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A STUDY UPON OCCUPATIONAL NOISE POLLUTION EXPOSURE AT A METALLIC CONFECTIONS PLANT

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Abstract Because of physical and psychological effects, hearing damage, in the main concern of safety regulations, should not be neglected. There are provable psychological reactions (strain, anger) and physical reactions (increased of blood pressure), which may give rise to long-time disorders. To obtain an accurate evaluation of the noise exposure of the workers, besides the sound level measurements were made noise dose determinations in order to estimate the noise dose indoor but also outdoor. In order to determine the framing inside the law limits sound levels and the doses inside and outside a metallic confections plant hall were measured. Data Logging Sound Meter 840013 was used to determine the noise level and the data was processed with SE 322 and a Personal Noise Dosimeter to determine the noise dose and the data was processed dBLink3. Regarding the sound level, it was seen that inside plant hall, the legal limits of 70dB were exceeded by 20.3dB, and outside, near the plant hall, they were higher by 2.8dB. The values of these sound levels go down with the distances increase, so at 20m from the plant hall, the values are between the normal limits. The measured doses were 528% of the accepted level (indoor for 4h of measurements), while the estimated dose for 8 hours is 951% and respectively 265% of the accepted level (outdoor for 4h of measurements) while the estimated dose for 8 hours is 480%. After these measurements were proposed a soundproofing of the hall and also the use of the earplugs by workers and installed wood panels between work teams, so that the workers would not hear noise except when they produce it themselves (and not by other work fellows).

Keywords: noise pollution, safety regulations, occupational exposure levels, noise dose

1. INTRODUCTION

Noise pollution is included between the damaging factors, which can affect living organisms: humans, animals and plants. Different aspects regarding noise pollution can be identified: noise effect, ultrasounds effect, electromagnetic radiations effect. The registered level for noise is 100dB (pain level), in order not to overwhelm human's health (Banerjee & Chakraborty, 2006).

Noise is generally produced by industrial activities, transportation and cultural activities, but also by the common individuals (Gloag, 2005). To eliminate and to keep the noise level under admissible limits, we must diminish it by isolation and acoustical

absorption of buildings elements (Bedi, 2006; Neitzel et al., 1999), place noise sources outside cities and simultaneous isolate them and also to up-date old equipment in order to function at safe parameters (Broadbent, 2006).

One of the most common and annoying effects of noise is interference with communication. In industry the disruption of communication can result in inefficiency and, possibly, fatal accidents (Park & Wang, 2008; Raitor & Neise, 2008).

2. THEORY

L_{inst} designates the instantaneous level indicated by a simple sound level meter, as far as the averaging time is concerned. Nowadays the L_{inst} parameter has been replaced by the A-weighted equivalent level $L_{Aeq,T}$, a continuous level which, over a given period of time, T, gives the same amount of acoustical energy as the actual noise (this is the ISO equal energy principle) (St Pierre Jr & Maguire, 2004).

Over a given period of time, personal dosimeters (personal sound exposure meters) offer usually the possibility of recording all or some of the following parameters:

L_{Aeq} - The level which, if maintained constant for the same period as the measurement, would contain the same amount of energy as the fluctuating noise level. "A" weighted and expressed in decibels (dBA). Doubling the energy leads to a 3dB change in the L_{eq}. This is denoted by Q=3. The threshold used in the calculation of L_{AVG} (see below) is not used for the calculation of L_{Aeq}.

L_{AE} or SEL - The level which, if maintained constant for a period of 1 second would have the same sound energy as that actually received by the doseBadge during the measurement period.

$L_{EX,8h}$ - Under the EU Physical Agents (Noise) Directive which will be introduced in member states of the EU by February 2006, the terminology for the Daily Personal Noise Level or $L_{EP,d}$ has been changed to be $L_{EX,8h}$. The calculation is the same and the data is calculated from the L_{Aeq} and Measurement Duration in the same way as for $L_{EP,d}$.

