BUREAU OF MINES OCCUPATIONAL NOISE CONTROL PROGRAM

By J. Harrison Daniel[1]

Excessive noise levels represent the most widespread occupational health problem in the mining and ore processing industries. Virtually every worker in underground and surface mines and in crushing and grinding ore processing mills is exposed to levels of noise that can cause permanent reduction in the ability to hear. Because of continuing developments in mining methods and new equipment designs, as well as expanding production goals, the noise levels in both underground and surface mines are becoming an increasing threat to the health and safety of the Nation's miners. With more than 500,000 persons now working in underground and surface mines and in preparation plants and mills, the seriousness of noise hazards cannot be overestimated.

The goal of the Bureau's noise control program is to reduce noise exposure of all miners and ore processing personnel to within the limits prescribed in the Federal Mine Safety and Health Amendments Act of 1977 without affecting increased production demands.

The 1977 act limits noise exposure to a 90-dBA level (dBA is a relative measure of sound pressure, weighted to match the frequency response of the human ear) for an 8-h duration. As noise levels increase, permissible exposure durations decrease. For example, the ceiling limit of 115 dBA requires that exposure be limited to 15 min or less. Noise exposure levels over 115 dBA are not permissible.

Extensive surveys have shown that the noise in underground and surface mines often exceeds the permissible exposures. In coal mining, most major equipment, including continuous miners, loaders, stoper drills, and cleaning plant apparatus, has been identified as contributing to excessive noise exposure. Figure 1 shows typical noise levels and operating times per shift of underground coal mining machines.

In metal and nonmetal mining, major equipment contributing to excessive noise levels includes bulldozers, rock drills, channel burners used in quarrying, load-haul-dump vehicles, and ore processing equipment. Although personal hearing protectors such as ear muffs or earplugs are widely used, these are only interim or short-term solutions to noise overexposure problems. Long-term solutions require that the noise be reduced at its source.

The following are the objectives of Bureau programs to develop noise abatement technology:

To determine major noise sources in underground and surface mines and mineral processing plants.

To develop and evaluate both factory-installed noise controls for equipment and processing operations and noise-control field modifications to existing equipment.

To provide more accurate noise exposure measuring techniques and instrumentation.

To establish a procedure to evaluate the actual noise attenuation of personal hearing protectors worn by miners.

To develop concepts and design techniques that will provide inherently quieter mining equipment and operations for the future.

To make available to industry the technical knowledge needed to select, design, and use the most effective noise-control measures.

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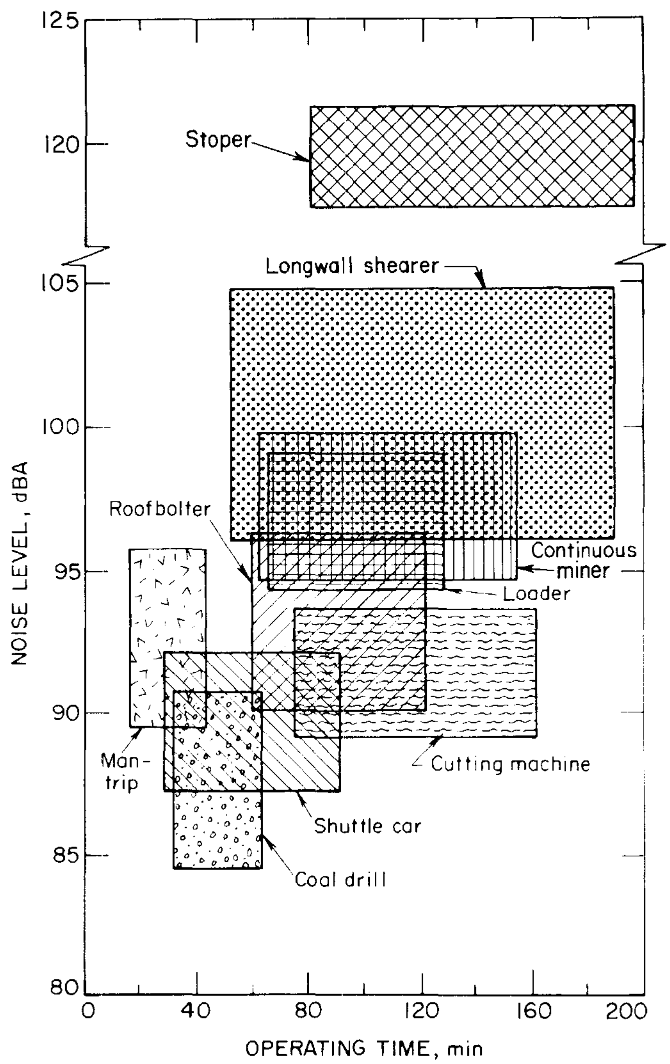

FIGURE 1. - Typical noise levels and operating times per 8-h shift of underground coal mining machines.

