Preprint 05-58

TESTING AND EVALUATION OF AN ENGINEERING NOISE CONTROL ON A LONGWALL STAGELOADER

ER Bauer, ER Reeves, and TM Durr, NIOSH, Pittsburgh, PA
DR Zuchelli, MSHA, Pittsburgh, PA
D Armour, Joy Manufacturing, Franklin, PA

Abstract

A team of noise specialists from the National Institute for Occupational Safety and Health (NIOSH), Mine Safety and Health Administration (MSHA), and Joy Manufacturing attempted to evaluate an engineering noise control on a Joy longwall stageloader. The team developed and executed a test plan to evaluate the noise attenuation of the engineering control in an underground coal-mining environment. An evaluation of the long-term noise effects and durability of the engineering control were also a focus of the research effort. Pre- and post-control measurements consisting of a combination of worker dosimetry and task observations, tape recordings, and sound level measurements were used to evaluate the engineering control. A description of the engineering noise control, pre- and post-control sound level measurements, and an evaluation of control success is presented. In the end, no evaluation was possible due to mining practices, miner task variations, and inconclusive data.

Introduction

Noise, which can be defined as any unwanted sound, is pervasive in the mining industry. Continued exposure to high levels of noise can cause damage to the inner ear. This damage eventually results in a permanent shift in hearing thresholds, known as noise-induced hearing loss (NIHL). NIHL is the most common occupational disease in the United States today, with 30 million workers exposed to excessive noise levels or toxicants that are potentially hazardous to their hearing (NIOSH, 1996a). The problem is particularly severe in all areas of mining (surface, processing plants, and underground) where large, noisy equipment predominates. Studies indicate that 70% to 90% of miners have NIHL great enough to be classified as a hearing disability (NIOSH, 1996b). An analysis of NIHL in miners presented a snapshot of the extent of NIHL in the mining industry, as shown in Figure 1 (NIOSH, 1996b). This analysis of a private company's 20,022 audiograms indicate the number of miners with hearing impairments (defined as an average hearing threshold level of 25 dB or greater for the frequencies 1000, 2000, 3000, and 4000 Hz) increased exponentially with age until age 50, at which time 90% of the miners had a hearing impairment (NIOSH, 1996b and 1997).

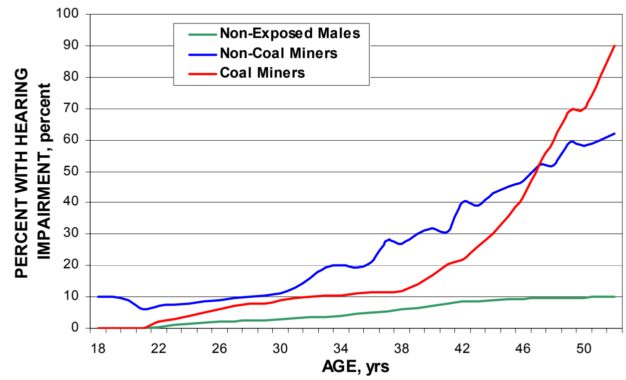

Figure 1. Hearing impairment in coal miners, non-coal miners, and non-exposed males (NIOSH, 1996b, 1997).

Despite the extensive work with engineering controls in the 1970s and 80s, NIHL is still a problem in the mining industry (Federal Register, 1996). To address the issue, MSHA published Health Standards for Occupational Noise Exposure (Federal Register, 1999). Requirements of the new regulation are the adoption of an OSHA-like Hearing Conservation Program with an 'Action Level' of 85 dB(A) TWA_8, a permissible exposure level (PEL) of 90 dB(A) TWA_8, no credit for the use of personal hearing protection, and the primacy of engineering and administrative controls for noise exposure reduction.

One factor that may reduce the incidences of hearing loss in underground miners would be the development of additional successful engineering noise controls for the equipment used in the underground mining industry. The relatively small market for mining equipment combined with the unique requirements imposed by the hostile mining environment has limited both manufacturer innovation and the transfer of technology from other industries. Fortunately, the mining industry has recognized the importance of engineering noise controls as a primary means of reducing noise exposure and preventing NIHL among miners. And even though a lack of readily- available proven control technology has hindered the implementation of controls, potential noise control solutions are being crafted and tried at the mine level by miners, operators, manufacturers, consultants, and government personnel (Reeves, 2004).

In an attempt to reduce worker noise exposures around a longwall stageloader, the stageloader manufacturer installed a noise control on the machine during the rebuild process in its shop facilities. NIOSH and MSHA personnel conducted in-mine surveys before and after the installation of the control in order to determine its effectiveness. The results are summarized in this report.

Background

MSHA's noise rule (30 CFR 62) requires mine operators to use all feasible engineering and administrative controls to reduce miners' noise exposure to the permissible exposure level (PEL). In an attempt to reduce noise levels around the longwall stageloader, an engineering noise control was designed and a study to evaluate the noise control was initiated. An underground coal mine in New Mexico volunteered its longwall for this study. This mine site was deemed suitable because the Joy stageloader, currently operating in the mine, was due to be rebuilt at the termination of mining of the current panel (LW 101). Prior to panel completion, underground measurements were completed to obtain the pre-control sound levels and worker noise exposure levels. For the rebuild, the stageloader was transported to the rebuild facility. During the rebuild period, Joy personnel installed the engineering control. Shortly after the rebuilt stageloader was in place and mining started on the new panel (LW 102), a set of measurements was made to determine the effect of the engineering control on the sound levels. An additional set of measurements was completed just prior to completion of mining of panel LW 102 to ascertain the long-term effect of the control.

