Noise in the Mining Industry—An Overview

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NOISE IN THE MINING INDUSTRY–AN OVERVIEW

by

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ABSTRACT

This paper surveys noise levels, noise exposure patterns, and frequency spectra found in the mining environment; the effects of mining noise on the working population; and the quantification of hearing loss in the coal mining industry. Federal mining noise regulations and the present state of the industry, with respect to noise control technology, are discussed. Examples of proven noise controls for mining are included along with measured noise reductions.

INTRODUCTION

One by-product of almost every industry is the generation of noise. This noise is produced by various machines and many people are exposed to it. Numerous problems exist because of it. This situation applies to the mining industry. Various types of mining equipment generate noise levels for different lengths of time. This results in employee noise exposure. Many times this exposure is in excess of the Federal mining noise regulations. Technology exists to correct some of these problems. More work needs to be done in some areas. This paper briefly describes the present status of noise in mining, hearing losses in the mining industry, and the current noise control technology. Data is presented with regard to populations of mines, miners, machines, noise levels, etc., obtained from Branch reports and other references.

PRESENT STATUS OF NOISE IN MINING

During the calendar year 1976, there were 20,700 mines in operation within the continental United States. Of this total 5,700 were coal and 15,000 were noncoal (metal or nonmetal) mines. A total of 487,000 miners were employed in the industry; 212,000 in coal mining and 275,000 in noncoal

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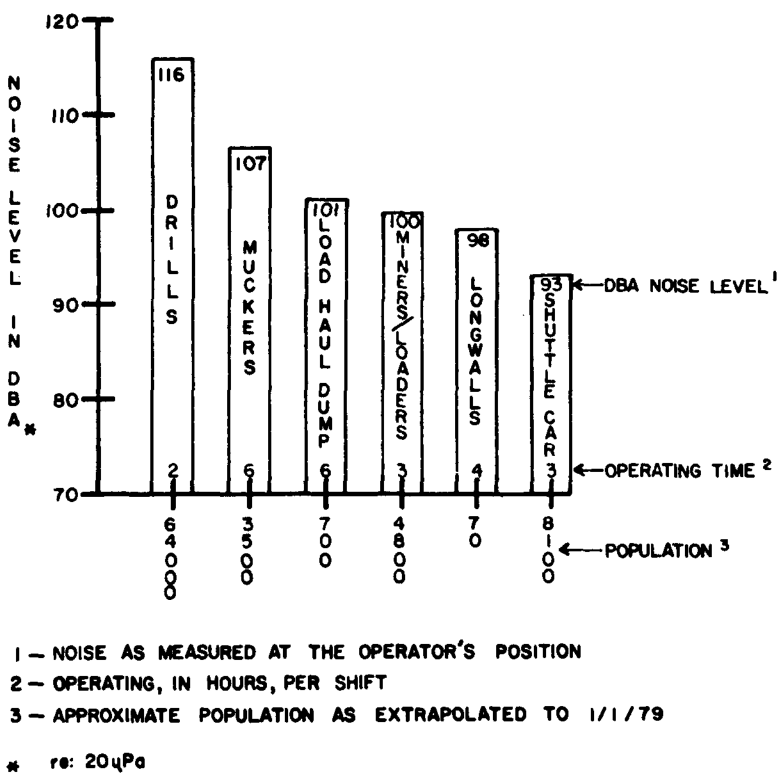

FIGURE 1. - Noise levels of underground mining machinery.

mining. In terms of the minerals mined, about 115,500 miners were engaged in sand, gravel, and crushed stone operations, 71,500 miners in iron or copper mines, 212,000 in coal, and 88,000 in other types of mines. In terms of quantity, 670 million tons of coal were mined in 1976. Given the energy crisis facing the United States, it has been projected that coal output will reach 1 billion tons by 1985.[3]

Mining, at its present level of development, is highly mechanized. Large amounts of mechanical energy are necessary in extracting, transporting, and processing minerals and ores. Unfortunately, a by-product of this energy expenditure is the generation of high levels of noise. Some examples of the noise levels that mining machines generate are given in figures 1 through 3. In these figures equipment has been divided into three categories: underground, surface, and treatment plant. The noise level for a given machine type is represented by a bar; the number at the top of each bar is the typical emitted noise level in dBA as measured at the operator's location, while the number at the bottom is the typical operating time. The number below the x axis is the approximate machine population.

