PROFILES OF NOISE EXPOSURE LEVELS IN SOUTH AFRICAN MINING

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Acknowledgements: Mine Health and Safety Council, South Africa, for funding of the study. Members of the CSIR research team in 2007 Erika Newberry and Nathi Ndlovu.

ABSTRACT

Objectives

A two-year study focused on current noise exposure levels in the South African mining industry, aimed at helping the Mine Health and Safety Council of South Africa meet its milestones for eliminating noise-induced hearing loss (NIHL).

Methods

A multi-task methodology was adapted from international baseline studies to determine the exposure to noise in both large-scale and small- to medium-scale mines.

Results

On average, 66.7 per cent of the employees sampled in year 1 and 78.4 per cent in year 2 were exposed to noise levels of above the 85 dBA legislated occupational exposure level.

Conclusions

Information obtained through the study could be developed into a national personal noise exposure database, including audiometric results, equipment noise emission levels and initiatives for noise engineering control by mines and equipment manufacturers to facilitate targets of eliminating NIHL.

[135 words]

Key words: noise exposure levels, mining industry, noise-induced hearing loss

INTRODUCTION

Excessive noise exposure in the workplace can limit workers' ability to communicate and hear warning signals and can impact on their safety and productivity.[1,2] A more significant risk is that long-term noise exposure increases the risk of hearing loss, with implications for workers' health, employment prospects and overall quality of life.[3] Noise-induced hearing loss (NIHL) can be prevented by introducing effective hearing conservation programmes. Such programmes advocate noise control engineering as the main method of reducing the risk of NIHL.[4]

In the mining industry the use of drilling and rock breaking equipment results in widespread exposure to high levels of noise [5,6] placing miners at risk for the development of NIHL. The U.S.A. National Institute for Occupational Safety and Health (NIOSH) reports that 80 per cent of U.S.A. miners work in an environment in which noise levels exceed the legislated permissible exposure limit.[5,7,8,9] Furthermore, it was found that all miners in occupations in longwall sections of U.S.A. coal mines are exposed to levels in excess of exposure levels regarded as safe for the prevention of NIHL. Examples of the reported coal miners' exposure levels are that stageloaders are exposed to noise levels ranging from 82 to 103 dBA, hydraulic pump attendants to a range of between 74 and 103 dBA and shearers to between 85 and 100 dBA.[4] Similarly, it was found that sand and gravel miners in the U.S.A. are exposed to excessively high noise levels; for example, 112 dBA near crushers, 108 dBA near screens, 107 dBA in the engine rooms of the cranes and up to 97 dBA in the plant areas.[6]

The information available on the noise exposure levels for South African miners suggests that more than 90 per cent work in areas in which noise exceeds the legislated occupational exposure limit (OEL), which is 85 dBA time weighted average (TWA).[5] Concerns have existed about the noise hazard in the South African mining industry since the mid-1960s and attempts to quantify the noise exposure levels have taken place since then.[10,11,12, 13,1] Noise exposure levels were reported to have increased marginally between 1980 and 1998; for example, stopers' exposures increased from 111.4 to 112 dBA, winch operators from 97.1 to 98.3 dBA and team leaders from 97.4 to 104.9 dBA.

Continued concerns about the high incidence of NIHL, and the costs to the South African mining industry, resulted in the setting of targets in 2003 by industry stakeholders to eliminate NIHL.[14] The targets are:

- After December 2008, hearing conservation programmes must ensure that deteriorations in hearing are no greater than 10 per cent amongst occupationally exposed individuals; and
- By December 2013, the total noise emitted by all equipment installed in any workplace must not exceed a sound pressure level of 110 dBA at any location in that workplace.

