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# Application of Prevention through Design for Hearing Loss in the Mining Industry

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**Abstract**

*Introduction:* Overexposure to noise remains a widespread and serious health hazard in the U.S. service providing and goods producing industries. Excessive noise can lead to poor verbal communication and reduce the ability to recognize warning signals. These dangerous work conditions can also cause stress and fatigue. Occupational hearing loss is a permanent illness, with no recovery currently possible. *Method:* National Institute for Occupational Safety and Health (NIOSH) has recognized Noise Induced Hearing Loss (NIHL) as one of the ten leading work-related diseases and injuries in the United States, and has emphasized its importance as one of the critical areas expressed in the National Occupational Research Agenda. *Results:* One of the most serious noise problems in the goods producing industries is the operation of continuous mining machines during underground coal mining. In order to minimize occupational hearing loss, noise hazards are "designed out" early in the design process. NIOSH is leading a national initiative called Prevention through Design (PTD) to promote this concept. This paper describes the quiet-by-design approach of a noise control that reduced noise exposures of continuous mining machine operators by 3dB(A) using the four functional areas of PTD, namely Practice, Policy, Research, and Education.
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*Keywords:* Noise Exposure; Hearing Loss; Occupational; PTD; Noise Control; Noise; Mining; Mine Heatlh

## 1. Problem

Prior to 2004, the Bureau of Labor Statistics (BLS) classified hearing loss in the "all other illnesses" category. In 2004, hearing loss was categorized as a separate illness that accounted for 11% of work related illnesses. In 2005, hearing loss cases stayed relatively unchanged at 11% from the previous year (U.S. Department of Labor, 2006a). Occupational data for coal, metal, and nonmetal mining were provided by the Department of Labor, Mine Safety and Health Administration (MSHA). MSHA has not adopted the revised OSHA recordkeeping requirements for 2005, therefore data for coal, metal, and nonmetal mining are not comparable with the data for other industries. The MSHA coal data from 2000 to 2005 showed operators that exceeded 100% noise dosage were from seven different types of machines: auger miners, bulldozers, continuous mining machines, front end loaders, roof bolters, shuttle cars (electric), and trucks (U.S. Department of Labor, Mine Safety and Health Administration, 2000–2005). Also, continuous mining machines were the number one machine among all the equipment whose operators exceed 100% dosage. There are approximately 600 mines with over 4,000 continuous mining machine operators (U.S. Department of Labor, Mine Safety and Health Administration, 2005; U.S. Department of Labor Bureau of Labor Statistics, 2006b). Fig. 1 shows the percentage of continuous mining machine operators that exceed 100% noise dose from 2000 to 2005 according to the MSHA database (U.S. Department of Labor, Mine Safety and Health Administration, 2000–2005).

Continuous mining machines are large underground machines that cut and gather coal at the working faces. The coal is transported via an onboard conveyor to the back of the machine where it is loaded onto either another conveyor or a piece of mining equipment designed to carry the coal away from the working face. One of the major noise sources on a continuous mining machine is this onboard conveyor, which consists of a chain with flight bars that drag the coal along the base of the conveyor system (Kovalchik, Johnson, Burdisso, Duda, & Durr,

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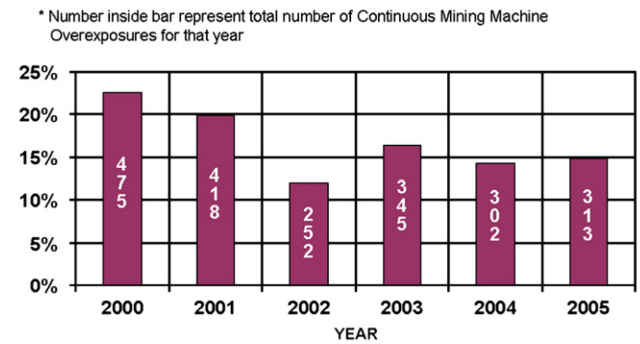


Fig. 1. CMM Operators that Exceed 100% Dose.

2002). The metal chain and flight bars in contact with the metal base and the coal itself are a significant noise source and contribute considerably to the noise exposure of workers at the face. Continuous miner operators stand near the chain conveyor, towards the back of the machine, and receive a significant portion of their noise dosage while the conveyor is running.

The quiet-by-design approach will be emphasized by utilizing noise treatments to reduce excessive exposure to noise on the job and prevent additional cases of NIHL in the mining population. This paper describes the quiet-by-design or Prevention through Design (PtD) approach. This is the latest effort by NIOSH's Pittsburgh Research Laboratory (PRL) Hearing Loss Prevention Branch (HLPB) to reduce noise exposure of continuous mining machine operators in coal mining environments. Specifically, this paper concentrates on how PtD was used to create a noise control for a conveyor of a Joy Mining Machinery continuous mining machine.