Stageloader Noise Sources

There are three primary sources of noise on a stageloader: the chain, the drives, and the crusher. Noise from the chain is most prevalent at the drive sprocket, the top of the gooseneck, and the return end at the headgate. The most effective control that can be implemented to reduce this noise is to maintain proper chain tension with either an automatic chain tensioning system or a rigorous maintenance program (Armour, 2003).

According to the stageloader manufacturer, the stageloader drive is usually louder than the crusher drive. If the stageloader gearbox can be located on the off-walkway side (panel side), the sound level on the walkway side will be reduced considerably. Covers and sound absorbing blankets are not recommended for the stageloader drive because of heat and maintenance considerations. Noise around the crusher is mostly a function of the amount of large chunks of coal and rock that pass through the crusher. Covers and sound absorbing blankets may be an option here, but the other nearby noise sources will limit their overall effectiveness. Entry doors should be maintained and kept as sealed as possible. Solid plates are better than chains (Armour, 2003).

Little can be done to reduce the actual crushing noise. Since it is intermittent, it does not significantly affect exposure unless the doors are not maintained (Armour, 2003).

Stageloader and Engineering Noise Control Specifications

The stageloader was manufactured by Joy Mining Machinery. It was 1350 mm (53 in) wide, with a chain speed of 151 mpm (496 fpm). From the longwall face outby to the panel belt, the stageloader sections consisted of the face side armored face conveyor (AFC) drive (head drive), swivel pans, crusher, gooseneck/incline section, discharge, and crawler mounted tailpiece (Figure 2). Total length was approximately 34 m (110 ft) excluding the tailpiece, with a height of 218 cm (86 in).

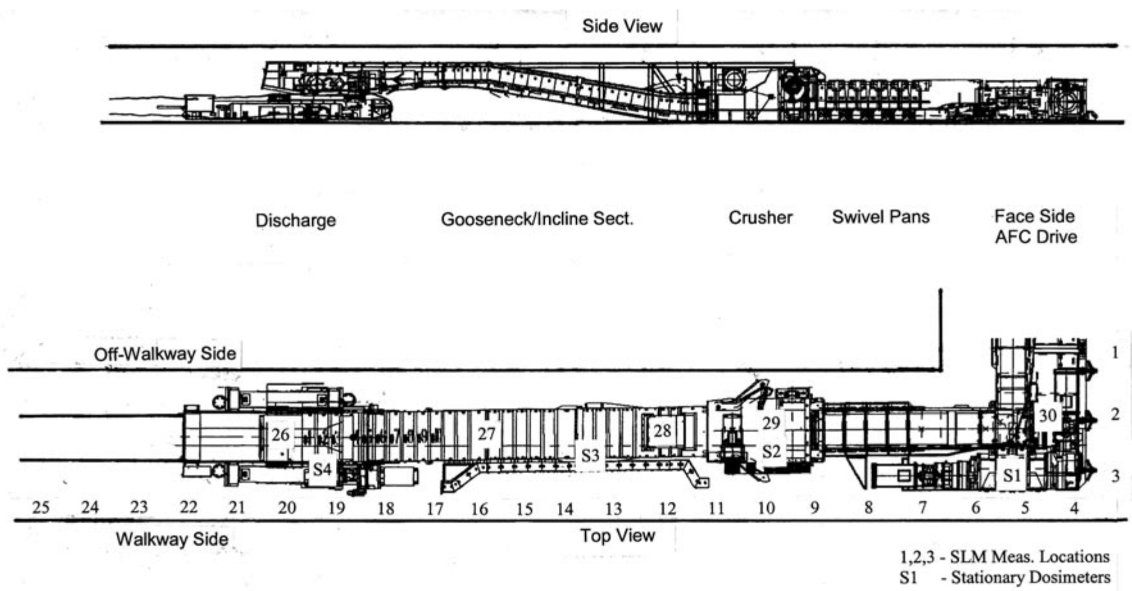

Figure 2. Longwall stageloader.

During a normal rebuild, several noise controls are routinely implemented to minimize the sound levels generated by the stageloader. These are listed in Table 1 and were completed to address attenuation, absorption, and to provide barriers to noise. In addition to the routine fixes, the most important engineering noise control installed utilized absorption filled cavities on the crusher and gooseneck. This involved fabricating and installing bagged fiberglass in the cavities on the top, bottom, and sides of the stageloader, then covering with conveyor belting. This control was selected by the stageloader manufacturer based on the results of a NIOSH research study examining the use of sand-filled cavities to reduce noise levels (Bauer, *et al.*, 2001). It was believed that this "prototype" control would reduce noise levels as effectively as sand, but last longer, be lighter in weight, and remain in place rather than settle to the bottom of the cavity as sand does over time. As shown in Figure 3, the fiberglass bags were constructed from fiberglass and brattice cloth with folded and stapled edges for water resistance. The bags were made and installed in the crusher and gooseneck cavities by Joy technicians in the rebuild shop (Figure 4). They were then covered by conveyor belt bolted at the cavity edges (Figure 5).

Mine and Longwall Specifications

The pre- and post-control studies were conducted in an underground coal mine in New Mexico. The longwall extracted coal from the Fruitland No. 8 seam. Panel lengths were 2743 to 3048 m (9,000 to 10,000 ft) with face widths of 305 m (1,000 ft). Extraction height during the studies was approximately 350 cm (138 in). Overburden averaged 91 to 137 m (300 to 450 ft) above the panels.

Table 1. Routine stageloader noise controls.