% Dose - A percentage of a fixed dose value based on the criterion level and criterion time. The criterion level and time are set by ISO standards.

Estimated Dose - Estimates the % dose (described above) that would have been received by the wearer if the average level measured had existed for the period defined by the criterion time.

For hearing conservation purposes or to estimate the individual risk of hearing loss of an exposed person, it is necessary to define an average level characterizing the mean exposure of the person using the daily noise exposure level $L_{EX,8h}=L_{Aeq,8h}=L_{EP,d}$ [dB(A)] – a continuous level, which would, over a standard daily period of 8h, produce the same amount of acoustical energy as the actual daily exposure; $L_{EP,d}$ is the daily personal noise exposure of a worker. This concept is used when the worker is exposed daily, for 5 days/week, to the same level. The standard ISO/FDIS 389-6:2007 indicates how to estimate the daily noise exposure level of a worker using a sample composed of n measurements having a noise level $L_{Aeq,Ti}$, carried out with a specified integration time T_i, where the total exposure time is: $T=\Sigma T_i$.

$$L_{Aeq,T} = 10\lg\left(\frac{1}{n}\sum_i 10^{\frac{L_{Aeq,T_i}}{10}}\right) \quad (1)$$

The next equation is used to estimate the confidence limit (CL) of the average value, and was proposed for the case of a normal distribution of noise levels [dB] to account for the fact that the addition of decibels is a complex procedure.

$$CL = t_{n-1}\sqrt{\frac{s^2}{n} + \frac{0.026 \cdot s^4}{n-1}} \quad (2)$$

where:

$$s = \sqrt{\frac{1}{n-1}\sum_i \left(L_{Aeq,T_i} - L_m\right)^2} \quad (3)$$

In the equations, L_m designates the arithmetic mean of the noise levels, s is their standard deviation t_{n-1} the variable value for n-1 degrees of freedom at a probability threshold of 95%, T is the total duration of the daily exposure, and T_0 is the reference duration of 1 working day (8h).

$$LCL = L_{Aeq,T} - CL \quad (4)$$

$$UCL = L_{Aeq,T} + CL \quad (5)$$

$$L_{EX,8h} = L_{Aeq,8h} = L_{Aeq,T} + 10\lg\frac{T}{T_0} \quad (6)$$

LCL and UCL are the lower and respectively the upper confidence limit of the $L_{Aeq,T}$. These relations apply the ISO criterion of equivalence (Exchange Rate) between the noise level and the duration, set at +3dB when the duration is reduced by half.

If the variance of the observed distribution is relatively small, the quadratic term in equation (2) has little impact and the relation becomes a classic estimator of the confidence interval of a normal distribution.

3. OCCUPATIONAL EXPOSURE LEVELS IN THE EUROPEAN UNION

The European Union has established a common policy aimed at controlling the risks due to the exposure of workers to noise and harmonizing the relevant legal requirements existing at national level. Its principal instrument is the Council Directive 86/188/EEC on the protection of workers from the risks related to exposure to noise at work. Council Directives concerning safety and health at work set out minimum requirements and Member States have power to introduce more stringent measures of protection.

(a) The mandatory values will apply only to the noise reaching the ear, so if noise emission cannot be prevented or reduced at source, other measures should be taken to regulate noise energy emission; furthermore the situation in the member States did not make it possible to fix a noise-exposure value below which there is no longer any risk to workers hearing.
(b) If a worker is exposed to noise bursts, the peak sound pressure must be limited and the acoustic energy must be included in the allowable daily exposure; in order that this requirement is fulfilled, an instrument capable of measuring directly the maximum (peak) value of the unweighted instantaneous sound pressure is needed (an instrument having an onset time constant not exceeding 100μs is suitable for industrial situations).
(c) A 3dB rate was chosen as the most appropriate rule for managing intensity and exposure duration, because it is consistent with international standardization and is simple to use in industrial situations, when a given level of workers protection has to be guaranteed.