## 2. Method

The PtD method was used to develop a noise control to reduce the noise exposure of continuous mining machine operators in coal mining environments. Through utilizing the four functional areas (research, policy, practice, and education) of the PtD process, the PtD approach consisted of developing collaborations or partnerships, procedures, resources, implementation plans, design strategies, case studies, and research to practice (r2p) initiatives from identification of the problem to implementation. Collaborations were established with Joy Mining Machinery, Consol Energy, C.U.E. Inc., MSHA, United Mine Workers of America (UMWA), and NIOSH to reduce the occurrence of NIHL among continuous mining machine operators. The collaborators were also representatives of the Coal Noise Partnership, which consists of representatives from the UMWA, Bituminous Coal Operators Association (BCOA), MSHA, and the National Mining Association (NMA). Additionally, mining equipment manufacturers and suppliers participated within the partnership. The purpose of the partnership is to collectively work as a team to reduce the worker exposure to noise and the prevention of NIHL among miners.

Research conducted to reduce continuous mining machine conveyor noise was divided up with NIOSH acting as the technical arm of the partnership. NIOSH developed the test plans, design strategies, and conducted the evaluations. Joy Mining Machinery provided resources such as the continuous mining machine and continuous mining machine parts. C.U.E. Inc. also provided resources that consisted of materials for the noise control. Consol Energy Inc. provided a mine site as a resource for field evaluation, and both MSHA and the UMWA supported the testing by providing input and participated in the in-mine testing.

In general, the design and implementation strategy consisted of five areas: (a) gathering and analyzing information on noise emission levels from the continuous mining machine conveyor; (b) design, development, implementation, and testing of engineering controls for the conveyor; (c) motivating the use of engineering noise control through collaboration with other government agencies, unions, equipment manufacturers, and standard setting bodies; (d) implementing the noise control and evaluating the effectiveness and feasibility; and (e) conducting a case study to determine the amount of reduction in operator noise exposure.

## 3. Results

NIOSH researchers addressed this issue by developing a chain conveyor with coated flights as a noise control to reduce the sound power emitted of continuous mining machines. By coating the flight bars with a heavy duty, highly-durable urethane, the metal to metal and metal to coal contact was reduced with a resulting reduction in noise levels. NIOSH designed, developed, lab tested, and field tested the noise control in partnership with labor (United Mine Workers of America), industry (National Mining Association, Bituminous Coal Operators Association), manufacturers (Joy Manufacturing), suppliers (C.U.E Inc), and MSHA stakeholders. The field tests demonstrated the coated flight bars as an effective noise control, obtaining a 3 dB(A) noise exposure reduction. In addition, the coated flights verified to be durable in a harsh underground environment.

A cost analysis was also conducted to determine if the coated flight bars were economically feasible. The results estimated the coated flight bars would increase the cost of the standard conveyor chain life by 20%. However, the coated flight bars extended conveyor chain life by a factor of three compared to chains with standard flight bars.

NIOSH accomplished policy initiatives with the use of a Cooperative Research and Development Agreement (CRADA), which provided an opportunity for NIOSH/CDC researchers to collaborate with colleagues from industry in the pursuit of common research. NIOSH was able to promote Joy Mining Machinery and C.U.E. Inc. in collaborating on reducing conveyor noise of the continuous mining machine. This was accomplished by showing Joy Mining Machinery and C.U.E. Inc. the benefits in implementing the control, which included: improved access to government researchers and facilities, better access to expertise related to research results and inventions, exclusive (or non-exclusive) licenses on inventions made under a CRADA, and potential profit from new products and processes developed.

Underground field evaluations were used to demonstrate to MSHA that the noise control developed for quieting the conveyor of continuous mining machines was a feasible engineering control according to the MSHA 30 Code of Federal Regulations (CFR)

Table 1
MSHA Dosimter Parameters

| Parameters | Setting | Designation |
|---|---|---|
| Weighting | A | MSHA Permissible Exposure Level (PEL) |
| Treshold Level | 90 dB | |
| Exchange Rate | 5 dB | |
| Criterion Level | 90 dB | |
| Response | Slow | |
| Upper Limit | 140 dB | |

section 62.130 (U.S. Department of Labor, Mine Safety and Health Administration, 2008). In order to be a feasible engineering noise control, the treatment should reduce noise exposure and be economically and technologically achievable. Technologically achievable requires that the noise control show any of the following requirements (U.S. Department of Labor, Mine Safety and Health Administration, 1999): (a) a 3 dB(A) or more reduction in exposure as a single noise control or in combination with other treatments, and/or (b) achieves compliance according to MSHA regulations.

