

Worker exposure and equipment noise in large surface coal mines

Introduction

Prolonged exposure to noise can cause permanent damage to the auditory nerve and/or its sensory components. This damage, known as noise-induced hearing loss (NIHL), is irreversible and makes it difficult to hear and also understand speech. NIHL is the most common occupational disease in the United States today, with 30 million workers exposed to excessive noise levels (NIOSH, 1996a). The problem is particularly severe in all areas of mining (surface, processing plants and underground) with studies indicating that 70 percent to 90 percent of miners have a NIHL large enough to be classified as a hearing disability (NIOSH, 1996b, 1997).

An analysis of NIHL in miners revealed an alarming prevalence of severe hearing loss among miners, as shown in Fig. 1 (NIOSH, 1976). For example, the median hearing threshold of retired miners was 20 dB greater than that of the general population. By age 60, more than 70 percent of miners had a hearing loss of more than 25 dB, and about 25 percent had a hearing loss of more than 40 dB.

In addition to government researchers, academics reported that the "policies and practices for preventing occupational hearing loss among miners are inadequate . . . there are deficiencies in nearly every sector: surveillance of exposure or of outcome, analysis and intervention" (Weeks, 1995). A 1996 analysis of NIHL in miners showed an apparent worsening of NIHL with age, as shown in Fig. 2. This recent analysis of a private company's 20,022 audiograms indicated that the number of miners with hearing impairments increased exponentially with age until at age 50, at which time 90 percent of the miners had a hearing impairment (NIOSH, 1996b and 1997).

The Federal Coal Mine Safety and Health Act of 1969, Public Law 91-173, established requirements for protecting coal miners from excessive noise and subsequently, the Federal Mine Safety and Health Act

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of 1977, Public Law 91-173 as Amended by Public Law 95-164, broadened the scope to include all miners, regardless of mineral type (the Acts are detailed in CFR 30, 1997).

Since the passage of these Acts, there has been some progress in controlling mining noise. However, the number of miners overexposed to noise, as defined by federal regulations, still exceeds their overexposure to all other health hazards. Data from more than 60,000 full-shift U.S. Mine Safety and Health Administration (MSHA) noise surveys show that the noise exposure of selected occupations has decreased since the 1970s, although the percentage of miners overexposed to current MSHA noise regulations remains high (Seiler et al., 1994). MSHA found that the percentage of coal miners with noise exposures exceeding federal regulations, and unadjusted for the wearing of hearing protection, was 26.5 percent and 21.6 percent for surface and underground mining, respectively.

Despite the extensive work done in the 1970s and 1980s, NIHL is still a pervasive problem (Federal Register, 1996). MSHA has published new Noise Health Standards for Mining (Federal Register, 1999). The new, unified noise standard became effective on Sept. 13, 2000. One of the changes is the adoption of a provision similar to U.S. Occupational Safety and Health Administration's (OSHA) Hearing Conservation Amendment. MSHA projected in a recent survey that if an OSHA-like hearing conservation program were adopted, hypothetically, 78 percent of the coal miners surveyed would be required to be in a hearing conservation program (Seiler and Giardino, 1994).

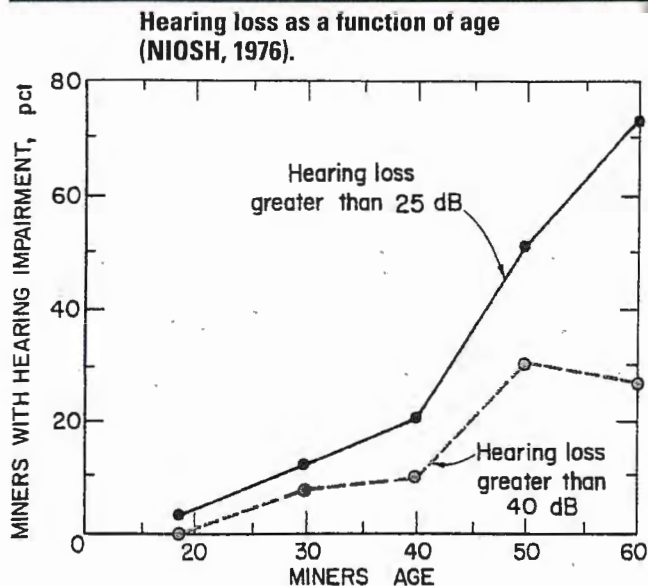
Other requirements of the new regulations are a Permissible Exposure Level (PEL) of 90 dBA TWA 8, no credit for the use of personal hearing protection, and the primacy of engineering and administrative controls for noise exposure reduction.