Stageloader Section	Noise Controls
Swivel Pan	Machined joints Enclosed Urethane entry flap - Barrier
Crusher	Machined joints Vibration isolation top covers (1/2" Neoprene)
Gooseneck and Incline	Machined joints Vibration isolation top covers (1/2" Neoprene)
Discharge	Machined joints Enclosed with hood Vibration absorbing top covers (Urethane foam filled)
Scrubber Fan	Flexible attenuator (24" dia flexible tube x 48" long)

The pre-control study was completed on panel LW 101, the first panel this longwall equipment mined, while the post-control studies were completed on panel LW 102, the second panel (Figure 6). At the time of the pre-control study, LW 101 was approximately 488 m (1,600 ft) from the recovery area and panel mining had been underway for 9 months. For the control studies, LW 102 was 183 m (600 ft) from the set-up rooms and in operation for 2 months for the first post-control study and 396 m (1,300 ft) from the recovery area and operating 8 months for the second post-control study. The rate of extraction was influenced by the release of hydrogen sulfide (H_2S), which was not allowed to exceed 15 ppm at the tailgate. The presence of H_2S resulted in widely varying production rates, especially during the first study on panel LW 102, which affected the noise measurements and comparisons as explained later.

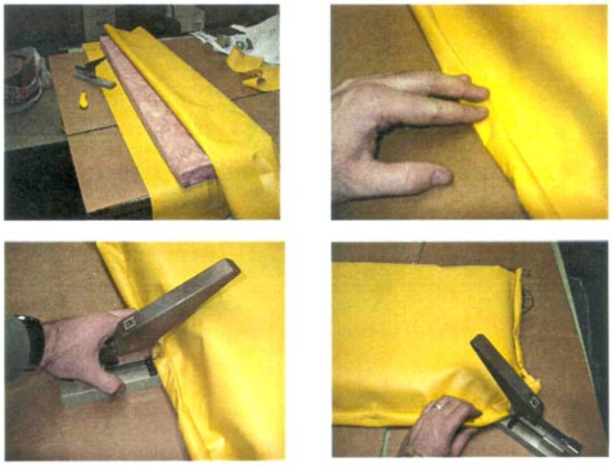

Figure 3. Fabrication of fiberglass insulation bags.

Results of Noise Surveys

Preliminary Noise Survey

Personnel from Joy conducted a preliminary noise survey soon after the startup of panel LW 101. The following summary of the headgate and stageloader sound measurements was presented:

> *Headgate readings were below average. The headgate drive was between 88 and 92 dB(A) on the gob side and 92-95 on the face side. The levels along the stageloader varied as noted on Figure 7. Noise levels increased when the conveyor was full (shearer to headgate as noted above). This may be due to an improperly tensioned stageloader chain. The loudest levels on the stageloader were near the top of the gooseneck section at ~94-97 dB(A).* (Joy, 2002)

1 **Figure 4. Bags installed on gooseneck.**

Figure 5. Conveyor belt covering bags.

Pre-Control Noise Survey

A noise survey was completed on panel LW 101 approximately 9 months into panel extraction to determine the sound levels of the stageloader and longwall worker noise exposures prior to implementing the noise control (fiberglass-filled bags in stageloader cavities). The evaluation included noise measurements along the side and over the top of the stageloader while the shearer cut both head-to-tail and tail-to-head. Measurements were also taken using stationary dosimeters located at the face side AFC drive, crusher, crossover, and discharge, and full-shift dosimetry of the longwall miners was acquired.

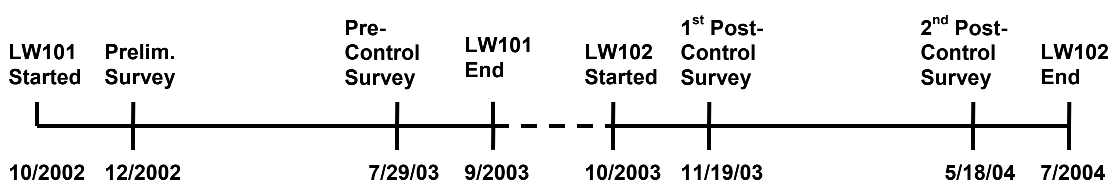

Figure 6. Time line of surveys.

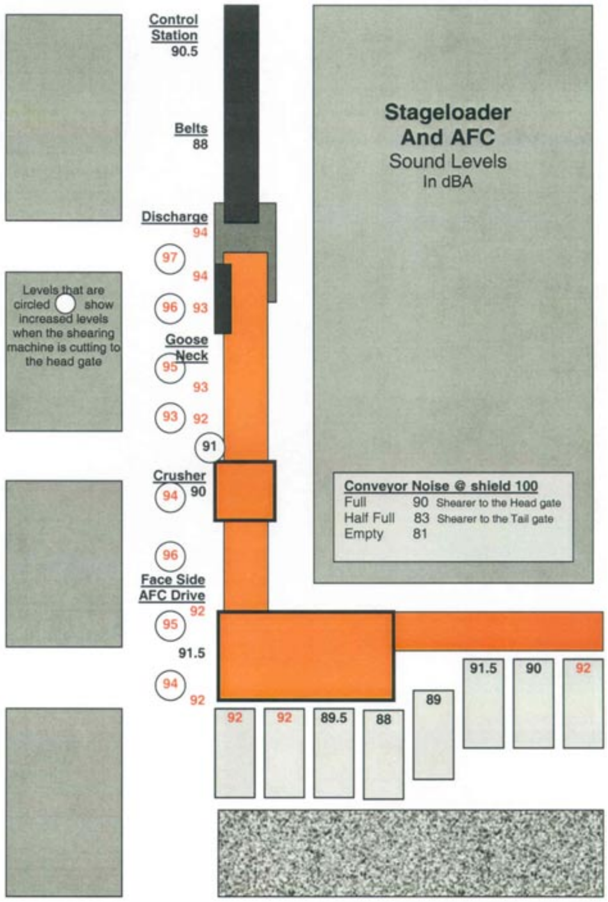

Figure 7. Results of a previous preliminary noise survey.