Underground Mines

In underground mines, drills are a major source of noise (fig. 1). This is especially true of the pneumatic, percussive-type drill, which emits noise levels in excess of 115 dBA. Rotary drills are less offensive, generating noise levels in the range of 93 to 97 dBA. Unfortunately, the rotary drill can only be used on relatively soft rock. Rotary drills account for less than 10 percent of the total drill population. Muckers and load-haul-dump machines are used only in noncoal mines. They have noise levels, respectively, of 107 and 101 dBA. Their operation time per shift is about 6 hours.

[3]Estimates based on data from: U.S. Bureau of Mines. Mineral Facts and Problems. BuMines Bull. 667, 1975.

Continous miners and loaders, which are used in 60 percent of all underground coal mines, typically generate noise levels of 100 dBA, and have typical operating times of three hours per work shift. Longwall mining systems typically generate noise levels of 98 dBA with operating times of approximately four hours per shift. Presently, only about 70 longwall mines are operational in the United States. However, because they have the capability for high production rates, it is expected that in the future a proliferation of this type of coal mining system will occur.

The last machine type shown, shuttle cars, are representative of the quieter varieties of equipment found in underground mines. Equipment such as cutting machines, mantrip vehicles, and coal drills emit noise levels and have operating times which usually do not result in worker overexposure.

Surface Mines

Surface mining equipment used in coal strip mines or pit and quarry operations is very similar to equipment used in the earth moving or construction industry. Typical examples, as shown in figure 2, would be dozers, draglines, front-end loaders, scrapers, graders, and trucks. Noise levels range from 93 to 106 dBA for this type of equipment, with operating times of 8 hours or more. Approximately 3,000 drills are also used in surface mining. Although many of these are pneumatic, percussive drills, the noise levels, as measured at the operator's position, are lower compared to the underground drills. This reduction is due to the increased distance between the operator and drill, and to the effects of partial barriers and cabs.

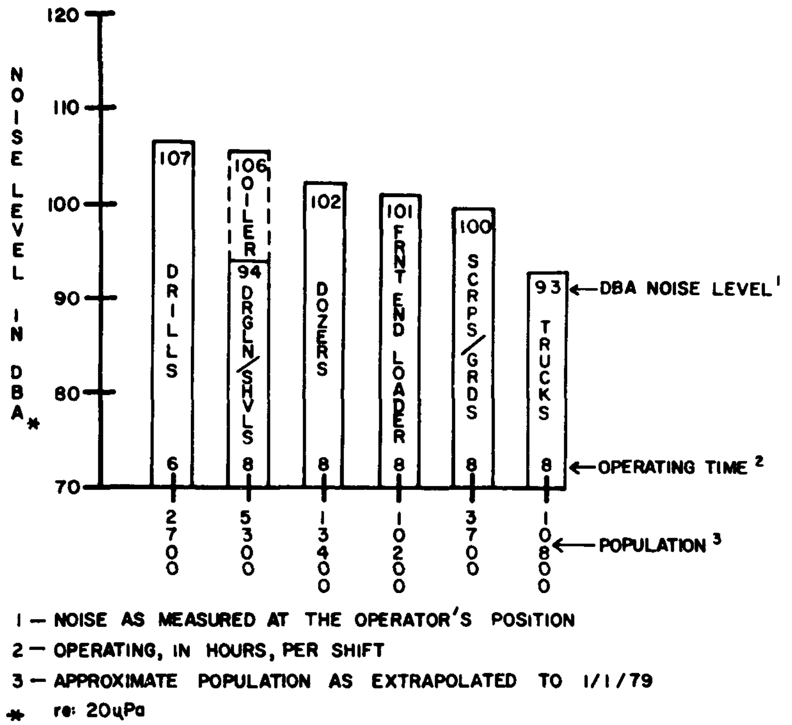

FIGURE 2. - Noise levels of surface mining machinery.