In order to achieve the targets set by industry and to monitor the progress towards meeting them, the mining industry needed reliable, representative and current noise exposure data. Therefore, the South African Mine Health and Safety Council (MHSC) initiated a study to quantify the noise exposure levels in the mining industry. The MHSC study incorporated objectives relating to both noise and dust exposure and prevention of NIHL and silicosis. However, the objectives reported in this article were aimed at quantifying the noise exposure levels of workers in different mining commodities and in different mining occupations. The results of other aspects of the study are reported elsewhere.[15,16]

METHODOLOGY

The multi-task research design implemented by the Concawe Health Management Group (CHMG) that assessed gasoline vapour exposures of European petroleum industry employees was adapted for the MHSC study to measure noise exposure levels in the various mining commodities and in different mining occupations.[17,18,19]

Participants

Workshops to explain the purpose of the MHSC study were held for stakeholders in the mining industry, both within the large-scale mining sector and the small- to medium-scale mining sector, and mines were asked to volunteer to participate in the study. In year 1 (2007) of the study, four large-scale mines volunteered to participate in the study: one underground platinum mine; one underground gold mine; one opencast coal mine; and one underground coal mine. In year 2 (2008) of the study, ten small- to medium-scale mines volunteered to take part in the study: two large diamond mines (employing more than 50 employees); three small opencast diamond mines (employing fewer than 50 employees); four sand and aggregate mines; and one Readymix concrete production site.

Sampling

The South African Department of Minerals and Energy (DME) guidelines for the compilation of noise codes of practice were used to determine the sampling protocols for the collection of personal exposure samples.[9] The number of samples required at each mine was calculated per Homogeneous Exposure Group (HEG) and occupations within the HEGs identified using the principles outlined in the guidelines. Table 1 provides a summary of the commodities surveyed, the number of samples taken and the occupations represented in each sample. In 2007, 355 personal noise exposure samples representing 101 occupations were measured in the large-scale mining sector. In 2008, 190 personal noise exposure samples were taken, representing 89 occupations in the small- to medium-scale mining sector.

Table 1: Sample sizes and occupations represented

Data collection

Personal noise exposure measurements were conducted by means of personal noise dosimeters. Employees were encouraged to conduct their normal work, and full-shift noise exposure levels in terms of average/equivalent sound pressure level (L_{aeq}), noise dose and shift time were recorded.

Data analysis

Descriptive statistics were calculated that included averages, standard deviations, and minimum and maximum noise exposure levels for the different commodities and different occupations. Percentages of the sample that were exposed to noise levels exceeding the OEL were also calculated. The averaged noise exposure levels for the different occupations in each commodity were calculated and ranked, with a view to prioritising the risks for different occupations.

RESULTS

The results of the study are presented, firstly, for the averaged noise exposure levels (L_{aeq}) for the different mining commodities and, secondly, the percentage of the miners sampled who were exposed to levels above the OEL, and therefore at risk for the development of NIHL. Finally, the averaged noise exposure levels for the occupations surveyed are presented in a ranked format.

Averaged noise exposure levels in the South African mining commodities

The combined noise exposure survey results for the large-scale sector of mines surveyed (gold, platinum and coal mines), and those surveyed in the small- to medium-scale sector mines (Readymix concrete, sand and aggregate, small and large opencast diamond and large underground diamond mines) are summarised in Figure 1. In the large-scale mining sector the highest maximum exposures occurred in the underground platinum mine (113.5 dBA), followed by the underground gold mine (105.5 dBA). In the small- to medium-scale mining sector, the highest maximum exposure levels occurred in the sand and aggregate mines (107 dBA), followed by the small opencast diamond mines (104.4 dBA).

Figure 1: Summary of averaged noise exposure levels for South African mining commodities

The mean noise exposure levels (Table 2) were found to be the highest in the underground platinum mine (91.1 dBA SD=7.546) followed by the gold mine (90.4 dBA SD=6.063).

Table 2: Mean noise exposure levels in South African mining industry

Percentage of results above the Occupational Exposure Limit

The percentage of the results that indicated exposure levels that exceeded the OEL of 85 dBA was calculated. The results are summarised in Table 3.

Table 3: Percentage of sample above OEL

Among the large-scale mining sector, on average, 66.7 per cent of the employees sampled were exposed to noise levels of above the legislated OEL of 85 dBA. The highest number of over exposures occurred at the underground gold mine (84 per cent), followed by the underground platinum mine (81 per cent). On average, in the small- to medium-scale mines, 78.4 per cent of the employees sampled were exposed to noise levels of above the OEL. The highest number of over exposures occurred at the Readymix production site (100 per cent), followed by the small opencast diamond mine (89 per cent). In the mining industry as a whole, on average, 73.2 per cent of the workers are exposed to noise levels above the OEL, and are therefore at risk for the development of NIHL.