Sound levels were measured between the face side AFC drive and shields, between the stageloader and rib on approx. 2-m (6-ft) intervals (see Figure 2), and out over the stageloader using a Type 2 Sound Level Meter (SLM) set for A-weighting, slow response, 3 dB(A) exchange rate, and 20 sec averaging, and a Nagra magnetic tape recorder. Readings were recorded for both directions of face cutting, but were averaged for display, analysis, and comparison. Averaging of the sound levels in dB(A) was completed by converting the sound levels to an equivalent sound pressure, averaging the sound pressure, then converting the averaged sound pressure back to an average sound level in dB(A) using the following equation:

$$Level = 10 \log \frac{P^2}{Pref^2}, \qquad (1)$$

Where *Level* = Measured sound pressure level in dB(A);
P = Sound pressure in pascals; and
P ref = Reference sound pressure, 0.00002 pascal.

Because little difference is seen between the SLM measurements and Nagra tape recorded measurements, the SLM measurements were used to construct the noise contour plots. A noise contour plot for the stageloader prior to installation of the noise control is illustrated in Figure 8. The results indicate sound levels from 87 to 98 dB(A) were present, with the discharge area being the loudest as expected, but that the face side AFC drive and crusher were quieter than expected.

The stationary dosimeters, placed as shown in Figure 2 (S1 – S4), provided a dose that is independent of the stageloader operator's position. It was thought that this would result in a more accurate estimate of the exposure reduction potential of the controls because it eliminated the variability associated with the stageloader operator's position along the stageloader. Table 2 lists the data for a full-shift. The highest doses were recorded at the discharge and head (AFC) drive.

Table 2. Pre-control dose (TWA_8) recorded by stationary dosimeters, 07/29/03.

Location	Full Shift MSHA PEL Dose (TWA_8), % (dB(A))
Face Side AFC Drive	91.31 (90.0)
Crusher	47.75 (85.3)
Crossover	62.84 (87.3)
Discharge	206.34 (95.9)
Prod., Raw Tons	7497

The longwall worker dosimetry measurements produced the following results: Mechanic – 30.1%; Production Longwall (Jacksetters) – 54.2, 74.6 and 131.9%; Foreman – 100.7%; Shearer Operator – 114%; and Stageloader Operator – 223.2%. The reasons for attempting to quiet the stageloader are obvious based on the stageloader operator's dose. Previous NIOSH studies conducted at other longwalls indicated the stageloader operators were the most exposed longwall workers, with recorded doses ranging from 36 to 386% (Bauer, *et al*, 2001). To ascertain the noise sources, locations, and/or tasks responsible for the stageloader operator's dose he was task observed for the shift the dose was recorded. Figure 9 is the cumulative dose plot with task observed annotations for the stageloader operator. The plot and annotated observations indicate that his exposure is highly dependent on his location. The most significant noise exposure occurred when he was located at the discharge area, which is where the highest sound levels and stationary dose were recorded. It should be noted that the recorded dose of 223% occurred even though the longwall system was not operating for nearly 3 hours during the shift.

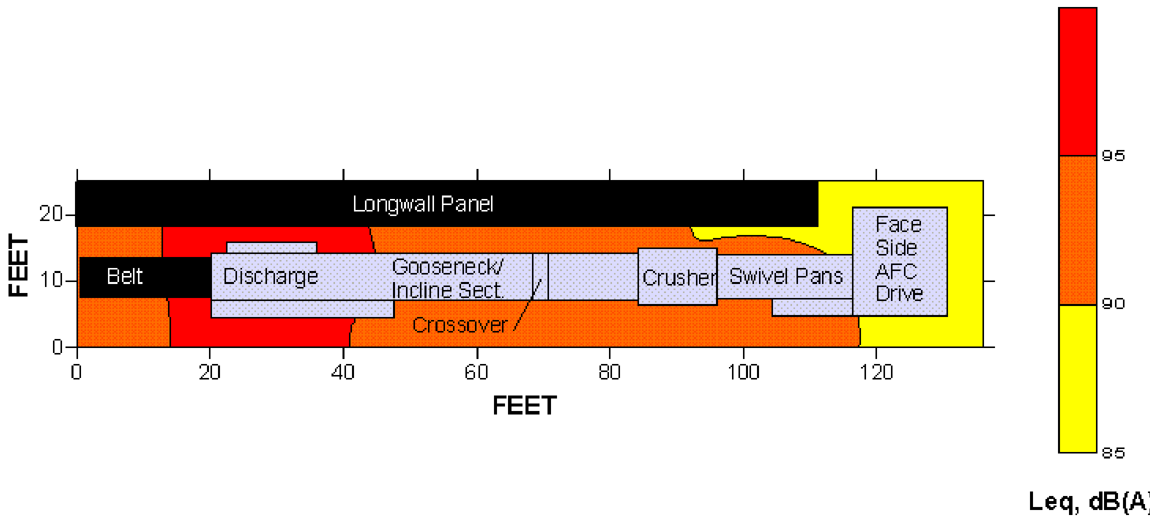

Figure 8. Pre-control sound levels.