ISO 11690-1/1996 gives maximum values for the A-weighted equivalent sound pressure level for the 8 hour work shift at industrial workplaces in the range 75 to 85dB, for routine office work in the range 45÷55dB and for meeting rooms or tasks involving concentration in the range 35÷45dB. A further detailed description of the mechanisms that lead to a decrease of efficiency and an allocation of tasks of different complexity proposed rating levels down to 40dB(A).

4. RESULTS AND DISCUSSIONS

This work presents the results of noise level measurements at a metallic confections plant in Braila. In this hall there are, beside the noise made by the production activity (due to machines, equipments, grinders, blowpipes, elevators, stacking conveyors, etc.) also very loud but short noises produced by hitting the parts with the hammers, sledges, chisels or by hitting the parts between themselves (Hager, 1998).

To obtain an accurate evaluation of the noise exposure of the workers, besides the sound level measurements were made noise dose determinations in order to estimate the noise dose indoor but also outdoor.

The Data Logging Sound Meter 840013 was used to measure the sound level, with a range of 30÷130dB, an accuracy of ±1.5dB and a resolution of 0.1dB on a digital display, time weighting SLOW (1s) and the results were processed with SE 322.

The CR:110A doseBadge, Personal Noise Dosimeter to determine the noise level and to calculate the noise dose with a range of 70÷130dB, a resolution of 0.1dB and the results were processed with dBLink3. The samples were taken every minute.

The whole set of measurements were taken between 8:00÷12:00.

The noise level indoor for a intense workshift is represented in figure 1 using the Data Logging Sound Meter 840013, for which the minimum is 20dB, the maximum is 117.9dB and a mean value of 90.3dB. With the help of doseBadge, Personal Noise Dosimeter the peaks due to very loud but short noises (made by hammering the parts) were eliminated (Fig. 2).