Treatment Plants

Coal or mineral treatment plants are designed to crush, clean, process, and size coal or minerals prior to shipment to the consumer. Treatment plants for coal are mainly of one type, referred to as coal preparation plants. Approximately 500 of these plants exist in the coal mining industry. Depending upon the mineral to be processed, various types of treatment plants are found throughout the noncoal mining industry. Some examples would be cement plants, taconite plants, crushed stone plants, and clay mills. In all,

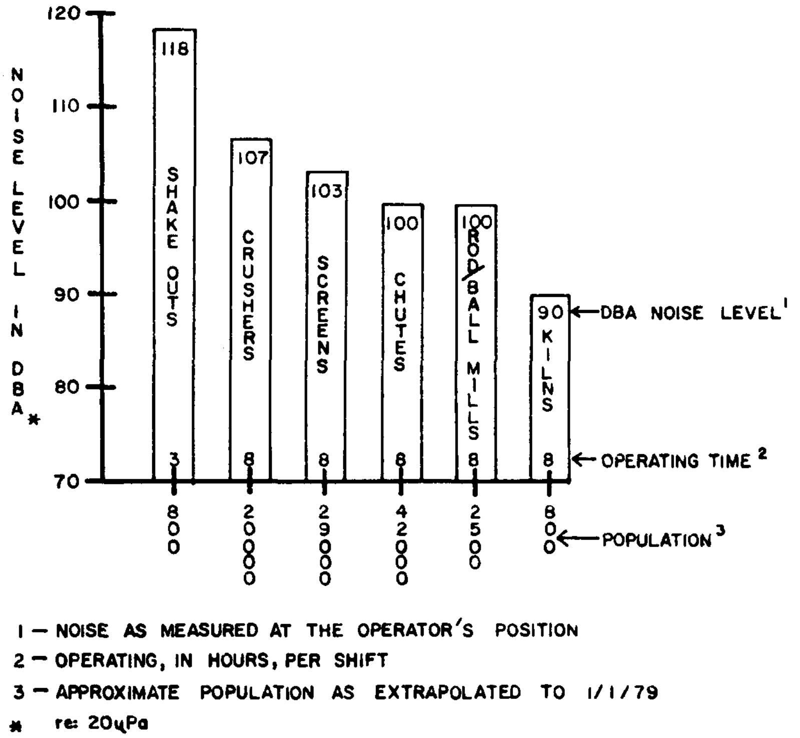

FIGURE 3. - Noise levels of treatment plants.

there are about 2,400 noncoal mineral treatment plants in the United States today.

Many coal and noncoal treatment plants are similar in construction--usually multilevel, with little isolation between levels. Steel gratings are used as floors and the entire assembly is housed in a corrugated tin structure. Much of the equipment used in the plants is similar, the major exception being that noncoal treatment plants use rod or ball mills and kilns. Typical noise levels and operating times, along with the approximate machine population, are shown in figure 3.

One major source of noise associated with treatment plants is the railroad car shakeout. This device, located outside the plant, is attached to a coal- or ore-loaded railroad car. When energized, it violently vibrates the entire vehicle, causing the discharge of the contents through the hopper doors on the underside of the car. Noise levels for this device, as measured at the operator's position, average about 118 to 122 dBA, with an operating time of approximately three hours. The major sources of noise inside the plant are crushers, used to reduce the size of large blocks of mineral or coal (100 to 107 dBA); vibrating screens used for sizing the mineral or coal (100 to 105 dBA); and slide chutes used for transporting the mineral or coal through the plant (95 to 100 dBA).

Frequency Spectra

Thus far, we have examined the noise levels emitted by various mining machines. Next, we would like to look at the frequency spectrum of the emitted noise. Figure 4 shows the frequency distribution of the noise for three general categories of mining equipment. Each spectrum was derived by averaging the spectra obtained from measurements made on many different machine types and brands in the same general category.

Surface equipment, which is usually powered by diesel engines, generates noise having a predominance of low frequencies. These low frequency components are mainly due to the reciprocating internal combustion nature of the diesel engine and are a function of engine type and operating RPM. The