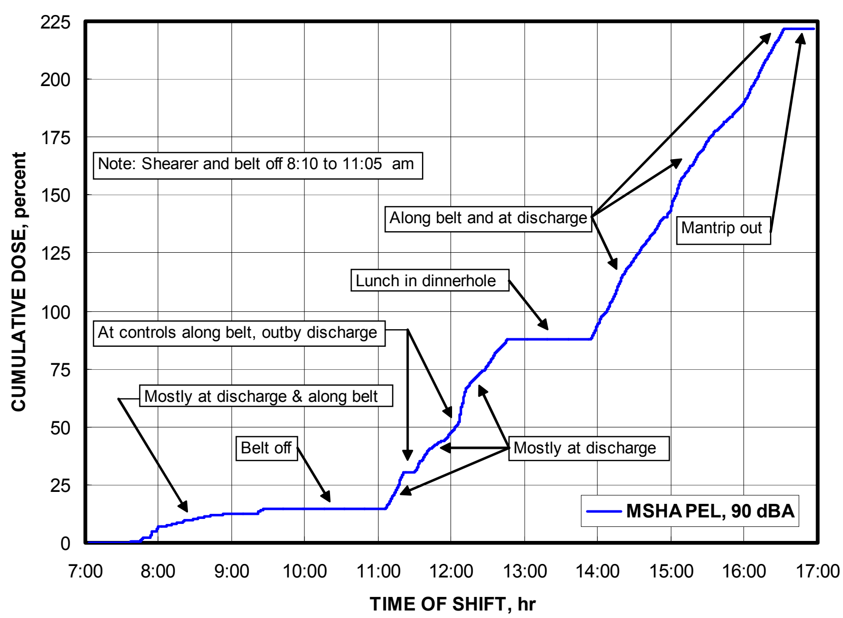

Figure 9. Cumulative dose plot for stageloader operator, pre-controls.

First Post-Control Noise Study

Approximately 5 weeks after the rebuilt longwall system was operating in panel LW 102, a noise study was completed to determine the sound levels of the noise-controlled stageloader. As before, sound level measurements along the stageloader, worker dosimetry and task observations, and stationary dosimeters were used during this phase of the study. The contour plot of average sound levels is shown in Figure 10. Measured sound levels from 90 dB(A) to almost 100 dB(A) were recorded. These post-control sound levels were two to three dB(A) greater than the pre-control sound levels. The stageloader manufacturer expected higher sound levels initially, because the rebuild introduced tighter clearances at connections and joints between stageloader sections that needed time to "break in."

The stationary dosimeters were situated in the same locations as the pre-control study. The results shown in Table 3, combined with the pre-control measurement, follow the similar trend as the pre-control dose except at a higher level, even though the shift production was less.

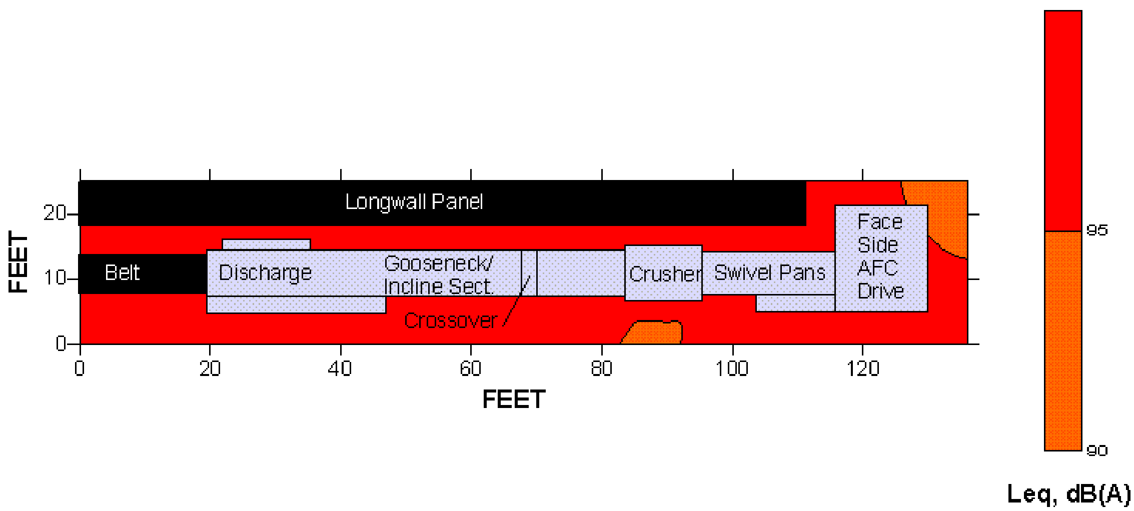

Figure 10. Post-control sound levels just after panel start-up.

2

Table 3. Pre- and post-control dose (TWA_8) for stationary dosimeters, 1st and 2nd studies.

Location	Full Shift MSHA PEL Dose (TWA_8), % (dB(A))	Full Shift MSHA PEL Dose (TWA_8), % (dB(A))
Face Side AFC Drive	91.31 (90.0)	334.89 (98.3)
Crusher	47.75 (85.3)	278.10 (96.9)
Crossover	62.84 (87.3)	265.28 (96.6)
Discharge	206.34 (95.9)	562.74 (102.0)
State of Control	Pre-control	Post-Control
Prod., Raw Tons	7497	6920
Date of Measurements	07/29/03	11/19/03

The worker dosimetry measurements were the following: Production Longwall (Jacksetters) – 65.1, 67.6, 86.5 and 163.1%; Foreman – 91.9%; and Stageloader Operator – 196.0%. Dosimeter results for the Mechanic and Shearer Operator were not available because of instrumentation malfunctions. Of interest is the fact that even though the sound levels average two to three dB(A) higher, the stageloader operator's dose was 27.2% less than the initial pre-control dose. Figure 11 is the cumulative dose plot with annotated observational information for the stageloader operator. The plot illustrates that because of the operator's work habits, he spent more time along the belt (app. 100 min) and away from the discharge, resulting in a lower dose.