Much of the existing noise and

Abstract

Noise-induced hearing loss (NIHL) continues to be a problem in the mining industry. New noise standards (Part 62) promulgated by the U.S. Mine Safety and Health Administration are aimed at reducing NIHL in the mining industry. The National Institute for Occupational Safety and Health is conducting a cross-sectional survey of noise sources and worker noise exposures to address NIHL in mining. Noise surveys, including full-shift worker noise exposure and equipment noise profiling, have been completed in several surface coal mines, with an emphasis on draglines. The results of these studies are reported, their implications concerning worker NIHL are addressed, and their application to administrative and engineering controls is discussed.

FIGURE 1



worker-exposure information is dated and has limited value for current research and engineering control decision making. In many cases, the data are specific to machine type and were obtained for characterizing noise sources rather than exposure assessment. There is also a great range in noise levels for a given occupation. For example, noise levels for continuous miner operators have a modal value of 90 dBA and a range that varies from 80 to 105 dBA (MSHA, 1997).

A noise level of 80 dBA translates into a daily noise dose of 0 percent, while a 105 dBA level represents a daily noise dose of 800 percent. Yet, at present, there is insufficient information to explain this variation in exposure for this and other mining occupations. An under-

TABLE 1

Range of noise for draglines.

Dragline			Range of Leq noise, dBA
Make	Model	Bucket size m ³ (cu yd)	
Page	736	16 (21)	93-104
	752	32 (42)	88-100
	757	54 (71)	92-104
Bucyrus Erie	1260W	27 (35)	98-105
	1570W	70 (92)	97-110
	1570W	70 (92)	101-112
	2570W	77 (100)	96-107
Marion	195M	13 (17)	97-109
	7800	28 (36)	93-99
	8050	56 (73)	93-105
	8200	57 (75)	88-105
	8750	69 (90)	91-100
	8750	84 (110)	98-108
	8750	84 (110)	98-108
8750	101 (132)	95-105	

standing of this variability will help in identifying appropriate solutions. Specifically, noise-level data are needed that provide a time exposure history for workers in addition to information on noise sources. This information will provide the basis for targeting and selecting engineering controls, in combination with administrative controls and personal-protection equipment, to reduce noise exposures among the mining workforce.

FIGURE 2

Hearing impairment in coal miners, non-coal miners and non-exposed males (NIOSH, 1996b, 1997). (Males with hearing impairment, average 1, 2, 3 and 4 kHz > 25dB HL, from ANSI S3.6-1989; coal and non-coal miners and non-exposed males from Annex A of ANSI S3.44-1996.)

