MANAGING NOISE EMISSIONS AND EXPOSURES IN UNDERGROUND COAL MINES

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1 INTRODUCTION

This is part of the technology transfer of NERDDC project number 1628 "Managing Noise Emissions and Exposures in Underground Coal Mines". The total value of research funds expended on this project was $305,000. The project started in February 1992 and the report is currently being finalised. The technology transfer component is currently in progress. The project was funded by NERDDC ($200,000), Oaky Creek Coal Mine ($50,000), and Worksafe Australia ($55,000).

2 PROJECT OBJECTIVES

The project was split into three streams.

The first and major stream was engineering source control, that is controlling the noise of machinery at its source. The aim of this part of the project was to demonstrate that noise control is achievable on underground mining equipment.

The second, and minor stream, was to trial a new method of detecting hearing loss called "Oto-Acoustic Emission Testing". The aim was to see if the technique, under development by the National Acoustics Laboratory, was of use in the coal industry to;

- Identify workers more susceptible to Noise Induced Hearing Loss.
- Assess the effectiveness of hearing protection in the workplace.
- Help in selection hearing of protection for individual miners.
- Replace the current test process.

The third stream was to identify the current effectiveness and usage of hearing protection used in the mining industry and initiate improvements where required including;

- Scientifically selecting hearing protection based on actual noise levels and frequency content of underground mining equipment.
- Identifying the human issues that effect hearing protection usage.
- The preparation of education material to address these issues and increase the usage of hearing protection amongst underground mine workers.

The final part of the project was to assimilate the three streams to assist the industry in implementing a strategy for the ongoing reduction of noise induced hearing loss in the mining industry. This paper will concentrate on implementing one of the findings related to the overall industry strategy. Namely the need for high level (CEO) management support to establish and maintain a successful noise abatement programme.

The key question is "**Why Manage Noise**"

3 NOISE INDUCED HEARING LOSS (NIHL) - THE HUMAN COST

Hearing loss is an invisible handicap. A worker can go down to the pub, and if they have a crippled arm from an industrial accident it is clearly visible, but they can still socialise with their mates. They may have to use their left hand to drink their beer, but they can still enjoy a beer with their mates. In this case the injury is clearly visible and the debilitating effects are obvious.

Hearing loss is not visible, the ear is not missing or visibly disfigured in any way. It is likely that a worker whose ear was torn off in an industrial accident with no loss of hearing would elicit some sympathetic reaction from observers. However those with hearing loss, whose incapacity severely restricts their social life, would not be given a second glance.

The exact effect of NIHL is often not fully understood and its effect outside the working environment are greater than at work. NIHL does not result in a total loss of hearing. It results in a significant loss of high frequency hearing ability. The effects of this are not that noticeable at work, workers can still hear diesel vehicles coming (due to the low frequency noise from diesel equipment). Instructions are expected: "pass me the drill", or a similar verbal instruction can be inferred from the context of the situation. Also in a high noise environment, such as the underground coal mining industry, visual signals are quite prevalent.

The effects of NIHL outside the work environment are real, far from trivial, and have a significant impact on personal, family, and broader social lives. The high frequency hearing loss associated with NIHL, results in effects that vary with circumstances. Personal enjoyment of simple things (dependent on personal interests), such as listening to music, can be severely restricted. Relating to family members is impaired, as listening to women and children is hard due to their higher pitch voices. Family relations may be strained by annoying relatives by turning the television up louder than others need it.

The most debilitating effect occurs when there is significant background noise present. A person with NIHL has extreme difficulty hearing people (particularly women) talk when there are high levels of background noise. The results of this are dramatic as a person with NIHL has significant problems in relating to people in simple social situations. Simply going down the pub to have a beer with your mates becomes impossible as you cannot talk or laugh with them. As this paper is addressed to a mining industry conference there are probably people in the audience who have first hand experience of this.

In conclusion NIHL is a debilitating occupational disease that results in a significant impairment of human ability and should be treated seriously by the mining industry.