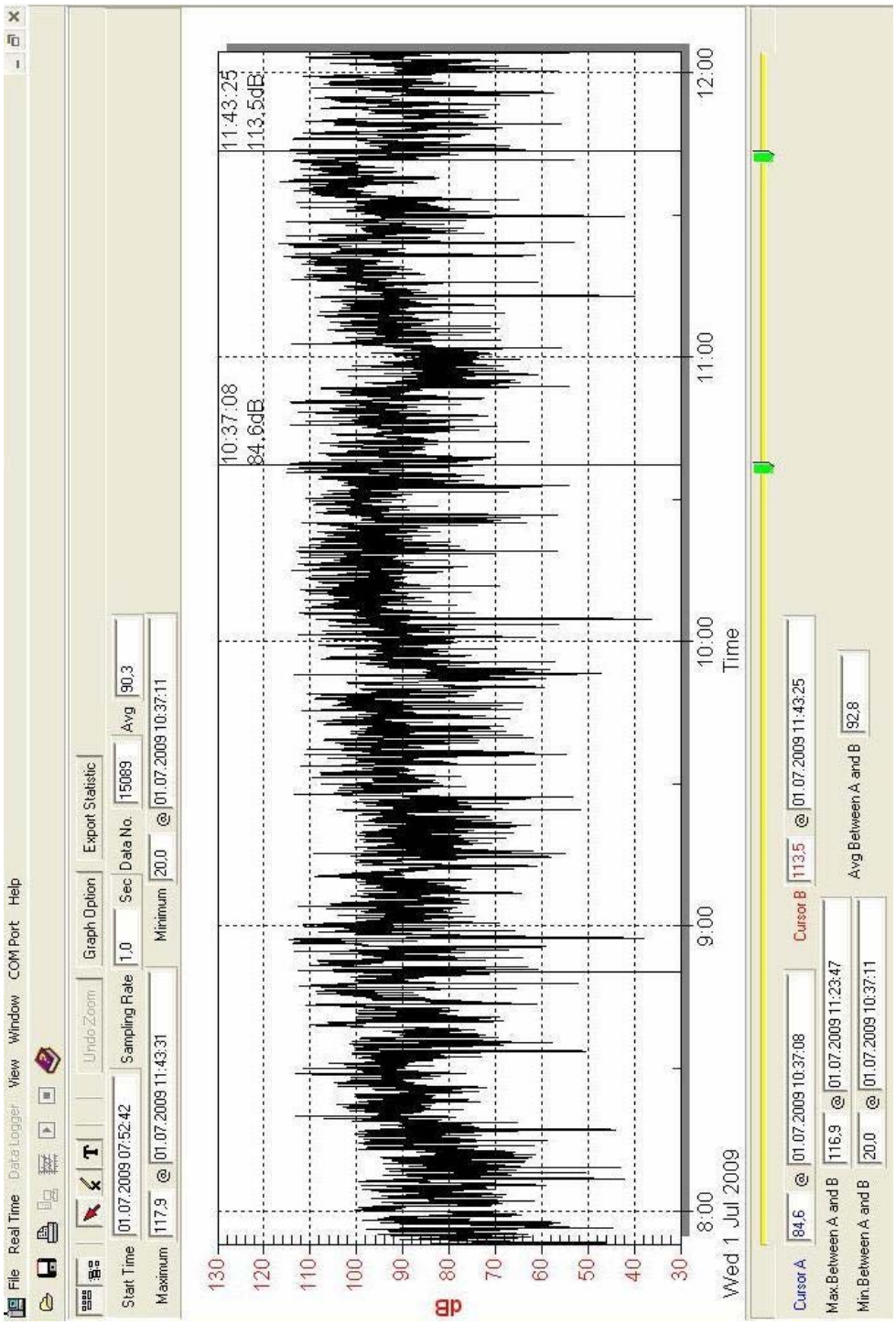

Figure 1, Variation of sound level in dB(A) between 8:00-12:00 the maximum is 117.9dB(C) (indoor)