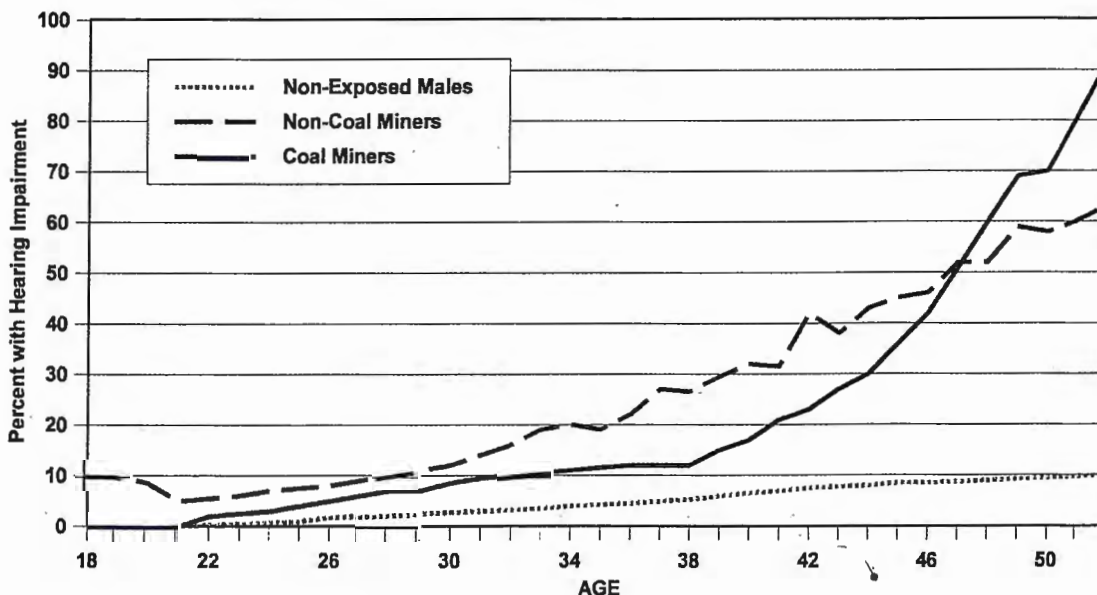
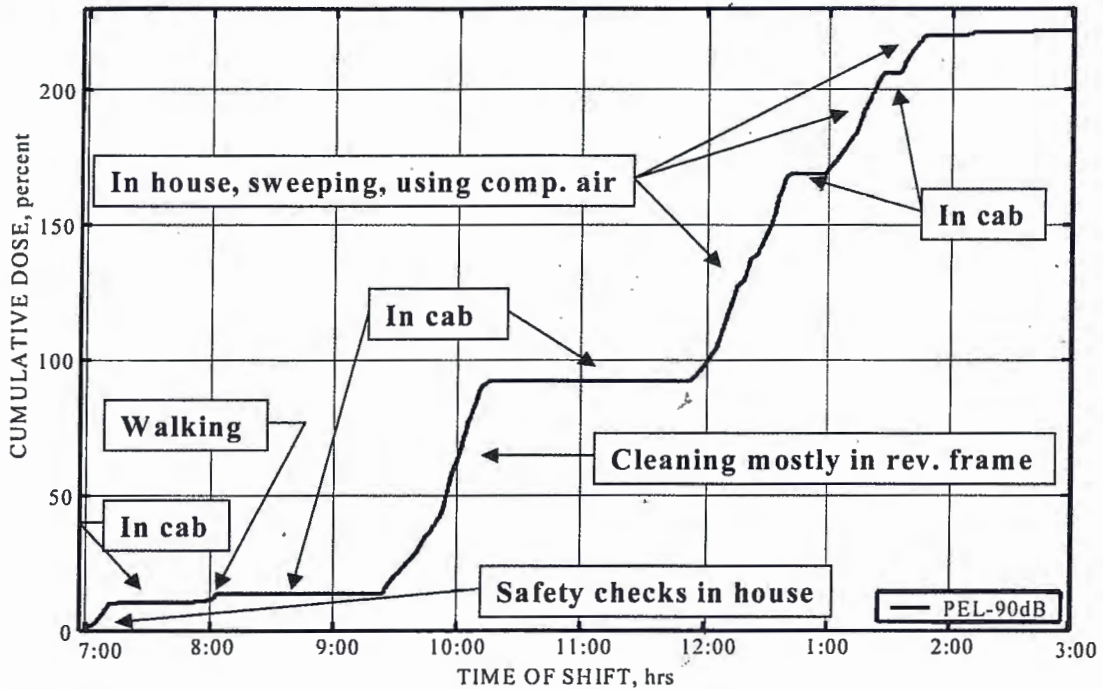


FIGURE 3

Cumulative dose plot for dragline oiler.