4 NIHL - COSTS DUE TO COMPENSATION PAY OUTS

Although this paper is being presented to a conference in Queensland it will initially discuss the costs to the New South Wales coal industry. It is important to understand the NSW experience as the new Qld "Health Order" may have a significant effect on the future cost of NIHL claims to the Qld mining industry.

4.1 Costs to the New South Wales Industry.

As can be seen from Table 1 on the right, the pay outs for NIHL have been on the increase over the past ten years. There has been a dramatic increase in costs over the past five years. Not only in terms of the dollar costs but also as a percentage of total claims.

These figures include claims from open cut mines as well as underground mines.

As the figures are compensation pay outs, not insurance premiums, these need to be multiplied by approximately 1.2 to get the insurance premium cost to the NSW mining industry. The total insurance cost of NIHL to the NSW coal industry over the past ten years is **16.4 Million Dollars.** If these trends continue then the cost over the next ten years will be in the order of **32 Million Dollars.** With this representing over 10% of total insurance costs by the year 2004.

Year	Dollar Pay out Millions	Percent of Total Pay out
83/84	1.21	-
84/85	1.09	-
85/86	1.21	-
86/87	0.87	-
87/88	0.87	1.5
88/89	1.31	2.1
89/90	1.17	2.0
90/91	1.44	1.8
91/92	2.22	2.8
92/93	2.28	3.0

Table 1: Noise compensation pay outs by the JCB covering the past ten years.

The **real** cost of workers compensation claims is estimated to be in the order of 6 or 7 times the actual compensation cost. In this light the real cost of NIHL to the NSW coal industry has been **100 Million Dollars** over the last ten years. Extrapolating this to the next ten years would make the true cost of NIHL to the NSW coal mining industry of **20 Million Dollars each year.** Worksafe Australia use a multiplier of 15 in their training module for managing noise in general industry (Reference 3).

Sixteen million dollars, or half the predicted direct insurance cost, spent on noise control could achieve significant noise reductions on equipment to aid in eliminating the problem. It should be recognised that the NIHL problem will not go away quickly. There is a lag between noise exposure and claims. However if the money is not spent in this coming ten year period then the cost to the industry in the following ten year period will be **64 Million Dollars.** Or viewed another way 8 million dollars spent over the last ten years would see a reduction in the coming ten year period.

4.2 Costs to the Queensland Industry and Comparisons with New South Wales.

The figures for the Qld underground coal mining industry are shown in Table 2 on the right. These figures are for underground coal mines only.

There are significant differences between the Qld figures and those in NSW. The pay out in NSW is much higher in dollar terms. The percentage of noise claims to total claims has been higher in Qld than in NSW. An understanding of the difference between the NSW and Qld coal industries is required to explain these differences.

Year	Dollar Pay out Thousands	Percent of Total Pay out
88/89	65	4.6
89/90	53	3.4
90/91	95	5.4
91/92	63	4.4
92/93	27	2.9

Table 2: Noise compensation pay outs in the Qld underground coal mining industry.

Statistics collected over the last five years in Qld have not had a separate category for open cut coal mining (this has been included with all open cut mines and quarries). This can explain some of the difference as the NSW figures are for the total coal industry. The number of underground mines in Qld is also at least half that in NSW. The differences are easier to see if the number of claims are compared and the average value of claims are compared. This comparison is made in Table 3 on the below. The number of claims made in NSW are on average ten times higher than those made in Qld. The average value of claims is also higher in NSW by a factor of three.

Year	Qld No. Claims	Average Claim $	NSW No. Claims	Average Claim $
88/89	54	1200	530	2480
89/90	42	1264	460	2550
90/91	63	1505	430	3350
91/92	44	1426	600	3700
92/93	36	750	546	4180

Table 3: Comparison of the number of claims and average cost per claim of NIHL claims in NSW and Qld.