The Bureau's main research efforts have focused on reduction of mining noise at the source by identifying specific noise sources and developing abatement technology and methods. Because mining machinery is expensive and much equipment now in use is not due to be replaced for many years, a large part of the research program has involved development of "retrofit" noise abatement techniques and materials that can be used to modify existing machinery. However, long-term work increasingly will be concerned with factory integration of control measures and the design of quieter machines. Increased emphasis will also be given to the development of new mining methods that will offer advantages in noise control over the established methods in use today.

Where possible, the Bureau seeks the advice and cooperation of both equipment manufacturers and operators experienced in using the equipment. Such cooperation is especially important in view of the high cost and limited availability of mining machinery. Cost sharing agreements with industry and the cooperation of mine operators are essential to the program. Over the past 5 yr at least 25 projects required the cooperation of over 100 mines for noise surveys, data collection, and operational testing of Bureau developed or modified equipment.

Technology and techniques that are developed are applied to test machines provided by mine operators or machinery manufacturers and evaluated under production conditions. Noise controls developed must be cost effective, must be readily adaptable to existing machines and operations, and must not reduce machinery efficiency or lower production levels.

The Bureau has been actively conducting noise abatement research and development programs both in-house and through Bureau funded contract studies since the passage of the Federal Coal Mine Health and Safety Act of 1969. This act was later amended by the 1977 act. Both acts cite the allowable noise exposure levels given in table 1 in the introduction to these proceedings. The research began in 1970 with an initial contract study of hearing protection in underground mines and an in-house project to develop a muffler jacket for a percussion drill. Through the mid-1970's and late 1970's, the research program grew substantially and consisted almost entirely of contract research until 1981 when the percentage of in-house work began to increase significantly. This increase in the in-house program was accompanied with overall Federal budget reductions.

The majority of the research done in the 1970's consisted of noise surveys and analyses to determine what were the major noise problems in both underground and surface mining, what the principal noise sources were for specific equipment and systems, and what remedial measures could be taken to alleviate the noise problem. In the late 1970's the emphasis was on retrofit noise controls of existing equipment. These retrofit modifications were designed to be installed on equipment either at a minesite or at an equipment rebuild or overhaul facility. These early efforts resulted in two important accomplishments. First, they provided significant short-term and cost-effective noise control measures. Second, they established an equipment noise level data base on which to plan long-term design research to incorporate noise control technology into the design and manufacture of mining equipment.

Thus, by 1981 the nature of the Bureau's noise control research had changed in a fundamental way. The emphasis now and in the coming years is on long-term basic research to develop and assure adequate noise control technology for future mining machinery concepts. Closely related to this goal is the development of noise controls that can be incorporated into equipment when it is sent to rebuild shops for scheduled maintenance. This is very cost effective and the Bureau has had recent success in working with the private sector in this area.

Simultaneous with this change to long-term research is an increase in the amount of work performed in-house. Since the late 1970's the Bureau has steadily built in-house expertise and facilities to the point that research that was previously performed on contract can now be accomplished in-house. During 1984, a noise test facility was constructed at the Bureau's Pittsburgh (PA) Research Center, which will allow the Bureau's technical staff to conduct equipment noise control research.

In summary, from 1970 to the 1980's, the noise control research program has changed from a contract program with goals of establishing the major noise problems and determining what could be done in the short term to provide immediate relief, to a principally in-house program to perform long-term research that will provide permanent solutions. The in-house test facility constructed during 1984 will enable the Bureau to cost effectively evaluate engineering noise controls, to redesign equipment components, and to provide a technically sound basis for the Bureau-funded contract program to complement the in-house efforts.

