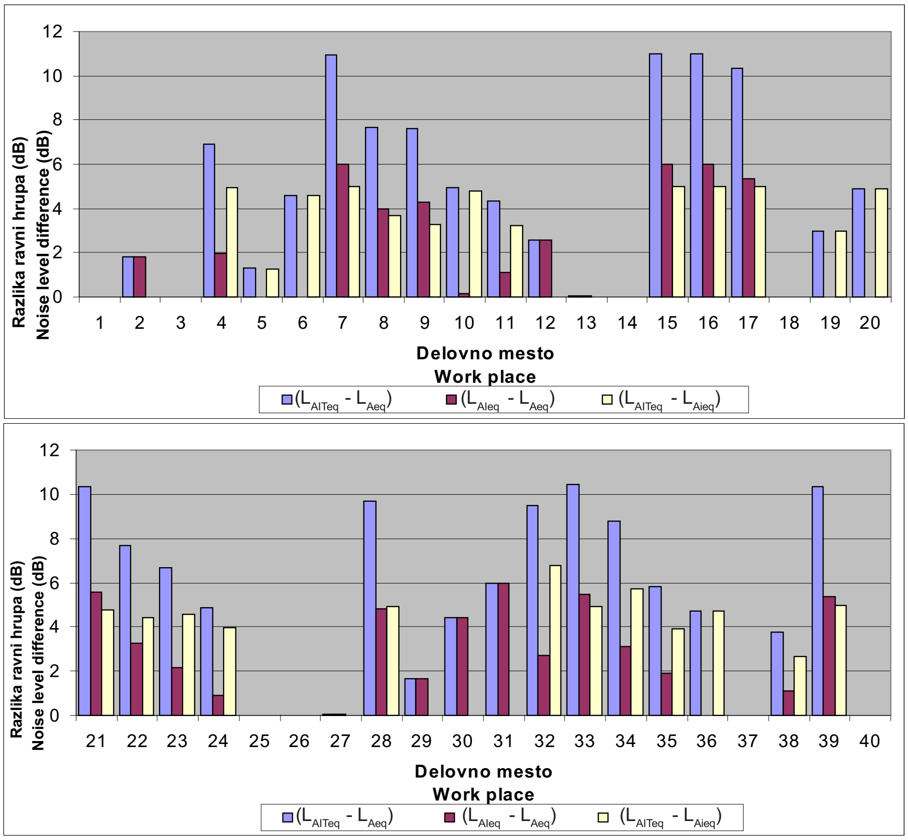
2.1 Comparison of the measured noise levels

The difference between the measured noise levels L_{AITeq}, L_{AIeq} and L_{Aeq} because of different corrections (in individual places) are shown in Figure 2.

• **Comparison of L_{AITeq} and $L_{A\,eq}$**
The calculated t-factor value is *t* = 7,93
Conclusion: with a high level of reliability (α= 0.0001) we can state that the noise levels obtained by considering the impulse and tone correction, L_{AITeq}, are statistically considerably higher in comparison to the noise levels obtained without the correction, L_{Aeq}, consideration.

• **Comparison of L_{AIeq} and $L_{A\,eq}$**
The calculated t-factor value is *t* = 6,09
Conclusion: with a high level of reliability (α= 0.0001) we can state that the noise levels obtained by considering the impulse and tone correction, L_{Aieq}, are statistically considerably higher in comparison to the noise levels obtained without the correction, L_{Aeq}, consideration.

• **Comparison of L_{AITeq} and L_{AIeq}**
The calculated t-factor value is *t* = 7,48



Sl. 2. *Razlika* $L_{AITeq} - L_{Aeq}$, $L_{AIeq} - L_{Aeq}$ *in* $L_{AITeq} - L_{Aieq}$
Fig. 2. *Difference* $L_{AITeq} - L_{Aeq}$, $L_{AIeq} - L_{Aeq}$ and $L_{AITeq} - L_{Aieq}$

Sklep: z veliko stopnjo zaupanja (α=0,0001) lahko trdimo, da so ravni hrupa, ki jih dobimo z upoštevanjem impulzne in tonske poprave - L_{AITeq}, statistično pomembno višje glede na ravni hrupa, ki jih dobimo z upoštevanjem le impulzne poprave L_{AIeq}.

Conclusion: with a high level of reliability (α= 0.0001) we can state that the noise levels obtained by considering the impulse and tone correction, L_{AITeq}, are statistically considerably higher in comparison to the noise levels obtained without the correction, L_{AIeq}, consideration.