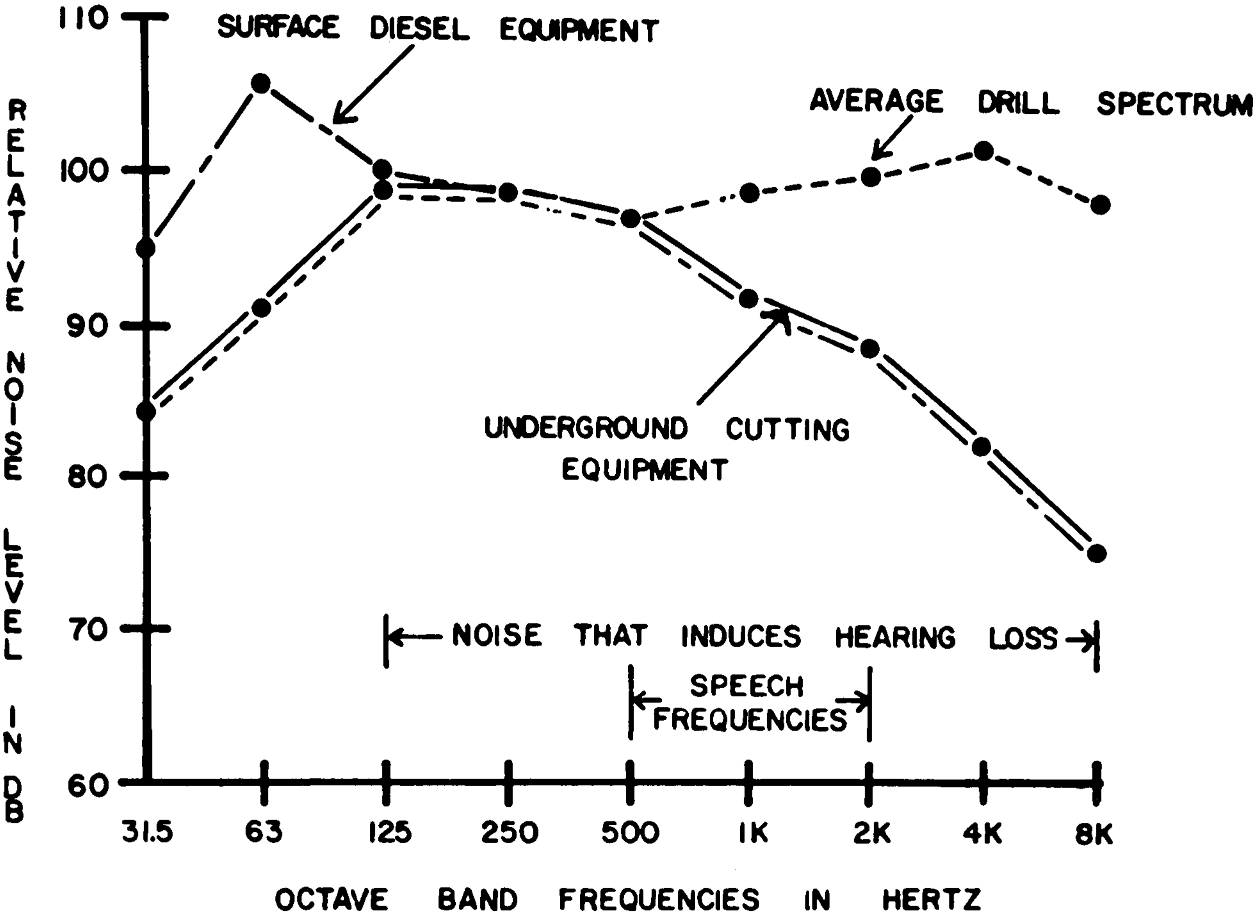

FIGURE 4. - Frequency distribution of mining noise.

average spectrum for surface diesel equipment given in figure 4 shows a maximum of noise energy in the 63 to 125 Hz octave bands with a rather rapid decrease in energy beyond the 500 Hz octave band.

The spectrum for underground cutting equipment shows that the noise is broadband, having most energy in the 125 to 500 Hz octave bands. Drill noise, although having a spectrum similar to most other underground equipment in the low and mid frequency ranges, has more noise energy in the high frequency end of the spectrum (1,000 to 8,000 Hz). These high frequency components are due to noise radiated by the drill steel as it impacts the coal or other mineral surface.

It is interesting to note that the frequency components of noise that are responsible for noise-induced hearing loss lie in the 125 to 8,000 Hz octave bands, while the frequency components most disruptive to verbal communication lie within 500 to 2,000 Hz octave bands. Most mining equipment generates noise with a significant amount of acoustic energy within these octave bands. It is logical to assume then that a hazard potential for hearing loss and communication interference does exist within the mining industry.