Scope of research

This research effort was conducted over several years at seven surface coal mines located in Arizona, New Mexico, North Dakota, Texas and Wyoming. Sixty-three man-shifts were spent collecting approximately 60 worker noise exposures (MSHA permissible exposure levels), 12 worker task observations, 15 dragline noise profiles and 20 noise investigations of other surface mining equipment. Worker noise exposure (dose) was measured using Quest Q-400 Personal Noise Dosimeters,

which was worn by the workers for a full shift. Dragline noise, in the form of equivalent sound level (Leq) in dBA, was recorded using a B&K 2260 Investigator at 1- to 2-m (3.3- to 6.6-ft) intervals throughout the dragline house.

Results

The volume of data collected prohibits including all results. Thus, summaries and/or examples are presented. The results reviewed include worker dose and overexpo-

FIGURE 4

Noise contour plot for a Page 752 dragline.

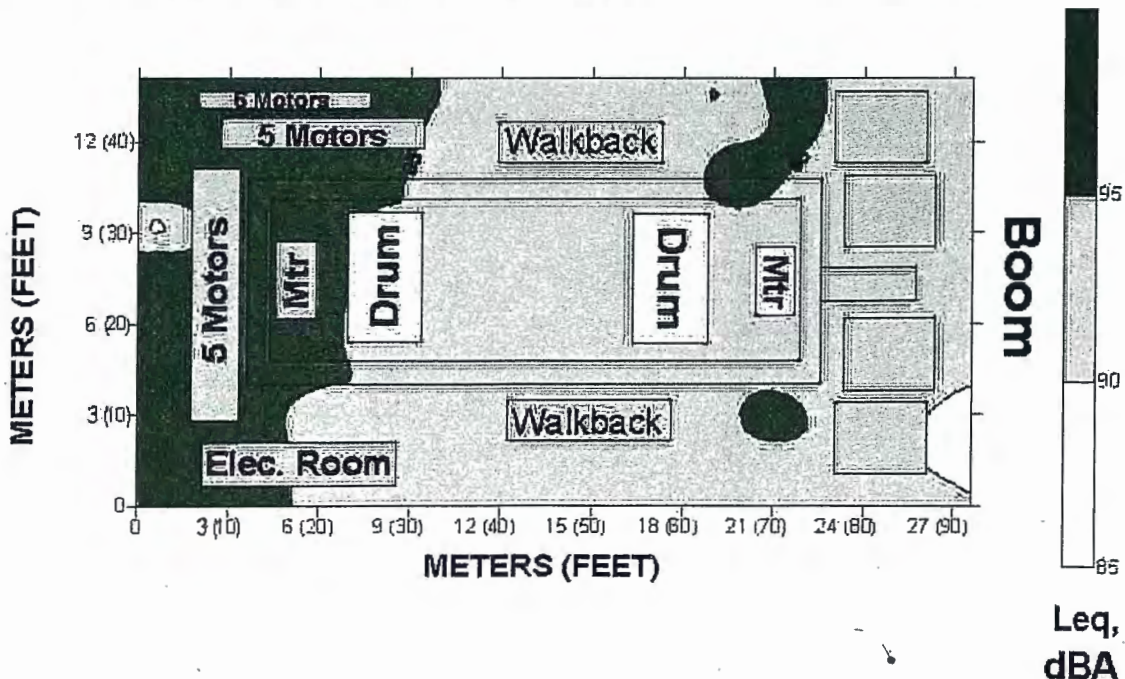


TABLE 2

Comparison of noise inside and outside cab of surface mining equipment.

