ICSV13 - Vienna
The Thirteenth International Congress on Sound and Vibration
Vienna, Austria, July 2-6, 2006

NOISE MAPS: A TOOL FOR THE DEMARCATION OF RISK AREAS OF NOISE EXPOSURE IN THE SURFACE MINING INDUSTRY

Ignacio Pavón*[1], and Manuel Recuero[1]

[1] Grupo de Investigación en Instrumentación y Acústica Aplicada GI^2A^2
Universidad Politécnica de Madrid - INSIA
Campus Sur UPM, Ctra. Valencia, Km. 7, 28031, Madrid, España
ipavon@insia.upm.es

Abstract

Exposure to noise at work is one of the hazards with greater presence in the mining industry. In the surface mining industry, different methods from mineral extraction, transport and processing are used. In general, all of these processes produce high levels of noise.

From various measurements of noise made with sound analyzers in different points within the strip mines, noise maps of three strip mine and treatment plants have been made: two gravel pits and one limestone quarry.

These maps can serve as a tool to delimit zones with different sound levels, as well as to define the regulations that must be taken in each case.

The paper presents the obtained results, the different solutions to adopt and also show the convenience, validity and limitations that this type of maps present for the management of the labour risks in mining operations.

INTRODUCTION

Noise is one of the physical contaminants with the greatest presence in the mining sector. Elevated levels of noise are generated in the sector caused by the use of materials and intrinsically noisy equipment given the abundance of noisy mechanical elements used in any operation of this type such as drills, heavy machinery, compressors, shoots, mills, sieves, hammer drills, etc.

In the region of Madrid there are numerous gravel pits and quarries for extracting sediment material providing raw material to the building sector.

The gravel pits and quarries show two very different areas: an extraction and transport area, and a distinct processing area. [3]

The extraction area mainly involves work with heavy machinery such as dredges, drag line excavators, excavators, backhoe excavators, etc. Once the material is extracted, whether this be gravel and sand or raw limestone rock, it is transported to the reception processing area via big trucks or dumpers.

The first item of this processing is an entry chute where trucks unload their goods. The material passes through different sieves and mills according to size and material aggregate grading and is distributed via conveyor belts to final stocks.

In the extraction and transport area elevated noise levels are produced. Here, all employees work with heavy machinery and remain inside vehicle cabins whilst carrying out their jobs. The noise level the worker is exposed to depends on both the level of noise produced by the process (drilling, digger extraction, etc.) and on the insulation in the cabin where the worker remains whilst doing the job.

Noise level assessment in these jobs must be carried out via noise measuring throughout the working day using personal sound exposure meters also known as "noise dosimeters".

Another way of estimating worker exposure levels inside the cabin is via measurements with integrating averaging sound level meters or with CPB analyzers.

The use of this equipment poses a series of problems and limitations: the job to be assessed is not static and the normal carrying out of the work implies vehicle movement, making this measurement method inadvisable for a whole working day, albeit with spot samples a possibility.

In these cases noise maps are also inadvisable since the results would show noise levels outside the cabins, the aim being to discover noise levels the workers are exposed to.

In the processing areas workers carry out their work moving on foot around the whole area. There are numerous sources of noise in these areas from the material entry chute, going on to engine compressors, conveyor belts, gear assemblies, etc. Workers in these areas carry out control and maintenance tasks and are thus not present in a well-defined spatial location and move around throughout the processing area.

Sound level exposure assessment of workers in these jobs must be carried out via personal sound exposure meters and noise maps. Assessment via fixed measuring positions is inadvisable here due to worker movement.

This research falls within an investigation carried out in 17 different types of mines where noise levels of all present jobs were analysed via different measuring techniques (dosimeters, sound level meters, head and torso simulators (HATS)), using different measurement procedures (spatial samples, fixed position measurements, etc.).

Partial results corresponding to noise maps made in the mineral processing plants of three mines are shown in this paper.

MINERAL PROCESSING PLANTS UNDER STUDY

Measurements in 3 processing plants have been carried out, two dedicated to gravel processing and the other to sand and dry goods processing based on limestone.

For gravel pits, the gravel and sand is extracted via dredges, load diggers and backhoe excavators. In the case of limestone quarry, blasting, drilling and extraction are produced in the extraction area via hammer drill and excavators.

In both operations a primary material milling is carried out which is then separated by sieves on the basis of material aggregate grading.

For a first approximation of worker exposure levels, a noise map in each processing area was decided to carry out.

Measurement and Sampling Methodology.

To prepare each of the noise maps the following process was decided upon:

Firstly, the area was analysed via aerial photography and a first measurement point design was carried out where the sampling would take place.

