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Measurement Method for Noise Exposure of Jobs of the Construction Sector

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Noise is one of the physical contaminants with a high presence in the construction sector. Nowadays, several negative effects produced by the exposure to noise are known, mainly regarding hearing. Although there is evidence of the existence of many other effects, some of them are not characterized precisely yet. Due to the importance that these effects have on the workers health and well-being , it is necessary to develop some mechanisms to study and suggest preventive solutions on these questions.
In this work, it has been studied the most appropriate measurement method for taking, as precisely as possible, the noise levels that the workers of the construction sector are exposed to. Several measures have been taken and analyzed to determine the best indexes and parameters to characterize the noise in the construction. For which, the current European regulations regarding the noise exposure (Directive 2003/10 of the EU) have always been taken into account.

1 Introduction

Noise is the most persistent physical contaminant in human environment. Especially in the developed countries, where the models of social and economical organization, the technological development and the growth of population are key factors in the increase of noise pollution.

It is difficult to define what noise means as a physical contaminant. Normally, it is the undesired sound. That concept is joined to a subjective perception, and therefore, a sound can be pleasant for some people but, at the same time, can also be annoying for some other people, or even the cause of physical or psychic illnesses. Even more, some sounds that can be acceptable in a certain period of time can change into annoying in other periods.

Unlike other contaminant agents, the effects of noise may be unnoticed instantaneously and its accumulation can lead to an obvious physical, psychic and social deterioration. The best studied effect of the overexposure to noise is the loss of hearing. The problem is that the exposed people are scarcely aware of the cause-effect relation given that it is produced slowly but progressively [1].

Every day, millions of European workers are exposed to noise and to all its consequent risks in their workplace. One out of five workers in Europe must raise his voice to be heard for more than half the working day and a 7% of them suffer from hearing problems related to work [2]. According to European data [3], the loss of hearing caused by the noise is the most common occupational illness in the European Union. Noise may be a clear problem in sectors like manufacturing or construction but, it can also be a problem in some other working environments. The most obvious parameter to characterize the noise can be its level, measured in decibels, but there are some other important factors to take into account, like duration of exposure, impulsivity, frequence and spectrum, incidence and distribution along the working day.

Noise exposure can cause several risks for the safety and health of workers. It is well known that the noise can mask both the speech and the alarm sounds. Voice problems, like nodules, loss of voice and abnormalities in the vocal chords can be suffered by the workers that have to communicate within noisy environments with levels higher than 85 dBA if there is no other way to communicate but the voice. Therefore, it is stated that noise is one factor that can increase the risk of accidents in the workplace [4]. Besides, the effects of the noise induced hearing loss, together with the requirement of using hearing protection devices, contribute to increase indirectly the rate of accidents due to interferences with sound signals and other non-hearing effects caused by the noise on the health, like stress, loss of attention, increase of blood pressure, etc [5].

Noise excess removal in the workplace is not just a legal responsibility of the companies, as it is also involved with the market interests of an organization. The safer and healthier a workplace is, the fewer probabilities of absenteeism, accidents and low performance, and consequently, cost savings will be achieved. A traditional approach for reducing risks due to noise in the workplace consists in a three-step process: assessment of risks; adoption of mechanisms for preventing or controlling risks; and, eventually, keeping a periodical monitoring and a revision of the effectiveness of the adopted mechanisms [6].

2 Methods

2.1 Regulations

The current regulation in the European Union regarding protection of workers is based on the Directive 2003/ 10/ CE [7], that in Spain corresponds to the Royal Decree 286/2006 [8]. These documents state a set of minimum disposals with the aim of protecting the workers from the risks for their safety and health, caused or that may be caused by the noise exposure, focusing on the hearing risks. They insist on mechanisms directed to the avoidance or reduction of exposure, so that the risks derived from exposure could disappear in their origin or might be reduced to the lowest possible level.

The indexes used for assessing the noise level in each workplace are the daily equivalent level of exposure and the peak level, $LAeq,d$ and $Lpeak$ respectively.

Generally, in this directive, and also in the royal decree, the noise exposure is strictly limited, as it is stated that, in no case, the real exposure of a worker may overpass the limit values of LAeq,d = 87 dBA and Lpeak = 140 dBC. So, those limits are the maximum, even considering the attenuation given by the personal hearing devices used by each worker.