Equipment	MSHA PEL Dose, %		
	Inside Cab ³	Outside Cab ⁴	Run time hr:min
Dozers			
Cat ¹ D10N	44.34	201.13	7:25
Cat D10N	46.08	121.15	6:50
Cat D10R	4.40	122.31	3:32
Cat D11N	11.74	297.70	7:45
Cat D11R	10.84	286.38	7:40
Cat D11R	24.75	374.57	7:48
Cat D11R	13.81	347.10	8:07
Komatsu D375A	53.18	238.34	8:27
Cat water truck	11.00	209.39	7:58
Rimpull coal hauler	7.53	69.83	8:28
Rimpull coal hauler	0.62	52.01	8:33
IR ² DM-M2 overburden drill	17.55	190.28	7:18
IR DM-M2 overburden drill	3.99	201.89	7:11
Volvo coal drill	11.83	103.02	7:40
Cat 16G motor grader	19.97	14.63	8:49
Cat 994 front-end loader	16.48	485.55	7:45
Euclid R85B ash truck	2.22	199.13	8:09
Euclid R90C ash truck	5.52	302.69	8:05
¹ Cat = Caterpillar			
² IR = Ingersoll Rand			
³ Personal exposure measurement			
⁴ Area measurement			

sure, task observations and cumulative dose plots, and contour plots of dragline noise profiles.

Worker dose. The results of the worker noise exposure measurements indicated that 28 percent of worker noise doses recorded were above the PEL of 100 percent, with 73 percent of those above the MSHA citable PEL of 132 percent. Workers in three occupations were found to experience noise exposures above the PEL, dragline oilers, dozer operators and welders using the air-arcing process to cut metals.

Dragline oilers spend much of their shift in the "house" of the dragline performing maintenance checks and cleaning. The range of doses recorded for dragline oilers was 46 percent to 318 percent. Attention certainly should be given to this occupation because workers in this job classification are periodically subjected to noise levels that have the potential to cause NIHL.

Task observations. Workers experiencing exposures above the PEL were task observed for one of the shifts they wore a dosimeter. The task observations included the start and stop times of the tasks the worker performed and their location with respect to the equipment

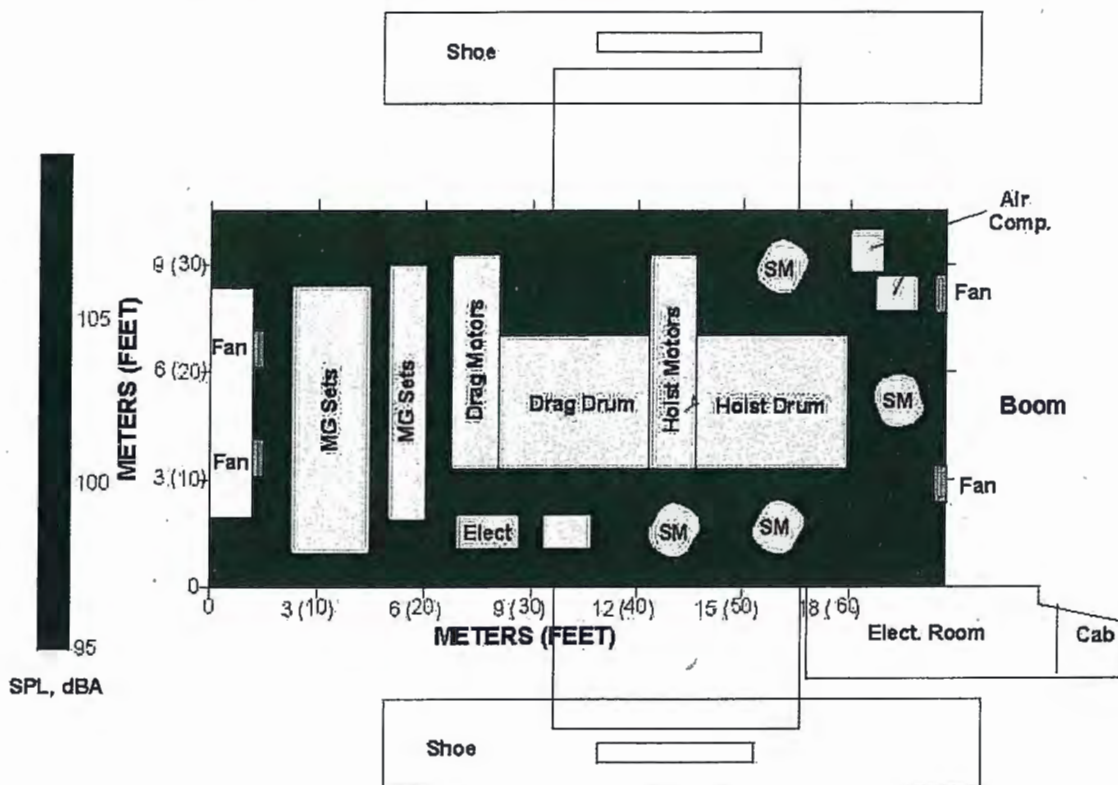
and/or noise sources. The goal was to identify the sound level and exposure time associated with each task, and the noise sources responsible, for the worker's measured dose and then provide mine operators with sufficient information to implement effective engineering and administrative noise controls. A cumulative dose plot for a dragline oiler, with task observations annotated, is illustrated in Fig. 3. Dose accumulations were greatest (indicated by the steep slope of the line) while sweeping and cleaning in the dragline house. Little dose was accumulated while at lunch and in the operators cab as illustrated by the flat slope.