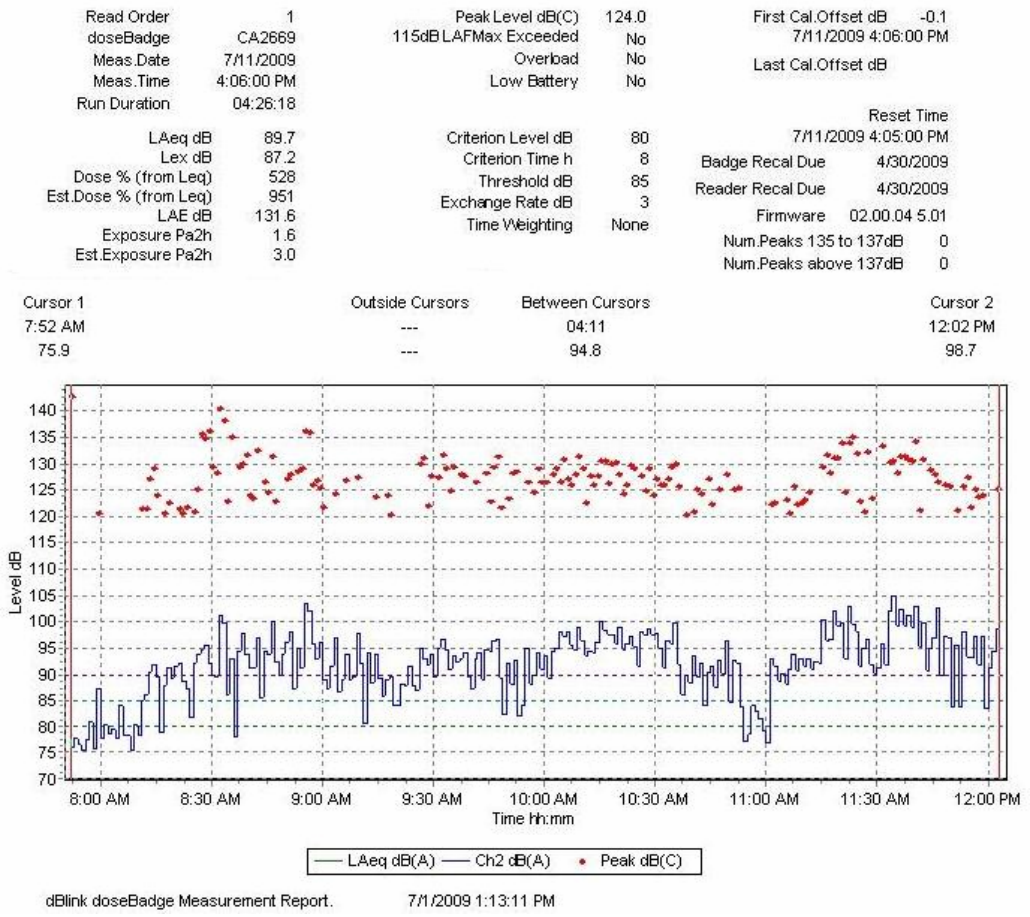

Figure 2, Variation of sound level in dB(A) between 8:00-12:00 - without peaks
L_{Aeq} = 89.7dB (indoor)

Using the equations (1)-(6), the SE322 and dBLink3 softwares calculated:

- Sound Exposure Level: L_{AE} = 131.6 dB
- Peak level: 124 dB(C)
- Daily noise exposure level $L_{EX,8h}$ = 87.73dB
- $L_{EX,4h\ 26min\ 18s}$ = 87.2 dB (the measured period: T = 4h 26min 18s)
- Confidence Limit: CL = 55.2dB
- Lower confidence limit: LCL = 41.35dB
- Upper confidence limit: UCL = 96.55dB
- Indoor, the dosimeter indicates a registered dose of 528% of the accepted level, measurements being taken for 4 h, the estimated dose for 8 h being 951%.