2.2 Scope of the study

There are several noise sources in the construction sector, which cover all the stages of a costruction work. Noise is different in each one of these stages, but, nevertheless, sometimes the same worker may be present in more than one stage, and therefore, we are more interested in the construction work in general than in each individual stage. Then, four different construction sites have been considered (two housing blocks, one of single family dwellings and one warehouse), where 20 workers distributed among the different stages have been measured. That number is representative of the workers belonging to a medium-size construction company in Spain who develop an average construction work in that country.

Then, a common construction work in Spain, based on concrete structure, is made of the following stages (number of workers measured in each stage appears in brackets):

- Excavation and land movements. (1)
- Foundations and structure. (2)
- Walls and brickwork. (9)
- Paving and tiling. (3)
- Facilities: electricity, drainage, plumbing, heating...(4)
- Carpentry and finishes. (0)
- Auxiliary activities and those of loading and unloading. (1)

2.3 Measurements

Whenever possible and according to the current regulations, measurements must be done in absence of the affected worker by placing the microphone at the same height as his ear. If the worker has to be present, the microphone will be placed preferably in front of his ear, aproximately at a distance of 10 centimetres [9].

For this study, an integrative and averaging soundmeter with spectrum analyzer has been used in order to have data related to the frequency components of the noise measured, given that this information is very useful, for instance, for choosing the most suitable personal hearing device in case it was necessary. A dosemeter has also been used to get the measurement of the noise exposure along the working day without interfering with the worker, given that the dosemeter can be placed in a pocket or in the belt. The microphone must be placed at a distance between 10 to 30 centimetres of the ear, for instance in a lapel or over a helmet. As the microphone is linked to the dosemeter with a cable, this must be carefully placed so as to avoid any risk for the worker.

The registered parameters either with the soundmeter or with the dosemeter are [10]:

- Equivalent continuous A-weighted sound pressure level (LAeq,T in dBA), registered along the whole measurement.
- Peak level registered along the whole measurement (Lpeak in dBC).
- Percentiles 10, 50, 90, 95 y 99 (L10, L50, L90, L95 y L99 in dBA).
- Duration of the measurement (T in s).
- Maximum sound pressure level registered with Fast time weighting (LAF,MAX in dBA).
- Noise exposure registered along the measurement (E in dBA).
- Noise dose (D in %).

A threshold (TH) of 75 dBA, a criteria level of 85 dBA, an exchange rate (ER) of 3 dB and a duration of 8 hours for the working day have been used for the exposition and dose measurements.

Other indexes can be known from the ones measured necessary for their comparation with the limits stablished by current regulations, as in the case of the daily sound exposure level LAeq,d.

A duration of the measurement was stated for assessing the measured workers. It should be enough to characterize properly the noise measured in each worker. Normally, a duration of 8 hours is assumed for the parameter LAeq,d, but the regulations permit the technician to choose that duration. Furthermore, the duration can be reduced even to only 30 minutes, depending on the stability of the noise, as it has been proved in [11]. An estimation of 2 hours is made for this study, taking into account the workers to be measured.

2.4 Measurement Record

A technical record has been registered for each worker measured, in which the most important data and the results of processing the captures of the dosemeter and the soundmeter are kept.

The records are composed by a photograph of the assessed worker, a brief description of the worker's tasks and technical parameters, which are the indispensable (LAeq,d y Lpico) for comparing with the current regulation and, besides, LAeq,T, LAF,MAX, LAF,MIN, L10, L50, L90, noise dose and noise exposure along the duration of the measurement. In addition, to make the results more realistic, two paremeters have been added to keep the noise dose calculated for 6 hours of the working day instead of 8 (to take into account the breaks) and the maximum allowable time that a worker should be exposed to the noise measured to receive a dose of 100%. The record includes also different plots about the measured data, as the time evolution of the signal, the spectral trace and the distribution of the levels depending on the percentiles. Finally, the record also has observations and data of interest regarding each occupation, such as the requirement of using machinery for the tasks or the continuous time that a machine is on, the use of personal hearing devices, etc.

2.5 Instruments

The experimental data of this study have been achieved with an integrative and averaging soundmeter with spectrum analyzer, a dosemeter and a sound calibrator.