Noise Regulations and Compliance

Federal regulations dealing with noise levels in the mining industry began with the Federal Coal Mine Safety and Health Act of 1969. This act established that the standards for local mining noise should be those prescribed by the Walsh-Healy Public Contracts Act. The Walsh-Healy criteria for noise are shown in table 1. Subsequently, standards on noise in metal and nonmetal mining were established under the Federal Metal and Nonmetallic Mine Safety Act.

TABLE 1. - Walsh-Healy criteria

Maximum noise level, dBA	Maximum exposure time, hours
90	8.00
95	4.00
100	2.00
105	1.00
110	.50
115	.25

The Federal Mine Safety and Health Act of 1977 amended the Federal Coal Mine Health and Safety Act of 1969 to include all mines, coal and metal and nonmetal, and repealed the Federal Metal and Nonmetallic Mine Safety Act. Current regulations concerning noise in mining can be found in Title 30, Code of Federal Regulations, Chapter I. Regulations pertaining to metal and nonmetal mining noise are in Subchapter N, Part 55, Section 55.5 (open pit mines); Part 56, Section 56.5 (sand, gravel and crushed stone operations); and Part 57, Section 57.5 (underground mines). Regulations pertaining to coal mining noise are in Subchapter O, Part 70, Subpart F (underground mines) and Part 71, Subpart D (surface mines).

The high noise levels radiated by many mining machines, coupled with their normal operating times, provide a significant potential for exceeding the noise standards. A Mine Safety and Health Administration (MSHA) study[4] conducted in 12 representative underground coal mines, in which 778 face workers were surveyed for noise, showed that approximately 20 percent of the miners were overexposed to noise according to the present noise standards. Similar studies have not yet been conducted for other areas of the mineral industries. When they are, there is little reason to believe that a better record of compliance will be found.

HEARING LOSS IN THE MINING INDUSTRY

In 1976 a study was conducted by the National Institute for Occupational Safety and Health (NIOSH) to assess the hazardous effects of occupational

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[4]Bobick, Thomas G., and Dennis A. Giardino. Noise Environment of the Underground Coal Mine. IR 1034, Mining Enforcement and Safety Administration (Department of Interior), 1976, 26 pp.

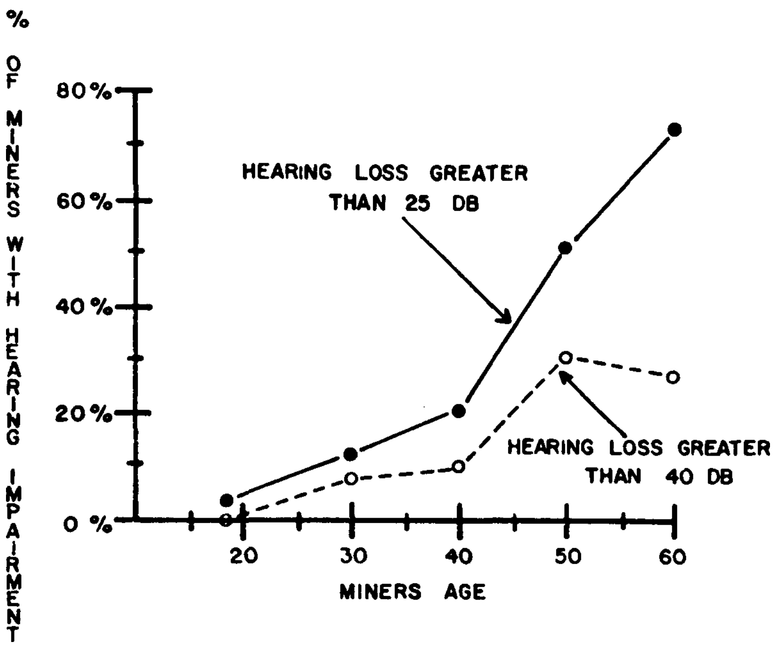

FIGURE 5. - Percentage of miners with hearing loss.

noise exposure on the hearing of coal miners.[5] Using a mobile test van, NIOSH personnel administered audiometric and otoscopic examinations to a selected group of miners prior to the start of their work shift. Exclusion criteria were used to eliminate the data on those miners who had a history of military or recreational firearms use or any significant nonoccupational noise exposure, severe head trauma, chronic ear infections or other relevant diseases. Miners who had not been out of the working environment for 14 hours or more or who had significant noise exposure prior to taking the audiometric examination were also excluded.