A later visit was made to each of the quarries. As a result of this visit the initial measuring points chosen were changed following measurement signification and representation criteria, i.e., carrying out a larger number of measurements in those area with greater probability of worker presence.

In each of the measuring points the equivalent continuous sound pressure level was registered for 10 minutes. The coordinates of each measurement point were obtained with Global Positioning System Receivers (GPS).

The next step was to download the measurements taken with the integrating averaging sound level meters – CPB analyzers and the coordinates taken with GPS onto a computer. These data are crossed with GIS (Geographical Information Systems), and a noise map for each mineral processing plant was carried out.

Finally, those areas with levels above 80 and 85 dBA were identified and the corresponding noise contours plotted.

Recorded Parameters

The measurements of each point were carried out for 10 minutes. The A-weighted equivalent continuous sound pressure level each second ($L_{Aeq,1sec}$) and the total A-weighted equivalent continuous sound pressure level of the measurement ($L_{Aeq,10min}$) as well as the equivalent continuous sound pressure level in third octave bands ($L_{eq,fc}$) were recorded at each measuring point.

Noise Map Purposes for this Research.

The aim of making out these noise maps is to carry out an initial approach to noise levels in the area.

It is not a question of valuating noise levels precisely in each spatial position but rather of defining the noise contours at 80 and 85 dBA.

The Directive 2003/10/EC [1] set out different limits for evaluating noise levels workers are exposed to known as *lower and upper exposure action values*. These values are set at 80 and 85 dBA respectively.

A worker carrying out their job within 80/85 dBA contours could be considered to be exposed to much higher levels. Specific action will have to be taken for all workers in these areas.

In the case of workers exposed to daily levels between 80 and 85 dBA, they will need to be informed and trained on the risk of hearing loss due to noise exposure. The owner should supply hearing protectors and workers should have the opportunity of medical control of their hearing.

If the worker is exposed to daily levels above 85 dBA they will need to be informed and trained on the risk of hearing loss due to noise exposure with the use of ear protection as well as medical control made obligatory.

In order to discover the real noise level the worker is exposed to, another analysis will be necessary (measuring with personal sound exposure meters or further more detailed analyses).

To calculate the real level a worker using ear protection is exposed to, an analysis with personal sound exposure meters is not valid – a more detailed noise analysis being necessary such as, octave band or third octave band analyzers as well as discovering the attenuation offered by the ear protectors. The exposure areas and frequency with which the worker uses ear protection must also be shown.

EQUIPMENT USED

Noise analyzers from the Brüel & Kjaer brand, model 2260, were used to carry out measurements. This equipment has been calibrated in an ENAC (National Accreditation Body) accredited laboratory in accordance with sound level meter and integrating averaging sound level meter standards (IEC 651:1979 and IEC 60804:2000). A filter calibration in third octaves from 20 Hz to 20 kHz was also carried out in accordance with IEC 61252:2002 standard.

The correct functioning of measuring equipment was checked before and after each measurement series with a sound calibrator.

Furthermore, the integrating averaging sound level meters have been put through legal metrological control to be applied annually to instruments for measuring audible sound.

RESULTS

Valuating noise levels was carried out with the L_{Aeq} indicator. This index allows existent noise levels in the area to be related to time-weighted average of the noise exposure levels for a nominal eight-hour working day ($L_{EX,8h}$), via the following equation [2]:

$$L_{EX,8h} = L_{Aeq,Te} + 10 \cdot Log(T_e / T_0) \qquad (dBA) \tag{1}$$

where T_e is the real exposure time and T_0 is 8 h (reference duration for a working day).

The registered noise levels in each measuring point remained static and constant throughout the whole evaluation period.