The difference in percentage of NIHL claims to total claims (2% on average in NSW and 4% in Qld) is most likely due to the lower number of total compensation claims in Qld to NSW (approximately 50% lower). No direct comparisons can be made regarding the difference in the average value of the claims as the methods used in calculating the pay outs are totally different between the two states.

The difference in the number of claims is due to numerous variables including the number of mines in NSW, both underground and open cut, age and distribution of the workforce in each of these mine categories. It is not the intention of this paper to conduct a full demographic study of these differences, rather to highlight that they exist and to identify the most important difference which will have a significant impact on the Qld mining industry in the near future.

The most significant difference effecting the number of claims is worker awareness of NIHL. In NSW the Joint Coal Board has been conducting audiometric testing on workers for many years. In Qld there has been no legislation requiring continued audiometric testing, only testing on entry to the industry. With the introduction of the new "Health Order" in Qld this is about to change. In this context the history in NSW is important to Qld. It is likely that with ongoing audiometric testing there will now be a rapid increase in compensation pay outs for NIHL in Qld in the near future. Even if compensation claims in Qld increased tenfold over the next five years this would only cost the underground coal mines in the order of 3 million dollars over this period. This is relatively minor when compared to the costs facing NSW. However there are other costs, namely common law claims, that will also increase dramatically.

The most important difference between NSW and Qld, that will have a dramatic effect on the cost of NIHL to the mining industry in Qld, is that there is no limitation in Qld on common law claims as there are in NSW. With the introduction of the "Work Cover Act" in NSW in 1987, common law claims were limited to workers who lost the use of more than 33% of a body part. This has virtually eliminated common law claims for NIHL in the NSW coal mining industry. The impact of increased common law claims in Qld for NIHL is discussed in the next section.

5 NIHL - COSTS DUE TO COMMON LAW CLAIMS

"The person claiming damages has to prove that damage to his hearing was foreseeable, that there was an alternative means of work which was safe or at least safer than the way in which he was asked to work, and therefore that his employer was negligent." Reference 1.

There can be no argument put forward in the mining industry that the noise loss was not foreseeable. There is an abundance of documentation showing the high machinery noise levels and excessive noise dose exposure of workers in the underground mining industry. The adverse effects of excess noise exposure have been known for the past twenty or thirty years and there is no excuse for not knowing that these noise levels are unsafe.

There has been over the last ten years, a large amount of noise control research carried out, mainly by the US Bureau of Mines. A large proportion of this has never reached commercial production. Various arguments can be raised as to exactly why this has not occurred. What ever the reason, as the technology exists, there is no excuse for not applying it.

Only one common law claim has failed in NSW, due to significant recreational exposure. Claims in NSW have averaged $60,000, plus legal costs add another $30,000 and this is **on top of** the compensation pay out. One case resulted in a pay out of $80,000 for a loss of **only 2%**. The highest award was $250,000 in 1991. (Source, Reference 1).

Applying this to Qld, if the current average of 50 claims per year succeed in court with each costing $90,000, this is an **annual cost to the industry of 4.5 million dollars.** In this context spending significant funds on noise control makes sound commercial sense in risk management.

The extent of the possible economic risk to the Queensland industry is dependent on the number of workers likely to make claims. Data from the JCB in NSW showed that in the period from 1985 to 1988 forty two percent (42%) of workers tested had a compensable level of NIHL. With the implementation of the Qld health order and the increased awareness of NIHL, the number of claims could jump rapidly.

To successfully defend a compensation claim the defendant must establish that they have a comprehensive hearing conservation program. This does not mean simply supplying hearing protection, the courts do not accept this as adequate. As an Australian Standard exists for implementing a hearing conservation program the courts accept this as the standard of program needed to successfully defend a common law claim for NIHL. AS-1270 has been in existence since 1976, (Reference 2).

Guidelines for a comprehensive hearing conservation program are supplied in reference 2, AS1270-1988 Acoustics-Hearing Conservation. Chapter 4 covers engineering noise control, maintenance of equipment to reduce noise, specifying and purchasing low noise equipment. Chapter 5 covers administering a hearing conservation programme including identification of hazardous areas, education of workers, selection of hearing protection and audiometric testing. These two chapters are written in plain english and is recommended reading for all personnel responsible for running a hearing conservation program.