Second Post-Control Noise Study

A second post-control study was completed 6 months after the first post-control study. It was hoped that this study would reveal the "true" post-control sound levels as opposed to the "break in" sound levels taken previously. At the time of the second post-control study (396 m (1,300 ft) from the recovery area) it was assumed that the condition of the stageloader should be similar to the pre-control condition, since both sets of measurements were completed near the end of the panel with similar total hours and production. The sound levels, worker dosimetry, and stationary dosimeter measurements were collected at similar locations and conditions as the previous two studies. A contour plot of average sound levels is shown in Figure 12. Measured sound levels from 88 dB(A) to 98 dB(A) were recorded. These post-control sound levels are on average two dB(A) less than the previous post-control sound levels and nearly the same as the pre-control sound levels.

The results of the stationary dosimeter measurements are shown in Table 4 and include all the previous stationary dosimeter readings. These measurements follow nearly the same trend as the previous doses but at a slightly lower level than the first post-control doses. Figure 13 illustrates the trend of the stationary dosimeter measurements. Comparing and developing conclusions from the stationary dosimetry measurements is difficult. One would expect that as the production tonnage increases, the sound levels and dose would increase as well. However, in the case of a longwall stageloader, increased tonnage results in more coal passing through the system to muffle the chain (metal-to-metal) noise. This produces lower sound levels. This trend (higher production-lower noise) was true, especially for the post-control studies. The first post-control study had a lower full-shift production, yet the highest doses. The second post-control study had the highest production level, but not the highest dose. Because of the higher production level, the stageloader ran "full" of coal for a greater percentage of the shift and thus was "quieter." It appears that the stageloader is continuing to act like an enclosed duct, keeping the sound inside, and eventually discharging the higher sound at the tail piece (discharge end). The increase in sound level at the discharge is evidence of this phenomenon.

Finally, the worker dosimetry measurements were the following: Production Longwall (Jacksetters) – 95.01%; Foreman – 77.92%; and Stageloader Operator – 73.46%; Mechanics – 38.84 and 74.92%; and Shearer Operator –

205.52%. Table 5 presents a summary of all the worker dosimetry results for all studies. Figure 14 is the cumulative dose plot with annotated observational information for the stageloader operator. As in the first post-control study, this miner spent considerably more time along the belt and less time along the stageloader and at the discharge. The result is a decrease in overall noise exposure.

Table 4. Pre- and post-control dose (TWA_8) recorded by stationary dosimeters, all studies.

Location	Full Shift MSHA PEL Dose (TWA_8), % (dB(A))	Full Shift MSHA PEL Dose (TWA_8), % (dB(A))	Full Shift MSHA PEL Dose (TWA_8), % (dB(A))
Face Side AFC Drive	91.31 (90.0)	334.89 (98.3)	188.39 (94.5)
Crusher	47.75 (85.3)	278.10 (96.9)	106.02 (90.3)
Crossover	62.84 (87.3)	265.28 (96.6)	125.60 (91.5)
Discharge	206.34 (95.9)	562.74 (102.0)	371.42 (99.3)
State of Control	Pre-control	Post-control	Post-control
Prod., Raw Tons	7497	6920	10,000 (App.)
Date of Measurements	07/29/03	11/19/03	05/18/04

Frequency Analysis

In order to determine the effect of the noise control on the sound levels produced by the stageloader, the frequency distribution of the noise was analyzed. Most passive engineering noise controls reduce noise levels by either blocking or absorbing sound energy. The fiberglass material used to fill the stageloader cavities would work as a sound absorber, while the conveyor belt material, which covers the cavity, would block sound energy.

When a sound wave enters an absorptive material, the amplitude of vibration of the air molecules is damped by friction against the material fibers. The amount of absorption provided by a material is dependent on the acoustical resistance of the material, the thickness of the material, the way the material is mounted, and the frequency of the incident sound. At lower frequencies the amount of sound absorbed is primarily due to the thickness of the material. To have the greatest effect, the thickness of the material should be at least one quarter wavelength of the lowest frequency of interest. Or,

$$t = \lambda/4 \quad (2)$$

where t = material thickness in meters, and

λ = wavelength of sound in meters.