The success of any health-related research program is difficult to measure. Significant trends take many years to evaluate, and there are many parameters that affect the results. It is also difficult to select a realistic measure with which to determine the results. Figure 2 illustrates one method of measuring the success of the Bureau's noise research in metal and nonmetal mines and mills. The figure is a summary plot of 88,498 Mine Safety and Health Administration (MSHA) noise dosimeter readings that were taken in metal and nonmetal mines and mills since 1974. The plot of the percentage of dosimeter readings that represent noise levels greater than Federal regulations allow, shows a gradual decrease from 1975 through 1982.

The noise dosimeter measures the cumulative noise exposure of workers over a working shift and thus records a noise dose reading. A meter reading of 1.00, or 100 pct, represents a dose equal to the maximum allowable noise exposure under current regulations and is referred to here as a threshold limit value (TLV). A reading of over 100 pct means the worker was overexposed, and a reading of less than 100 pct means the worker was exposed to less than the allowable maximum.

The left-hand axis of the plot in figure 2 shows the percent of samples that exceed the TLV in each year. The right-hand axis of the plot shows the geometric mean concentration in percent for each year. The two lines shown are simple linear regression lines depicting the general trend in exposure for all years. A log-probability plot of the dosimeter

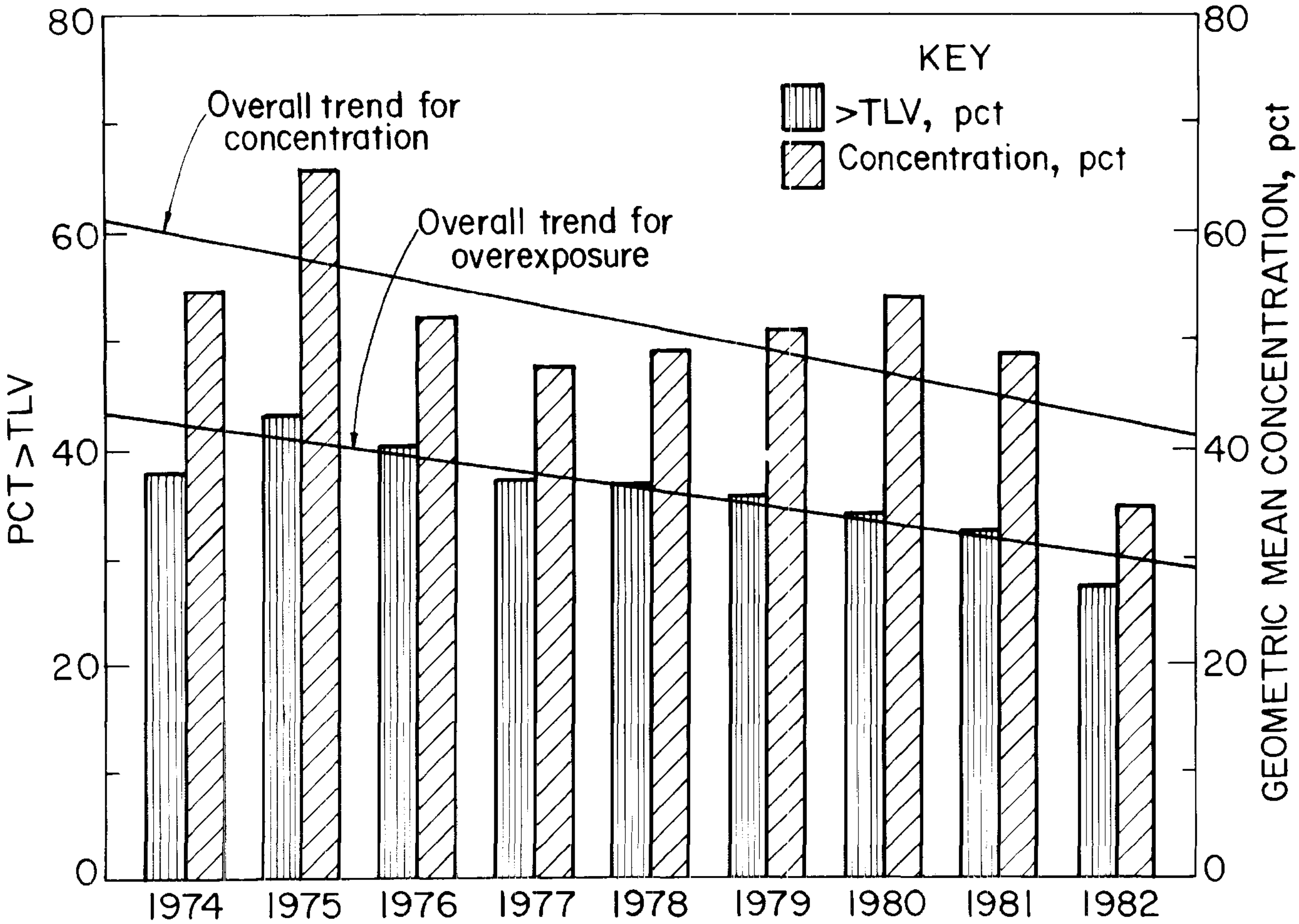

FIGURE 2. - Summary plot of MSHA noise dosimeter readings in metal and nonmetal mines and mills since 1974.

data reveals that the concentrations recorded in percent follow a log-normal distribution, that is the plot looks like a straight line, thus the geometric mean and standard deviation are appropriate measures of central tendency and dispersion.

The research objectives of determining the major noise sources in the mining industry, developing and evaluating retrofit noise control treatments for mining equipment, and providing more accurate noise exposure measuring instrumentation, have largely been accomplished. Current program emphasis is on designing and developing concepts that will result in inherently quieter equipment and mining operations and on evaluating the actual noise attenuation provided by personal hearing protectors. The current program focus is on the following four major research areas:

Coal Extraction.--This area of research will develop noise control technology for coal extraction equipment and will transfer this technology to equipment manufacturers for incorporation into newly manufactured equipment. Long-term projects on both continuous miners and longwall systems were initiated several years ago and have reached milestones for scheduled completion by 1987. These projects are of particular significance since together these mining techniques account for approximately 70 pct of the U.S. coal production. Emphasis is on a systems approach, so that noise reduction of the major noise sources of each machine is being