In conclusion; high noise levels are well documented in the mining industry demonstrating that hearing loss is foreseeable, noise control technology has been available for most equipment over the last ten years, and guidelines for hearing conservation (AS 1270) have been well established for over 20 years. Therefore, the Qld mining industry in general has little defence against common law claims for NIHL, and is facing a risk of significant pay outs for common law claims. This could cost the Qld mining industry something in the order of **5 Million Dollars per year.**

6 NOISE - THE UNSEEN COSTS

As mentioned in section 4.1, Worksafe Australia attribute a value on the true cost of noise exposure at 15 times the insurance cost for NIHL. This is based on the effects of noise on; productivity, absenteeism, staff turnover, employee quality, and the cost of personal hearing protection programs. This section will review the more important aspects of the unseen effects of noise namely the effects on; productivity, increased risk of other accidents, and absenteeism.

6.1 Noise versus Productivity.

A study of the economic impacts of occupational health versus productivity in the coal mining industry was conducted by Worksafe in 1992, (reference 4). The conclusion of this study, conducted using statistics from 1970 to 1988, was that there was a strong correlation between productivity and safety performance. The most productive mines were also the safest mines. An American study conducted in 1987 on 62 underground coal mines, all using continuous miner technology, came to the same conclusions (referenced in the Worksafe paper).

Examining reference 4 more closely the exact correlations found were;

Productivity	versus	lost time injuries	-0.17
"	"	frequency rate	-0.46
"	"	incidence rate	-0.46
"	"	disease	-0.88

These results show (because of the negative sign) that as each of these four variables increase, productivity goes down. The higher the correlation number the stronger the correlation is. The highest correlation is with occupational disease. **In 1991/92 NIHL accounted for 85% of all occupational disease claims made to the JCB.**

The effects of high noise levels on productivity have been subject to numerous studies. Most studies however caution that in most instances noise was not the only variable that changed. In some instances the low noise machines were in different factories from the high noise machines. Other studies are of low noise areas of one factory compared with high noise areas of the same factory but using different machinery. There are few studies on the before and after effects of noise control and productivity on the same piece of machinery.

One study (reference 5) was conducted on film perforation machines where noise levels on some machines were reduced by 10 dBC . Operators were rotated to ensure that no bias was observed due to better operators. The study concluded that although operator speed did not increase on the quiet machines the number of operator errors were significantly reduced on the quiet machines.

This is supported by reference 6 which concludes that "If accidents or errors caused by momentary inefficiency are a serious risk, then noise increases the hazard and should be reduced". And also by reference 7, "increased noise increases human error, which impacts on accident rates and productivity, which is more pronounced the more complex the task is". Reference 8, a study in textile mills showed an increase of productivity of 1% from low noise exposed workers, and referred to previous studies with similar results. Worksafe, reference 3, use a figure of 2% for general manufacturing industries. Although of no great significance to the textile industry, a productivity increase of 1% in an underground coal mine would have dramatic economic advantages to the owners.

In conclusion there is sufficient evidence to show that the effects of worker exposure to high noise can have a negative impact on productivity.

6.2 Noise versus Accidents.

Similar comments can be made regarding studies of noise versus accidents as those versus productivity. A lot of studies do not have high noise as the only changing variable. Reference 8 has a good study where the number of variables have been reduced to a minimum. The study compares productivity of two departments of spinning and weaving machines. The main differences between the departments were, the number of machines per floor area, and building construction. One building was concrete with high machine density, the other was corrugated iron with lower machine density. Noise levels, accident frequency rate, and severity rates are shown in Table 4 on the next page.

Department	Noise Level	Accident Frequency Rate	Accident Severity Rate	Number of People
Spinning	90 dBA (low)	22	128	494
Spinning	94 dBA (high)	35	191	1007
Weaving	81 dBA (low)	67	405	622
Weaving	94 dBA (high)	89	511	388

Table 4: Accident frequency and severity rate versus noise exposure, from reference 8.