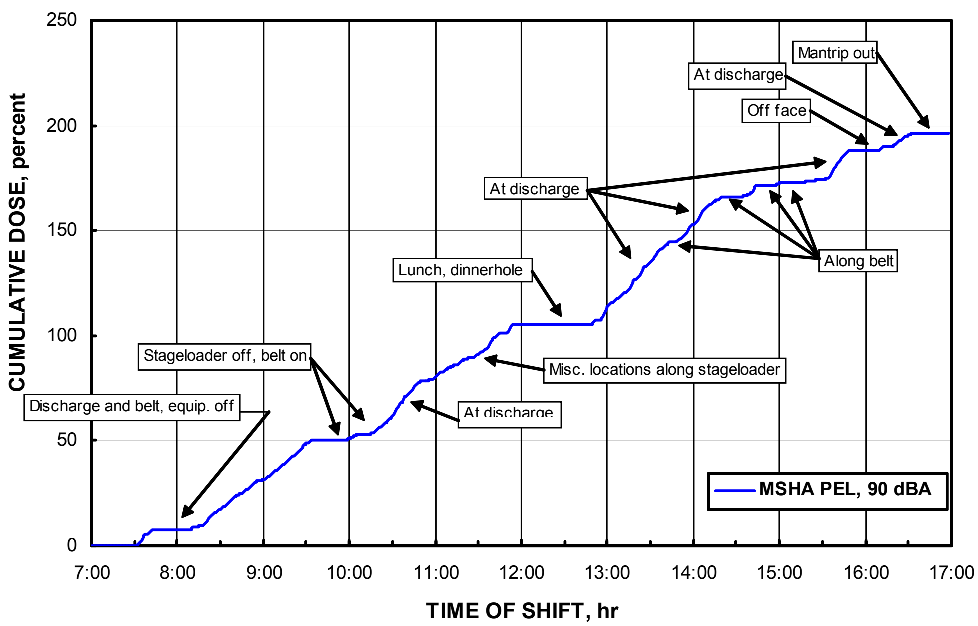

Figure 11. Cumulative dose plot for stageloader operator, 1st post-control study.

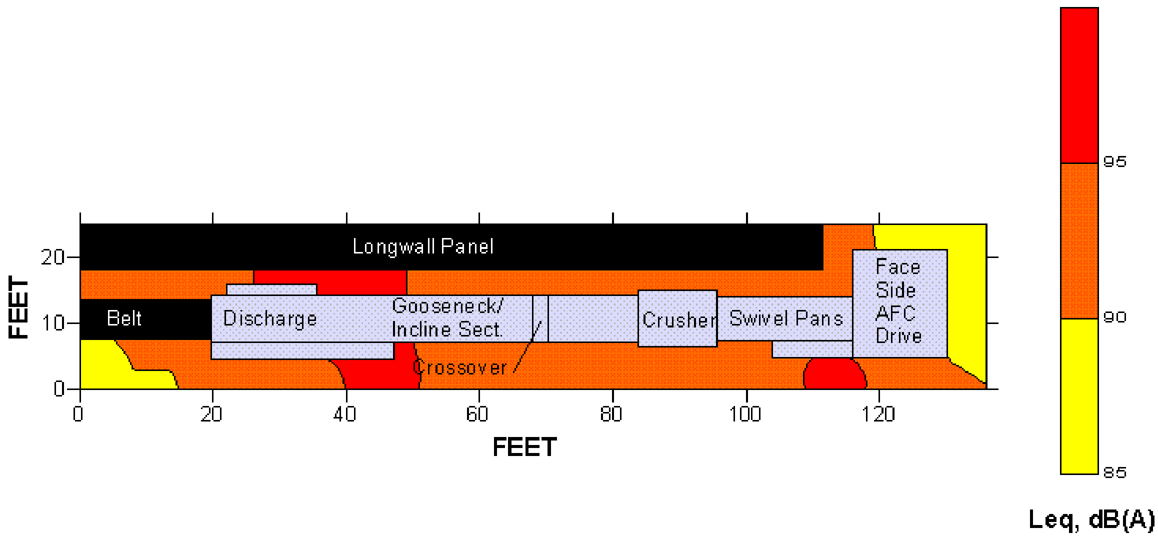

Figure 12. Post-control sound levels after 6 month break-in period.

3

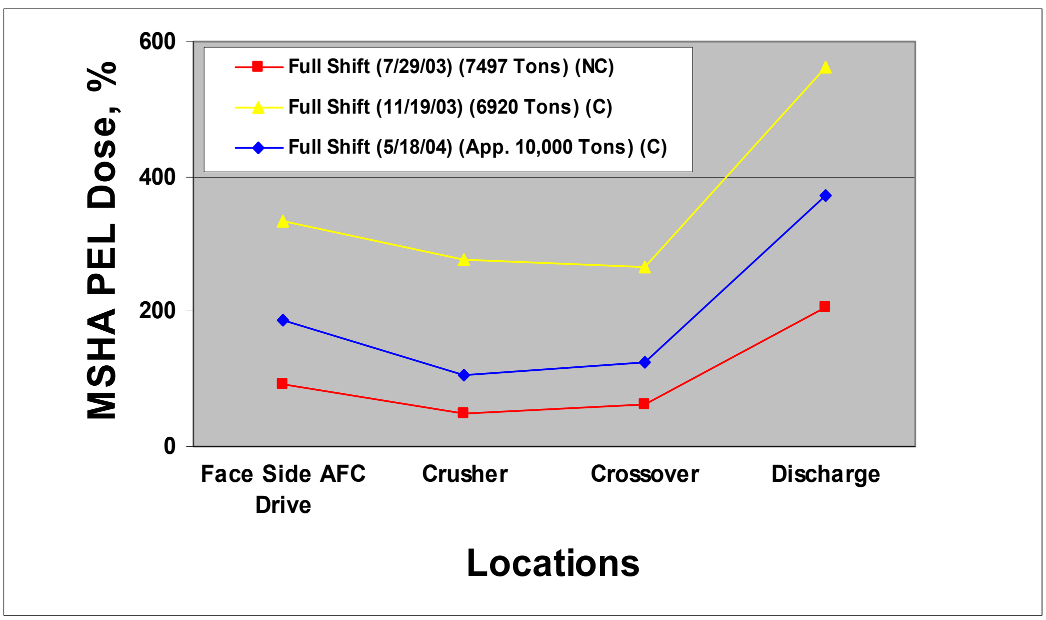

Figure 13. Stationary dosimeter readings for all studies.