Sound level and noise exposure measurements were recorded near an air-arcing operation. The noise exposure for a welder who air-arc'd for approximately one hour, took a 30-minute break and then did some plasma cutting for 30 minutes was 376 percent. The maximum equivalent sound level (Leq) (recorded at a 3-dB exchange rate) recorded during these three tasks was 126 dBA for air-arcing, 106 dBA for plasma cutting and 86 dBA during the break. A projected eight-hour dose based on a 90 dBA criterion level, 90 dBA threshold, and 5 dB exchange rate was 1,489 percent and a TWA₈ of 109.5 dB.

Equipment noise. Draglines: Eleven different draglines (15 total) were analyzed by conducting noise profiles in the house, cab and revolving frame. The draglines surveyed included Page 736, 752 and 757 models, Bucyrus Erie 1260W and 2570W models, Marion 195M, 7800, 8050 and 8200 models, as well as two Bucyrus Erie 1570W models and four Marion 8750 models. Noise data collected in the draglines were converted to noise contour plots to display area noise levels. Space limitations prevent presenting all the noise profiles. Therefore, examples of several different draglines are included. Table 1 summarizes the range of noise levels measured in the draglines and Fig. 4 is a noise contour plot for a Page 752 dragline. This figure illustrates that the highest noise levels are in the back near the motor/generator (MG) sets.

Figure 5 presents a contour plot for a Bucyrus Erie 1260W dragline. Again, the highest noise levels are near the MG sets (Fig. 6). Figure 7 is from a Marion 8050 dragline. As is the case for most of the draglines, the highest noise levels are near the motor/generator sets, although the rest of the house is still above 90 dBA.

Other surface equipment: Other types of surface equipment were monitored by placing a dosimeter on the operator and a dosimeter outside the cab. The purpose was to evaluate the effectiveness of the cabs to isolate the operator from outside noise sources that

FIGURE 5**Noise contour plot for a BE 1260W dragline.**

included operation of the equipment, engine and surrounding equipment. Table 2 compares dosimeter readings in and outside the cabs of various pieces of surface equipment. In all cases, the cabs are sufficiently isolating the operator from the major noise sources.

Engineering and administrative noise controls

The development of noise controls was not a goal of this research effort. However, an attempt will be made to suggest possible engineering and administrative controls based on observations made during the course of the research and analysis of the research results. Administrative controls are defined as "methods that reduce exposure by limiting the time a worker is exposed to noise," or *isolating the worker from the noise*.