Miners were chosen using a stratified random sampling procedure. The total number of miners tested was 1,499. Of this total, 1,349 were working and 150 were nonworking or retired miners.

Figure 5 summarizes the results of the study, showing the distribution of hearing impairment for the mining population as a function of age. As defined by NIOSH criteria, the solid curve represents a hearing loss greater than 25 dB while the dashed curve corresponds to a hearing loss in excess of 40 dB for the frequencies of 1,000, 2,000, and 3,000 Hz using the average of the results for both ears.

As can be seen, a significant incidence of hearing impairment exists in the mining population. By the age of 50 approximately half the miners have a hearing loss in excess of 25 dB, while about 30 percent have a hearing loss exceeding 40 dB. Three of the most important conclusions NIOSH drew from the study are as follows:

1. Coal miners have measurably worse hearing than the national average. The characteristics of the hearing test results are suggestive of noise-induced hearing loss.

2. Preliminary evidence suggests that the incidence of otoscopically observable ear abnormalities is unusually high among coal miners.

3. The problem of occupational hearing loss among coal miners is unquestionably serious enough to warrant attention and preventive action.

[5] Survey of Hearing Loss in the Coal Mining Industry. HEW publication (NIOSH) 76-172, National Institute for Occupational Safety and Health, 1976

NOISE CONTROL TECHNOLOGY FOR THE MINING INDUSTRY

Considering only the major categories of equipment discussed in this presentation, there are approximately 222,000 different pieces of mining equipment in use today which have a potential for exceeding the present noise standard. Of this total approximately 81,000 are underground, 46,000 are surface, and 95,000 are treatment plant equipment. This is by no means the total quantity of equipment in the industry, but only of those types that have attracted the most attention as noise sources at this time.

Underground Equipment

The availability, use, and effectiveness of noise control technology for underground mining equipment is marginal. Several factors are responsible for this dearth of viable technology. A relatively large selection of models and brands of machines are currently in use in underground mines. Many of these machines are custom made, tailored to suit a particular type of coal or type of mine. This often results in machines of similar brand and model being substantially different in mechanical configuration or performance. Thus, it is difficult to develop a standard retrofit noise control package for a given machine type. In many instances, a machine-by-machine approach is necessary for noise control.

Restrictions concerning flammability and toxicity significantly limit the availability of noise control materials for underground use. In addition, the remoteness and harshness of the underground environment places a severe limitation on the durability of usable noise control technology.

During the past 3 to 4 years, there has been some effective noise control technology developed for underground equipment. Bureau of Mines research contracts have resulted in a noise control package developed for the load-haul-dump machine. This package, when properly installed, can reduce the noise level at the operator's position from 101 to 94 dBA, thus achieving compliance with the noise regulations for the entire work shift.

MSHA'S Physical Agents Division, in conjunction with the manufacturer, has developed noise controls for the Wilcox auger-type continuous miner.[6] These controls resulted in a noise reduction from 102 to 97 dBA at the operator's position and from 104 to 102 dBA at the right jacksetter's position. Further work conducted on the auger cutting head shows that these levels can be reduced by an additional 2 to 3 dBA. Presently a noise control package is commercially available for the Wilcox miner. The package is sufficiently versatile that it can be adapted to the various machine designs which are used. The Bureau of Mines has been involved with the development of retrofit noise controls for the Jeffrey 100L[7] continuous auger miner. Reductions of 3 to 5 dBA at the operator's position have been achieved.

[6]Giardino, Dennis A., Leonard C. Marraccini, and Thomas G. Bobick. Noise Control of an Underground Continuous Miner, Auger Type. IR 1056, Mining Enforcement and Safety Administration, 1977, 57 pp.

[7]Reference to specific brands, equipment, or trade names in this report is made to facilitate understanding and does not constitute endorsement by the Mine Safety and Health Administration.

For some pneumatic drills, exhaust mufflers are commercially available at reasonable cost. In addition, a Bureau of Mines developed jacket muffler is also available. This muffler was originally designed for use on the stoper drill, a small hand-held drill used in underground coal mines, but has been used on some larger, machine-mounted pneumatic drillls. Unfortunately these devices only reduce drill noise to a level of about 108 to 110 dBA.