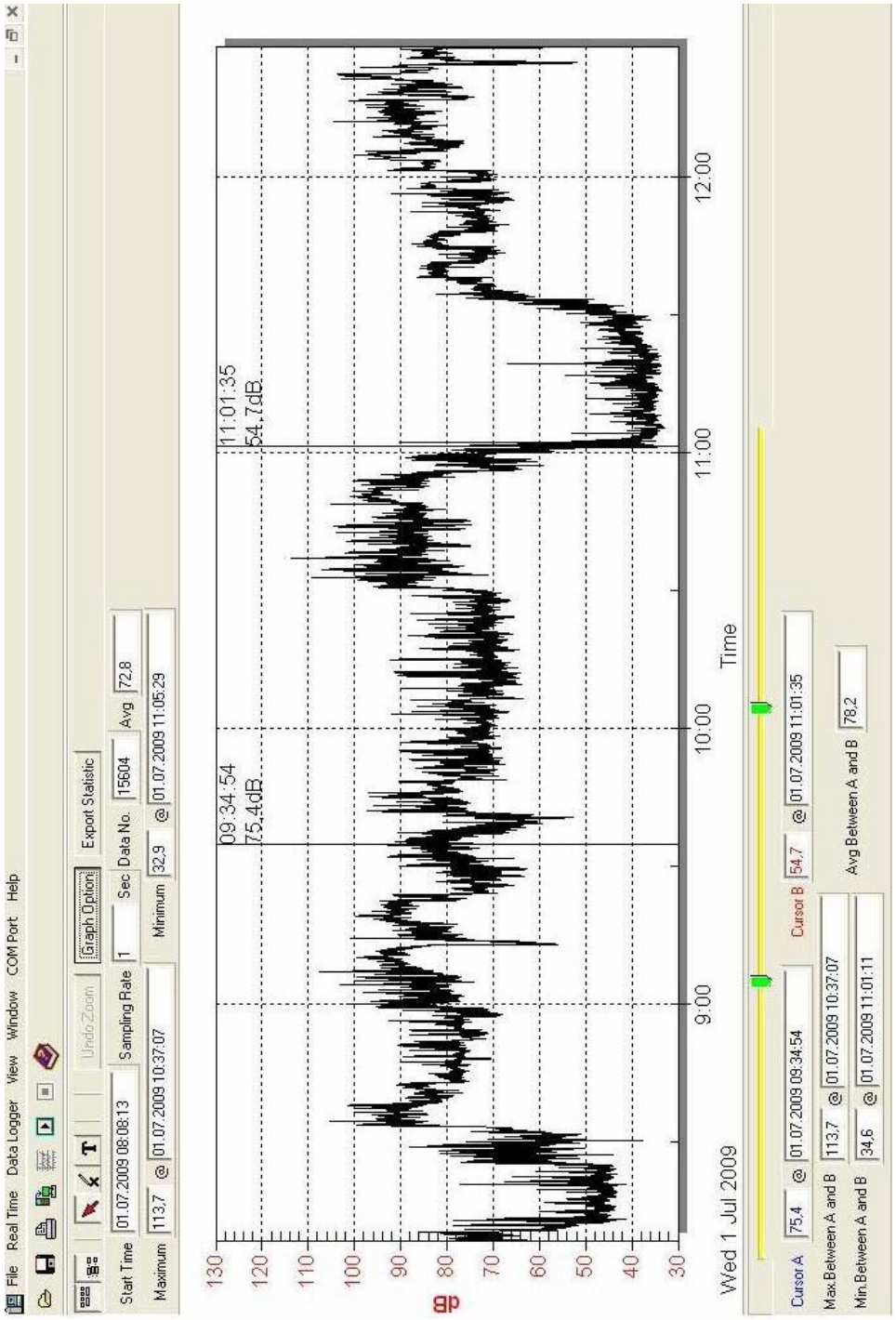

Figure 3, Variation of sound level in dB(A) between 8:00-12:00 the maximum is 113.7dB(C) (outdoor)