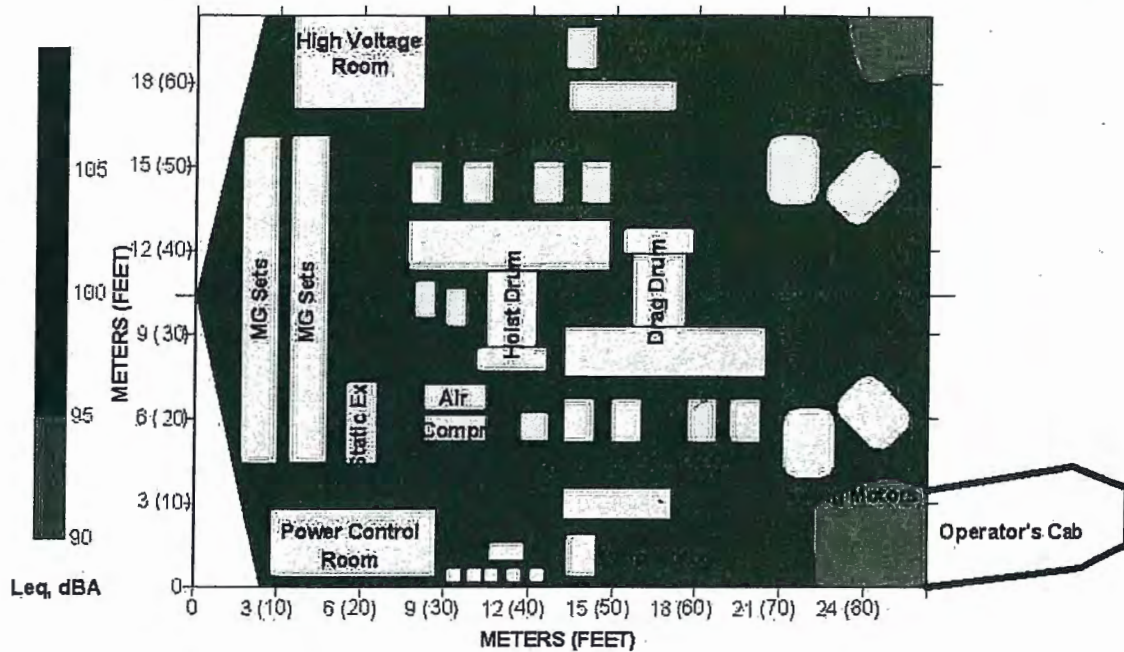
By evaluating the cumulative dose plots, task observations and noise contour plots, the tasks or areas that significantly impact a worker's dose can be identified and avoided or the exposures minimized. Examples of administrative controls include job rotation, restricting access to noisy areas, providing quiet areas and remote monitoring.

On the other hand, engineering controls are defined as "methods that reduce noise exposure by de-

creasing the amount of noise reaching a worker," or *isolating the noise from the worker*. The noise contour plots can indicate where the highest noise levels are generated, but not what specific component of the piece of equipment is responsible. This at least gives mine operators a starting point based on reliable and accurate information.

Examples of engineering controls include mainte-

FIGURE 6**Example of a M/G set in back of dragline house.**

FIGURE 7**Noise contour plot for a Marion 8050 dragline.**

nance, acoustic isolation or absorption, modification of machine mounting, or replacement of noisy equipment with quieter equipment (buy quiet).

Summary

The continuing problem of noise-induced hearing loss among mine workers is a situation that must be addressed by all mining concerns, including government, academia and the mining industry. This research effort indicates that most of the equipment operators at surface coal mines are protected from noise by the equipment cabs and experience noise exposures well below the PEL. Of those occupations surveyed, the workers found most likely to experience exposures above the PEL are the dragline oilers if they spend a considerable portion of their shift in the dragline house and welders who conduct air arcing. It should be noted that this statement holds true only at the operations studied and may not apply at all other operations.

The equipment generating the highest noise levels in the draglines are the motor/generator sets. The solutions to reducing worker noise exposure are many and difficult to resolve and will include a combination of engineering and administrative approaches. ■

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