The configuration of the soundmeter is as follows:

- Range 49.7 - 129.7 dB
- Bandwidth 1/3 octave
- Peaks over 140 dB
- Global statistics Fast time weighting and A frequency weighting
- Spectrum Fast time weighting and A frequency weighting
- Global measures A & L frequency weightings

The configuration of the dosemeter is as follows:

- Range 50 - 120 dB
- Time weighting Fast
- Frequency weighting A
- Frequency weighting for peaks C
- Exchange rate 3 dB
- Threshold 75 dB
- Criteria level 85 dB

3 Results

To test this methodology, measurements have been carried out with 20 workers. Some remarkable results have been obtained that validate this proposal of mesurement methodology. For instance, two of these results are shown graphically:

- The daily equivalent A-weighted level is shown in the chart of the figure 1. It clearly shows that most of the workers (17 out of 20) suffer a daily exposure that exceeds 80 dBA, which is the lower limit that implies an action according to the current regulation. But, what is worse, is that 14 out of 20 workers exceed 87 dBA, which is the top limit. The workers that suffer more than 100 dBA said explicitly that they needed machines for their tasks, whereas those with levels below 85 dBA hardly ever used machines in the working day.
- The chart of the figure 2 shows the dose received by each worker. There are extremely high values, as the graph reveals, that exceed the 500%. In all the cases, those workers are the ones under the highest exposures and, besides, they also exceed 80 dB in the 90-percentile parameter. The worker that suffers the greatest dose measured, 50000%, is exposed, with the exchange rate used of 3 dB, to a noise level that is nine times the double of the maximum level allowed.

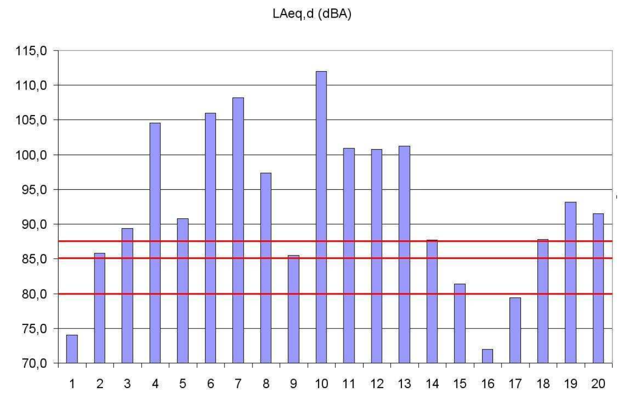

Figure 1: Daily equivalent level.

In general, from the data obtained with this proposed methodology, it can be stated that the sound environment which the construction workers are within is quite noisy and potentially harmful to health, since the lower limit of 80 dBA is exceeded in most of the cases, and even more, the percentage of cases that go beyond the top limit of 87 dBA is quite high. In addition, the use of personal hearing devices is very low although their use is compulsory in many occasions.

This fact reveals two fundamental aspects to deal with the problem of noise at work: first, the workers are not aware of this problem and they are the first that overlook their own hearing health by rejecting the use of the personal hearing devices; and second, many companies are not persistent with the observance of the directives against noise. These two aspects turn the noise into a first class problem regarding the health at work and it is also one of the main physical contaminants in the industrial precincts [12, 13].

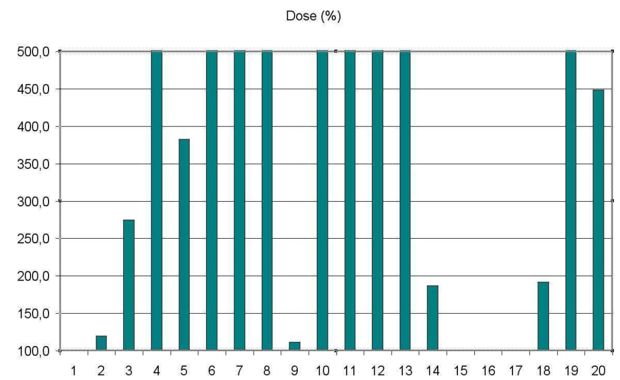

Figure 2: Daily noise dose.

4 Conclusion

This study states a proposal for measuring the noise levels that the construction workers are exposed to and a validation of this porposal is also carried out through a representative number of measurements on workers involved in an average construction work in the country where the study has been done.

The main conclusion that can be obtained is that this methodology is appropriate for measuring the desired industrial sector, the construction, and as the results of the tests, it is remarkable that the noise values measured are so high that between the 70% and the 80% of the construction workers are exposed to a noise dose higher than the 100% along their working day.

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