accomplished. For the continuous miner, noise from the chain conveyor has been successfully reduced and current work is concentrating on designing quieter cutting heads. In 1984, in-mine testing of a continuous miner that has a noise-controlled chain conveyor and cutting head will be conducted. In the longwall system, coal cutting was identified as the major source of noise. New cutting drum designs are being developed and in-mine testing of a prototype should commence in 1985.

Percussion Drills.--Percussion drills expose their operators to some of the highest levels of noise in the mining industry, often to intolerable levels of 120 dBA. Because there are over 60,000 percussion drills in use in U.S. underground mines, the significance of this problem is clear. The Bureau's work on percussion drills is composed of three efforts: (1) jumbo mounted drills used principally for drilling blastholes in hard-rock mines and tunnels, (2) handheld hard-rock drills, and (3) drill steel design concepts for attenuating noise generated and radiated by the drill steel. In 1984, these efforts will be in various stages of development from prototype fabrication of the jumbo drill to final design formulation of a concentrically enclosed drill steel.

Mobile Equipment.--Noise control techniques have been developed for many of the mobile equipment types used in mining operations. To date, successful controls have been applied to personnel carriers, auger-type continuous miners, chain-type conveyor systems, and diesel-engine-powered vehicles including utility vehicles, dozers, front-end loaders, and load-haul-dump machines. These programs will continue with less emphasis and with the principal research being conducted at the Bureau's noise test facility. Emphasis in 1984 and the future will be directed to redesign efforts pertaining to specific equipment types.

Hearing Protectors.--Although the use of hearing protectors is permitted by MSHA only when other means of noise control are not available, these devices represent an important protective measure because of the high noise levels of some mining equipment such as percussion drills. The Bureau is establishing a capability to investigate methods of evaluating hearing protector performance that can be used in the field. Conventionally, the effectiveness of ear muffs is determined by a psychophysical laboratory technique that measures the hearing threshold for a person wearing the ear muffs. However, there is some question as to whether this measurement is equivalent to a physical measurement of the noise attenuation provided by the same ear muffs.

The final result of the protector program is to develop a method for evaluating ear protector effectiveness that is simpler, less costly, and less time consuming to perform than the conventional audiometric approach. The results will not only provide workers with the actual protection they can expect from wearing hearing protectors, but also will allow for realistic noise reduction goals to be established for the equipment and operations that exhibit noise levels in excess of 115 dBA.

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