In general the evaluation consisted of portal to portal dosimetry data utilizing a time motion study. Dosimetry determines the amount of acoustic noise that a worker is exposed to during a work shift. The time motion study relates the task with the noise exposure time of the operator. Two days of dosimetry data are needed. On one day, dosimetry data would be collected on the standard chain and on the other day dosimetry data would be collected on the treated chain. All measurements were performed with dosimeters set to MSHA parameters shown in Table 1.

The same continuous mining machine and operator was used for all underground measurements. Results demonstrated the amount of acoustic noise the continuous mining operator was exposed to with the standard chain and the treated chain during each work shift. The results were published and presented to MSHA. The information provided impact evidence to MSHA for citing the control as a noise control in the Program Information Bulletin (PIB) P04-18, "Technologically Achievable, Administratively Achievable, and Promising Noise Controls (30 CFR Part 62)." The PIB provides information and guidance relative to promising and technologically and administratively achievable noise controls.

## 4. Discussion

Through educating the Coal Noise Partnership, NIOSH addressed representatives of the workers, the mining companies, the mining machine manufacturers, and the regulatory/enforcement arm of the government for coal mining. The acceptance of the technology as an effective noise control by members of the Coal Noise Partnership was the starting point in getting a manufacturer to produce and sell the coated flight bar chain conveyor, along with getting several mines to use the noise control. NIOSH provided evidence on the effectiveness and feasibility of the noise control to the Coal Noise Partnership. As a result, MSHA cited the coated flight bar concept as part of the "Technologically Achievable, Administratively Achievable, and Promising Noise Controls (30 CFR Part 62)" on the MSHA Program Information Bulletin P04-18.

NIOSH also obtained testimonies from several mine operators at two coal mine sites that were using the noise control as an educational tool. The operators stated they observed a clear reduction in the noise level of the continuous mining machine. In addition, the mine workers have reported that the control was easy to implement and has a high level of durability.

NIOSH has transferred the findings of this research effort to interested industry parties. This was accomplished through journal articles, conference proceedings, conference presentations, industry/labor workshops, and industry/labor/NIOSH partnership meetings. Technology transfer efforts, such as workshops, conference presentations, and journal articles are selected based upon their ability to reach the target audience for the research. These findings were used to show the merit of the coated flight bars to manufacturers. The coated flight bar chain conveyor is currently being manufactured and sold by Joy Manufacturing, Inc. (package number: 100201770), who produces over 80% of the continuous mining machines in the United States. In addition, Joy Mining Machinery has provided an initial investment of one-million dollars to a new chain facility in pursing a "quiet-by-design" approach for continuous mining machine chains.

## 5. Impact on industry

Within the mining industry, MSHA provides information relative to promising and feasible noise engineering controls through a PIB. The PIB provides guidance to the industry on technology and administratively achievable engineering and administrative noise controls. At this time, there is limited information for industry representatives on the process of implementing noise engineering controls at their respective companies. Introduction and implementation of engineering controls in the workplace is an organizational issue that intersects across management, safety, training, and maintenance departments in an organization. The impact of successful acceptance and implementation at the higher levels of an organization will directly impact the acceptance and consistent usage of engineering controls at the employee level.

## 6. Summary

Developing collaborations or partnerships, procedures, implementation plans, design strategies, and case studies was the PtD approach for reducing exposure of continuous mining machine operators. NIOSH PRL policy was to take the leadership role and present financial incentives to the manufacturers and sound research to MSHA for updating the Program Information Bulletin (PIB) P04-18, which would provide information about promising and feasible engineering noise controls.

All representatives of the Coal Noise Partnership understood their role. The key was getting upper management of the manufacturer to buy into the benefits of the downstream users, which in turn would benefit them in a long term. Having the regulatory/enforcement arm of the government, MSHA, being part of the Coal Noise Partnership was also a key in having upper management of the manufacturer to buy in, knowing that MSHA was serious about enforcing the regulations. In addition, since the manufacturer had such a large percentage of the market they understood that if MHSA would enforce the regulations then the mining companies had to purchase the noise control. Joy Mining Machinery has provided an initial investment of one-million dollars for a new chain facility in pursing a "quiet-by-design" approach for continuous mining machine chains. The PtD method was successfully utilized to develop a noise control for the conveyor of a Joy Mining Machinery continuous mining machine. However, introduction and implementation of engineering controls in the workplace needs to consider the organizational issue that intersects across management, safety, training, and maintenance departments in an organization. The impact of successful acceptance and implementation with management of mining companies and mining machine manufacturers will directly impact the acceptance and consistent usage of engineering controls at the employee level.

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