3 SKLEP

Na podlagi slike 2 lahko ugotovimo, na katerih delovnih mestih se je upoštevanje poprav izkazalo kot najočitnejše:

- **izrazit impulzni značaj:**
  - dela s stroji, ki povzročajo izrazite impulze: strojne škarje, stiskalnica, kovaško kladivo, prebijalni stroj, nekatere serije varenja, grobi postopki odrezovanja ipd. (delovna mesta: 21, 7, 15, 16, 28, 9, 33 - sl. 2);
  - postopki, kakor so: uporaba ročnega orodja (kladivo ipd.), trki, padci ipd. (delovna mesta: 34, 9, 22, 33 - sl. 2);
- **opaznost izrazitih tonov:**
  - dela s stroji, ki povzročajo izrazite tone: *hitrorotacijski stroji*: črpalke, brusilka, brusilni stroj, polirni stroj, poravnalni stroj, vrtanje, krožna žaga ipd. (delovna mesta: 10, 22, 23, 32, 6 - sl. 2),
    stroji z impulznim značajem: prebijalni stroj, stiskalnica, kovaško kladivo, strojne škarje ipd. (delovna mesta: 28, 7, 15, 16, 21 - sl. 2),

3 CONCLUSION

Based on Figure 2 we can conclude in which workplaces the correction consideration proved to be the most obvious:

- **pronounced impulse character:**
  - work on machines causing pronounced impulses: machine scissors, press, sledge-hammer, punching machine, some welding series, coarse milling procedures and the like (work places: 21, 7, 15, 16, 28, 9, 33 - Fig. 2);
  - procedures like the use of hand tools (hammer and the like), shocks, falls and the like (workplaces: 34, 9, 22, 33 - Fig. 2);
- **presence of pronounced tones:**
  - work on machines causing pronounced tones: *high-speed rotating machines*: pumps, turning machine, polishing machine, levelling/evening machine, drilling, circular saw and the like (workplaces: 10, 22, 23, 32, 6 - Fig. 2),
    impulse character machines: punching machine, press, sledge-hammer, machine-scissors and the like (work places: 28, 7, 15, 16, 21 - Fig. 2),

drugi stroji: krožna žaga, grobo frezanje, viličar idr. (delovna mesta: 6, 4, 24 - sl. 2);
- postopki, povezani z uporabo kladiva ipd.

Vpliv impulzne in/ali tonske poprave je zanemarljiv na delovnih mestih, kjer:
- postopki ne povzročajo impulzov in tonov (struženje, frezanje, kompresorska postaja, razrez s plazmo, ličarstvo ipd.);
- prevladuje relativna tišina (miselna dela).

Iz rezultatov analize lahko ugotovimo, da so ravni hrupa ob upoštevanju poprav statistično pomembno višje kakor ravni brez poprav. Še posebej to velja za upoštevanje tonske poprave. Tako hrup ob upoštevanju tonske in impulzne poprave hkrati večkrat za 10 dB presega ravni, ki jih dobimo brez upoštevanja poprav. To so pa že vrednosti, zaradi katerih se lahko upravičeno vprašamo o smiselnosti uporabe takšnih poprav ali pa po drugi strani o nujnosti njihovega upoštevanja.

Hrup v delovnem okolju predstavlja enega bistvenih, predvsem pa enega najpogostejših obremenilnih faktorjev. Kot dodatno zaščito pred hrupom lahko uporabimo ergonomski koeficient K_{er}, ki služi kot poprava v smislu dodatnega časa, potrebnega za okrevanje organizma [10].

other machines: circular saw, coarse milling, fork-lift truck and the like (workplaces: 6, 4, 24 - Fig. 2);
- procedures bound to use a hammer and the like

The influence of impulse and/or tone correction is negligible in workplaces:
- where the procedures do not cause impulses or tones (turning, milling, power station, plasma cutting, lacquering and the like);
- with relative silence (mental work).

From the results of the analysis we can conclude that the noise levels when considering the corrections, are statistically higher than those without corrections. This is especially valid when considering the tone correction. In this way, noise, when considering the tone and impulse correction at the same time, often exceeds the levels obtained without correction consideration by more than 10 dB. These are the values that make us think about the suitability of using such corrections, or on the other hand, about the necessity of considering them.

Noise in the working environment is one of the major and certainly most frequent stressors at work. The ergonomic coefficient K_{er} can be used as an additional protection against the effects of noise on workers because it offers extra time for human organism to recover [10].

4 LITERATURA
4 REFERENCES

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