Recently the Physical Agents Division has been involved in reducing worker noise exposure from longwall mining systems. To date the Division has explored the use of administrative controls for these devices, that is, moving workers from task to task so they are exposed to high noise levels for only part of each shift. The possibility of remote control for these systems is also being investigated.[8]

Surface Equipment

The status of noise control technology for mobile surface equipment is more advanced than that for underground equipment. For many dozers and front-end loaders used in the industry, retrofit noise reducing cabs or cab kits are commercially available. The noise reduction provided by these units is usually sufficient for compliance. For those machines for which noise-reducing cabs or kits are not available, the Division has developed a method for the accoustical treatment of an existing cab.[9] When a machine does not have a cab, a different method using a partial frontal barrier is employed. By using acoustic materials that have good absorption and transmission loss properties and a special stud welding technique for installation, considerable success has been achieved with haulage trucks, bulldozers, and front-end loaders. Table 2 illustrates some of the results obtained.

TABLE 2. - Examples of noise reductions obtained for mobile surface equipment

Equipment	dBA before treatment	dBA after treatment	Compliance
Euclid 30-ton truck........................	95	85	Yes
International Payhauler 50-ton truck.......	96	89	Yes
Cat 773 50-ton truck.......................	96	89	Yes
Cat D-7 bulldozer..........................	99	89	Yes
Cat D-9 bulldozer[1].......................	103	93	No
Cat 988 front-end loader...................	99	89	Yes

[1]Only a frontal barrier was used on this machine.

[8]Antel, Jerry W. Noise in Longwall Mining. Unpublished manuscript. Available at or from MSHA, Physical Agents Division, Pittsburgh, Pa.

[9]Marraccini, Leonard C. Retrofit Noise control Application for Mobile Surface Equipment. Green Jacket Technical Assessment No. 4. Mine Safety and Health Administration, 1980, 10 pp.

Treatment Plant Equipment

Noise control problems in treatment plants are complex. Several years ago, the Bureau of Mines completed a research contract at the request of MSHA's predecessor agency, concerning noise control in preparation plants. Work was done at a preparation plant in Ohio. Various noise controls such as acoustically treated operator booths, treated chutes, treated sizing screens, and partial barrier curtains were used. Portions of these techniques have been used in other treatment plants throughout the United States. Typical results are shown in table 3.

TABLE 3. - Noise reductions obtained for treatment plant equipment

Equipment	dBA before treatment	dBA after treatment
Car shakeout...............	118	90
Crushers...................	107	90
Screens....................	103	95
Chutes.....................	100	92

Hearing Protection

When other means of noise controls are not available, MSHA permits the use of hearing protectors. Present policy specifies their use only as an interim measure until more effective engineering noise control technology is developed. Hearing protectors are not a positive means of noise control. Their use does not clean up the mine environment, but merely isolates the miner from it. They also isolate the miner from hearing lifesaving warning signals such as emergency and back-up alarms. In some cases, hearing protectors could also impair miner's ability to hear sounds emanating from the roof ("roof talk") that could give warning of dangerous roof conditions.

The validity of the manufacturer's rating of ear protector effectiveness, when the protectors are used under field conditions, has been questioned. Our tests, conducted on both a dummy and live subjects, indicate that the in-mine effectiveness of ear protectors is less than that advertised by manufacturers by as much as 10 to 15 dBA.[10]

Studies conducted by NIOSH,[11] by Regan, Kent State University,[12] and by other research groups have produced similar conclusions on ear protector effectiveness. It will probably be some time before the results of these studies have any effect in the marketplace. In the meantime, however, miners who must depend on hearing protectors should be aware of the limitations and dangers inherent in the devices.

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[10] Marraccini, Leonard C., and George Durkt. In-Mine Effectiveness of Ear Muffs. 1979, unpublished report. Available at or from MSHA, Physical Agents Division.

[11] Method of NIOSH Attenuation of Insert-Type A Real Ear Field Hearing Protection. HEW publication (NIOSH) 76-191, National Institute for Occupational Safety and Health, 1976.

[12] Regan, D. Real Ear Attenuation of Personal Ear Protective Devices Worn in Industry. University Microfilms International, 1975, 155 pp.

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