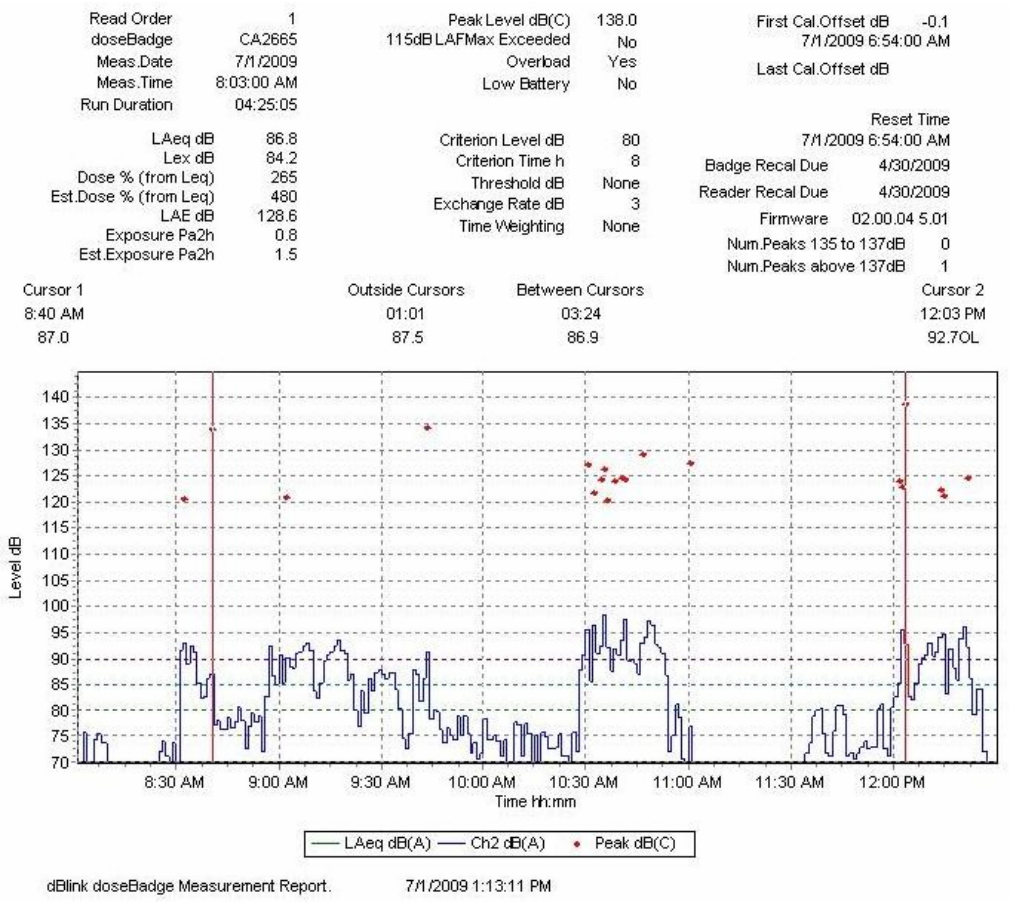

Figure 4, Variation of sound level in dB(A) between 8:00-12:00 - without peaks L_{Aeq} = 86.8dB (outdoor)

The same procedure was followed outiside the plant hall and the results are shown in figures 3 and 4. In this case the minimum is 32.9dB and the maximum is 113.7dB with a mean value of 72.8dB. In figure 4 it can be seen that some noises are attenuated. This attenuation is due o the fact that the walls absorbe or scatter the sound waves.

Also, there were obtained:

- Sound Exposure Level: L_{AE} = 128.6 dB
- Peak level: 138 dB(C)
- Daily noise exposure level $L_{EX,8h}$ = 70.22dB
- $L_{EX,4h\ 25min\ 25s}$ = 84.2 dB (the measured period: T = 4h 25min 25s)
- Confidence Limit: CL = 79.8dB
- Lower confidence limit: LCL = 33.4dB
- Upper confidence limit: UCL = 113.2dB

- Outdoor, the dosimeter indicates a registered dose of 265% of the accepted level, measurements being taken for 4 h, the estimated dose for 8 h being 480%.

After the measurements were completed, the results were compared to the admitted limits (65÷70dB). It can be seen that the noise level inside the hall, obtained during an intense work shift, is way higher than the one appointed by STAS 10009-88, *Acoustics in civil engineering-Urban acoustics*.

The obtained L_{Aeq} level of 90.3 dB inside the hall 72.8 dB outside indicates a very high noise the workers must endure at the working place. These levels are with 20.3 dB, respectively with 2.8 dB higher than the maximum limit admitted by the law.

From these data it can be seen that the workers are very amenable to hearing problems or even deafness. Immediately and urgent action must be taken to reduce the noise or to diminish the exposure time.

5. CONCLUSIONS

Whereas hearing damage is the main concern of safety regulations the other physical and psychological effects should not be neglected. There are provable psychological and physical reactions, which may give rise to long-term disorders of regulation mechanisms also at A-weighted sound pressure levels below 85dB. The efficiency can be affected too, the more likely, the more complex the task to be performed (Lee & Brand, 2005).

Generally if a job is more complex (the more information must be kept in mind), the more intellectual operations have to be performed, the higher the requirements for precise fine motor activity or the more responsible the worker is for consequences of mistakes. The more complex a task, the more sensitive a person will react to disturbances like noise, in the end with an increase of the number of mistakes and a slowdown of completion of the task – a efficiency decrease. It was proposed that the workers must use earplugs.

From the measurements results it can be seen that it is necessarily to take actions regarding the soundproofing of the working areas, for example: avoid having loud areas near logistic offices, isolated areas should be interpose between noisy areas (lobbies, storerooms, magazines), soundproof floors and partitions (walls and boards) should be put up; areas must be isolated against the noises made by mechanical shock on the floors; soundproof suspended ceilings, encased equipments, source orientated sound-absorbing shields, 1.20 – 1.50 meters high sound-absorbing screens.

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