In both cases, both the accident frequency rate and severity rate have increased in the high noise departments.

There are other more direct effects than statistical studies that show how noise has been a direct contributor to either causing the accident or increasing the severity of the accident. Several cases are reported in reference 9. Case 1 involved workers on a collapsing motorway bridge unable to hear warning shouts due to noisy equipment. Case 2 involved a worker using noisy equipment near a train line being killed by a loco despite a colleague sounding an alarm. A case where the severity of the injury was increased occurred when a worker trapped his hand in a piece of noisy machinery, colleagues were unable to hear his cries for help, and he consequently lost his hand.

In conclusion it is worth reiterating the quote from reference 6 which concludes that "If accidents or errors caused by momentary inefficiency are a serious risk, then noise increases the hazard and should be reduced". Added to this there are studies that show increased accident rates amongst workers in high noise areas and there are documented examples of where high noise has directly contributed to the occurrence or severity of an accident.

6.3 Noise versus Absenteeism.

It should be remembered during studies of absenteeism that reasons for worker absenteeism are as complex and variable as human nature itself. The statistical study in reference 9 concluded that absenteeism was significantly higher amongst high noise workers than low noise workers. Reference 3 (Worksafe) comes to the same conclusion using different sources. Worksafe allow for 4 extra days absenteeism per year for workers exposed to high noise levels.

In conclusion absenteeism is a complex issue dependent on worker attitude and work environment. Increased noise levels decrease the quality of the work environment and increase the risk of high absenteeism.

7 CONCLUSIONS - WHY MANAGE NOISE

NIHL is a debilitating occupational disease that results in a significant impairment of human ability and should be treated seriously by the mining industry.

NIHL has directly cost the NSW coal industry 16 Million Dollars over the last ten years. The indirect costs could be as high as 100 Million Dollars. If noise control measures are not instigated then the direct cost to the industry over the next ten years is likely to be 32 Million Dollars, rising to 64 Million dollars in the following ten year period.

With the implementation of the "Health Order" in Qld the number of claims is likely to increase rapidly. The Qld mining industry is exposed to a significant risk of high costs due to common law claims for NIHL over the next few years. This could cost the Qld mining industry something in the order of 5 Million Dollars per year.

There is a significant body of evidence to show that increased noise levels reduce productivity, increase accident incidence and severity rates, and increase absenteeism. These hidden costs have a significant impact on the profitability of the mining industry.

In conclusion reducing noise levels in both the Queensland and New South Wales will directly impact on the productivity and profitability of the coal mining industry. It is in the interests of both the New South Wales and Queensland industries to cooperate closely to reduce this operational hazard.

8 PROJECT CONCLUSIONS

The literature survey highlighted that solutions already exist for many of the problem areas and need following up for introduction into Australian mines. The engineering source control was successful in reducing the noise of two pieces of equipment. An auxiliary fan by 6 dBA at its control panel and 10 dBA at the fan exit. Noise at the ear of a driver of a PJB Minecruiser was reduced by 3 dBA. Design specifications have been produced for quietening a Stage Loader.

The Oto-Acoustic technique has been evaluated and is of use in predicting the onset of audiometric loss, as lower Oto-acoustic emissions occur prior to audiometric loss occurring. At the current stage of development the use is limited to using this information for worker awareness of potential audiometric hearing loss.

Usage of hearing protection in underground miners is low, typically only 40% wear protection regularly and a further 20% wear protection sometimes. The issues regarding the usage of hearing protection were identified and a pilot scheme implemented in a mine to increase the usage of hearing protection. This included selection of hearing protection based on noise levels and frequency, and worker comfort. Mine specific education material was supplied to increase the knowledge of mine workers on the need to wear hearing protection and showing them the areas in their mine where hearing protection is required.

Further technology transfer activities are planned to provide the mines with the skills they need to implement their own hearing conservation program.

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