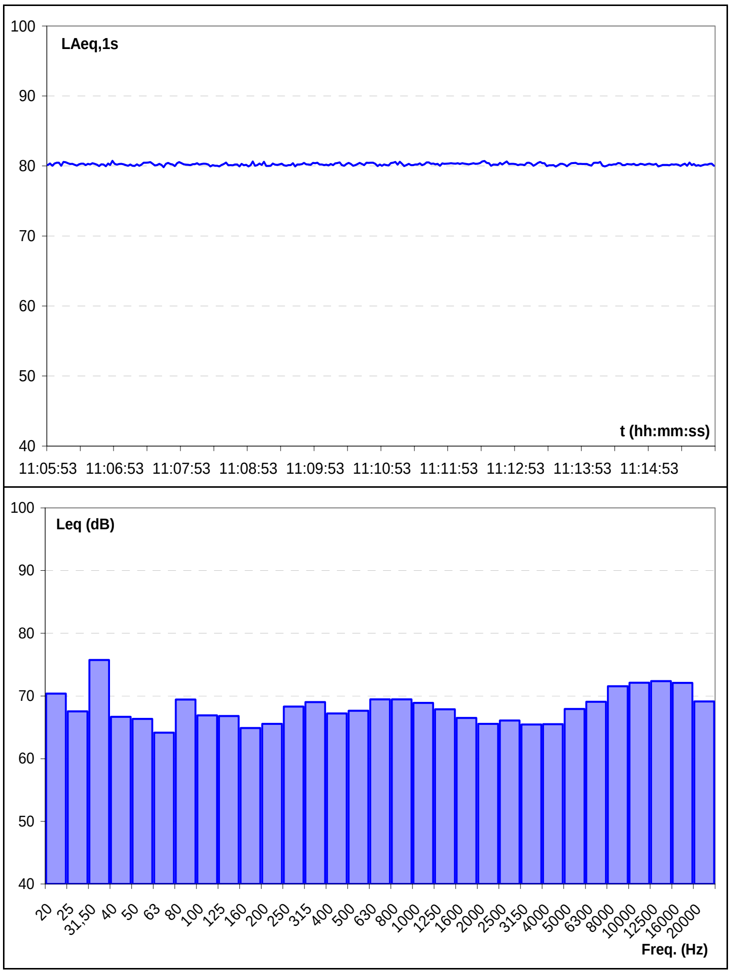


Figure 1. Measurement carried out in measuring point 7 in gravel pit II.

For future analyses the Leq was registered in the third octave band for each measuring point. As can be seen in the last figure, the spectral characteristics of the different noises registered were from broadband without predominant tonal components.

With GIS software the $L_{Aeq,10min}$ and geographical coordinate data were crossed for each measuring point, building up a scenario for each operation studied and carrying out a spatial representation of sound levels in the form of a noise map (figure *2b*).

From the noise map, the noise contours corresponding to L_{Aeq} of 80 dBA and 85 dBA were determined (figures *3*, *4a* and *4b*).

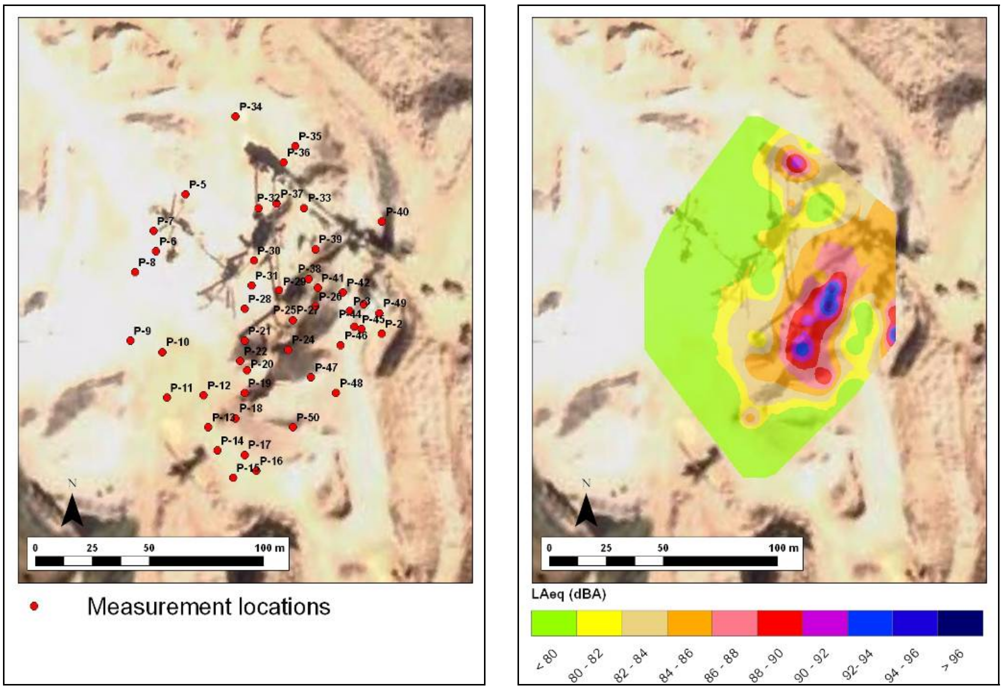
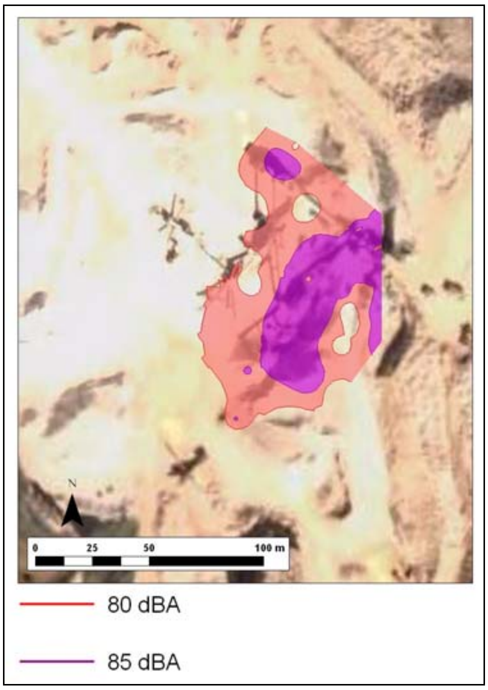