Noise exposure for occupations in the mining industry

The summarised noise exposure data per occupation for underground gold mine occupations is presented in Figure 2. The five occupations most at risk for NIHL caused by the maximum and mean exposure levels were drillers (mean=105.5 dBA), loco drivers (mean=95.3 dBA), development team leaders (mean=93.2 dBA), multi-task workers (mean=92.3 dBA) and scrape winch operators (mean=92.1 dBA).

Figure 2: Summary of averaged (L_{aeq}) exposures in underground gold mining occupations

The summarised noise exposure data per occupation for the underground platinum mining is presented in Figure 3. The five occupations most at risk for NIHL owing to the maximum and mean exposure levels were stopers (mean=113.5 dBA), mechanical assistants (mean=98.5 dBA), stoper miners (mean=96.1 dBA), development team rock drill operators (mean=93.9 dBA) and workers in the sectional gangs (mean=93.8 dBA).

Figure 3: Summary of averaged TWA (L_{aeq}) exposures in underground platinum mining occupations

The summarised noise exposure data per occupation for the underground coal mine is presented in Figure 4. The five occupations most at risk for NIHL because of the maximum and mean exposure levels were continuous miner operators (mean=97 dBA), shuttle car drivers (mean=91 dBA), mine production workers (mean=90 dBA), heavy motor vehicle drivers (mean=89 dBA) and engineering technicians (mean=89 dBA).

Figure 4: Summary of averaged TWA (L_{aeq}) exposures in underground coal mining occupations

The summarised noise exposure data per occupation for the opencast coal mine is presented in Figure 5. The five occupations most at risk for NIHL owing to the maximum and mean exposure levels were workers who were blasting (mean=93.7 dBA), drivers in the building sections (mean=92.2 dBA), fitters (mean=87.9 dBA), drillers (mean=87.8 dBA), and rock breaking drillers (mean=87.6 dBA).

Figure 5: Summary of averaged TWA (L_{aeq}) exposures in opencast coal mining occupations

The summarised personal noise exposure data per occupation for the Readymix site is presented in Figure 6. The two occupations with the highest exposure levels were loader operator and plant operator, both with a mean of 91.2 dBA.

Figure 6: Summary of averaged TWA (L_{aeq}) exposures in Readymix concrete production site occupations

The averaged noise exposure data per occupation for all four of the sand and aggregate mines is given in Figure 7. From Figure 7 it is evident that the highest noise exposure levels occurred in this commodity amongst the jaw crusher operators (mean=99.7 dBA) and the general equipment operators (mean=98.2 dBA), followed by the general workers (mean=96.2 dBA), the cone crusher operators (mean=95.4 dBA) and the foremen (mean=95.3 dBA).

Figure 7: Summary of averaged TWA (L_{aeq}) exposures in sand and aggregate mining occupations

The summarised noise exposure data per occupation for the three small opencast diamond mines is presented in Figure 8. The workers in the most-at-risk occupations were those operating the feeder belt (mean=96.6 dBA), the pan operators (mean=93.6 dBA) and the DMS operators (mean=93 dBA).

Figure 8: Summary of averaged TWA (L_{aeq}) exposures in small opencast diamond mining occupations

The miners in the large underground diamond mines are exposed to averaged noise levels ranging from 73 to 98 dBA (see Figure 9). The occupations found to be most at-risk in this type of diamond mining were the water tanker operators (mean=98 dBA) and the shovel operators (mean=91.8 dBA). They were followed by sandblasters and secondary crusher operators, both exposed to mean noise levels of 90.8 dBA.

Figure 9: Summary of averaged TWA (L_{aeq}) exposures in large underground diamond mining occupations

The summarised noise exposure data per occupation for the large opencast diamond mine is shown in Figure 10. From Figure 10 it is evident that drilling is a very at-risk activity in this mining type since, for the highest mean noise exposure level occurring in the top five exposed occupations, drilling was involved in three of the occupations: the drill operator (mean=95.6 dBA), drilling supervisor (mean=93.2 dBA) and drilling assistant (mean=92.7 dBA).