Figure 2a. Location of the measuring points in the limestone quarry processing plant. Figure 2b. Noise map.

These noise contours are perfectly georeferenced, each of their coordinates being known. This fact allows risk areas inside the mineral processing plants to be set out and measures considered appropriate by managers and leaders with regards to working risk prevention in each operation to be taken.

Figure 3. Noise contour map (80 and 85 dBA) in gravel pit II.



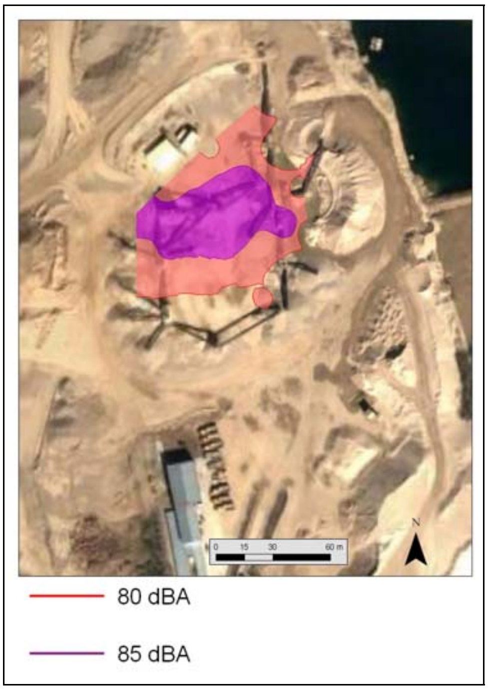


Figure 4a. Noise contour map (80 and 85 dBA) in limestone quarry.
Figure 4b. Noise contour map (80 and 85 dBA) in gravel pit I.

CONCLUSIONS

The noise maps shown here are valid for mineral processing plants where fixed noise sources exist, where the type of noise may be considered stationary, stable, more or less constant and continuous over time, and in those places where workers carry out their jobs outside.

This tool is not valid for those cases where mobile sources are found, where workers (recipient and object of the noise evaluation) carry out their jobs inside vehicle cabins, buildings, etc. Neither is it intended for those locations where noise sources are not continuous

These noise maps show certain methodological limitations. The measurements have been taken in free field conditions , at a height of 1.5 metres from floor level and at distances over 1 metre from the noise source, and with reflective surfaces so as to avoid the near field. The original grid designed from aerial photography had to be reset and modified in large part from viewing the area under study.

At these facilities the workers often carry out work at other heights, located at distances under 1 metre from noise sources meaning these maps do not reflect, nor do they intend to show, the real level at each spatial coordinate.

The maps' validity is restricted to providing contour lines identification above certain levels; above these levels there is a risk of hearing loss due to noise exposure. These contour lines will thus delimit areas with different ranges. This tool shows the advantages of rapid fulfilment and the possibility to reduce costs when carrying out preliminary evaluations of the number of employees exposed to specific sound levels.

REFERENCES

[1] European Union. “Directive 2003/10/EC of the European Parliament and of the Council of 6 February 2003 on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (noise)”. Official Journal L 042 , 15/02/2003 P. 0038 - 0044Rd1316.

[2] International Organization for Standardization. Acoustics – “Determination of occupational noise exposure and estimation of noise-induced hearing impairment”. ISO 1999:1990. Geneva: ISO, 1990.

[3] ITGE. Instituto Tecnológico Geominero de España., *Manual de arranque, carga y transporte en minería a cielo abierto*, (ITGE, Madrid, 1995).

Others:

Heal & Safety Executive. “Noise Mapping in paper mills”. Paper and Board Information Sheet 2. Available [Online] [10 April 2006]: http://www.hse.gov.uk/pubns/pbis2.pdf

Harris C. M., Handbook of acoustical measurements and noise control. 3rd Edition, Melville, NY: Acoustical Society of America, 1998.