Figure 10: Summary of averaged TWA (L_{aeq}) exposures in large opencast diamond mining occupations

DISCUSSION

The results indicate that the mean noise exposure levels in the South African mining industry range from 63.9 dBA to 113.5 dBA and that approximately 73.2 per cent of miners in the industry are exposed to noise levels of above the legislated OEL of 85 dBA. The percentage of overexposed miners is lower than those reported in 2007, when it was assumed that 90 per cent of workers were overexposed,[4] and lower than the reported overexposure in U.S.A. mining [5] The apparent reduction, however, is not cause for complacency within the industry, since the results indicate that more than 70 per cent of the mine workforce is at-risk for the development of NIHL and therefore a reduction in quality of life. Similarly, the findings of this study confirm the reports that all longwall coal miners are overexposed since South African coal miner's exposure levels range between 92 dBA and 100 dBA.

Comparisons of results from previous studies must be made with caution because the wide range of exposure data for each occupation is a result of many factors, including: mining methods; work habits; worker location; age of equipment; equipment operation; and downtime. In addition, the results reported combine data from a number of mines; thus, the exposures are the result of different equipment as well.[20] With these limitations in mind, the highest level measured near U.S.A. crushers in the sand and gravel commodity was 112 dBA, while for South African sand and aggregate crusher operators the highest level recorded was 107 dBA.

In general, comparisons in specific commodities appear to indicate that in the past ten years, since the Franz et al. study in 1997,[1] there has been some progress towards reduced noise exposure levels in certain occupations, and no or little progress in others. Examples of progress are that winch operators were reported to be exposed to 98.3 dBA in 1997 and found to be exposed to 92.1 dBA in the current study. Similarly, team leaders' exposure has been reduced from 104.9 in 1997 to 90.9 dBA in the current study. In contrast stopers in the platinum commodity were reported to be exposed to 112 dBA in 1997 and found to have a maximum exposure of 113.5 dBA in this study.

Exposure data can be used to reduce NIHL in a number of ways. First, exposure data alerts mine operators as to which workers are being overexposed and thus which occupations need to be prioritised to reduce exposure levels. Secondly, the exposure data provides a measure of the success of noise reduction efforts. Thirdly, as with the current baseline exposure study, it can provide mining industries with priorities to enable them to achieve any elimination targets set.

The first of the milestones has passed, namely that by 2008 no deterioration in hearing greater than 10 per cent amongst occupationally exposed individuals should occur. The current study was not able to evaluate whether the first milestone had been met by industry because of the limitations of the scope of the MHSC study in which the noise exposure levels were not related to the prevalence or the incidence of NIHL in the mining industry. Another limitation of the study was that personal exposure levels were measured while the second milestone is aimed at equipment noise emission levels. These limitations and the results of the study highlight the urgent need for multi-disciplinary, integrated NIHL prevention programmes at the level of individual mines and mining houses which are tailor made for the commodity and the occupations. These mine-specific NIHL prevention programmes must include integrated hearing test results and noise exposure data. The monitoring of equipment noise exposure levels and the effects on the hearing of individual miners will require close collaboration between audiologists, occupational hygienists and engineers to ensure achieving the industry goal of the elimination of NIHL.

CONCLUSIONS

The study achieved its aims of assessing the current noise exposure levels of employees in the mining industries of South Africa, thereby providing a baseline for the evaluation of any future control methods and the facilitation of the prioritising of necessary control strategies.

From the study recommendations are, firstly, that integrated and multi-disciplinary prevention strategies be implemented to provide a model for individual stakeholders in the industry that can use the information gained from this study as a baseline to measure the success of such prevention strategies.

Secondly, it is recommended that the establishment and maintenance of a national database of personal noise exposure that could be accessed from the public domain and by the industry stakeholders be a priority. The inclusion of audiometric results in such a database would improve the prevention of NIHL and enable the monitoring of progress towards the milestones. Such a database would facilitate an improved knowledge of the status of personal exposures to occupational health hazards in the mining industry as well as facilitate improved epidemiological analysis of trends in exposure and success of intervention strategies.

Finally, equipment noise exposure levels must be assessed and an evaluation made which could identify the current and required initiatives for noise control engineering by involving equipment manufacturers, suppliers and control specialists for improving noise control efficiencies.

[word length without abstract, tables and figures, and references = 2687 words]

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