Table 5. Summary of workers dosimetry measurements, all studies.

Worker	Range MSHA PEL Dose, %	Range MSHA PEL Dose, %	Range MSHA PEL Dose, %
Stageloader Operator	223.2	196.0	73.46
Shearer Operator	114.0	ND[1]	205.52
Jacksetters	54.2 – 131.9	65.1 – 163.1	95.01
Mechanic	30.1	ND	38.84 – 74.92
Foreman	100.7	91.9	77.92
State of Control	Pre-control	Post-control	Post-control
Prod., Raw Tons	7497	6920	10,000 (App.)
Date of Measurements	07/29/03	11/19/03	05/18/04

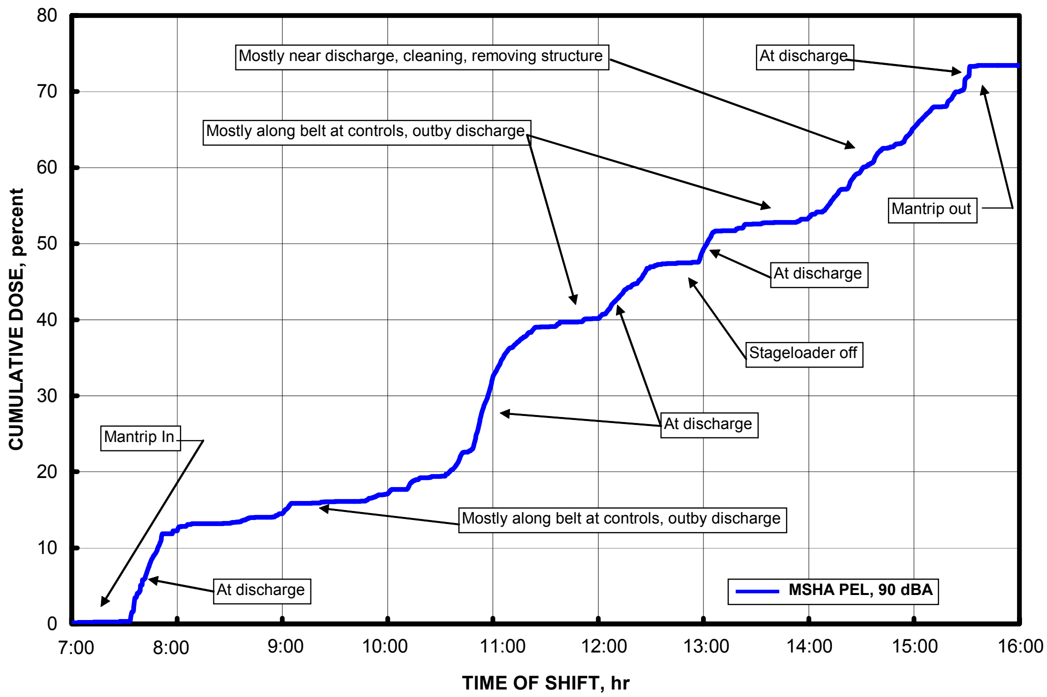

Figure 14. Cumulative dose plot for stageloader operator, 2nd post-control study.

In this case, the thickness of the material was limited by the size of the cavities on the machine. On the sides of the stageloader the thickness of the material in the bags was about 0.125 m (5 in). Substituting 0.125 m into the equation above yields a value of $\lambda = 0.5$ m (1.6 ft). Using a value of 343 m/s (1,125 ft/s) for the speed of sound in air shows the wavelength corresponds to a frequency of 686 Hz. This suggests that 686 Hz would be the lowest frequency significantly affected by the bags of material. Therefore, an examination of the one-third octave band spectral plots of the sound levels measured before and after the installation of the noise control treatment should indicate whether the control had any effect on sound levels.

Figure 15 shows the frequency content at measurement location 14 (see Figure 2) before the installation of the noise control treatment (pre-control) and after the noise control treatment (post-control). The vertical line (Figure 15) between 630 Hz and 1000 Hz designates the point above which the control should be the most effective.

It can be seen in Figure 15 that the post-control sound levels are slightly lower than the pre-control sound levels in the mid-frequency range (125 Hz to 2000 Hz). However, one would expect that the noise treatment would have a greater effect on the higher frequencies since these are more readily blocked or absorbed due to their shorter wavelengths. Therefore, it is difficult to determine whether the difference in sound level is due to the control or due to other measurement variables. Some possible causes for variations in pre- and post-control measurements are discussed below.

Measurement Difficulties

The task of accurately determining the effect of an engineering noise control on sound levels and/or worker noise exposures on a longwall stageloader, and for that matter any other piece of underground mining equipment, is difficult at best. Many variables are introduced that can affect the evaluation such as the mine environment, production level, operator position, equipment operation, and equipment position. Although these variables are normal day-to-day occurrences, unless they are controlled and kept constant from study-to-study, the final determination of an engineering control's success may be called into question.

Mine Environment

The physical environment of a mine can change from one study to another, possibly affecting the measurements. Entry dimensions, width and height, in combination with equipment location could affect the measured sound levels. As the opening dimensions change, the equipment can be further from or closer to the ribs and roof changing the amount of reflected sound that reaches the measurement locations. Changes in the composition of the environment may also change the measured sound levels. More or less rock in the seam, a change in roof rock, or the amount of roof rock mined may alter the sound levels irrespective of any engineering noise controls applied.

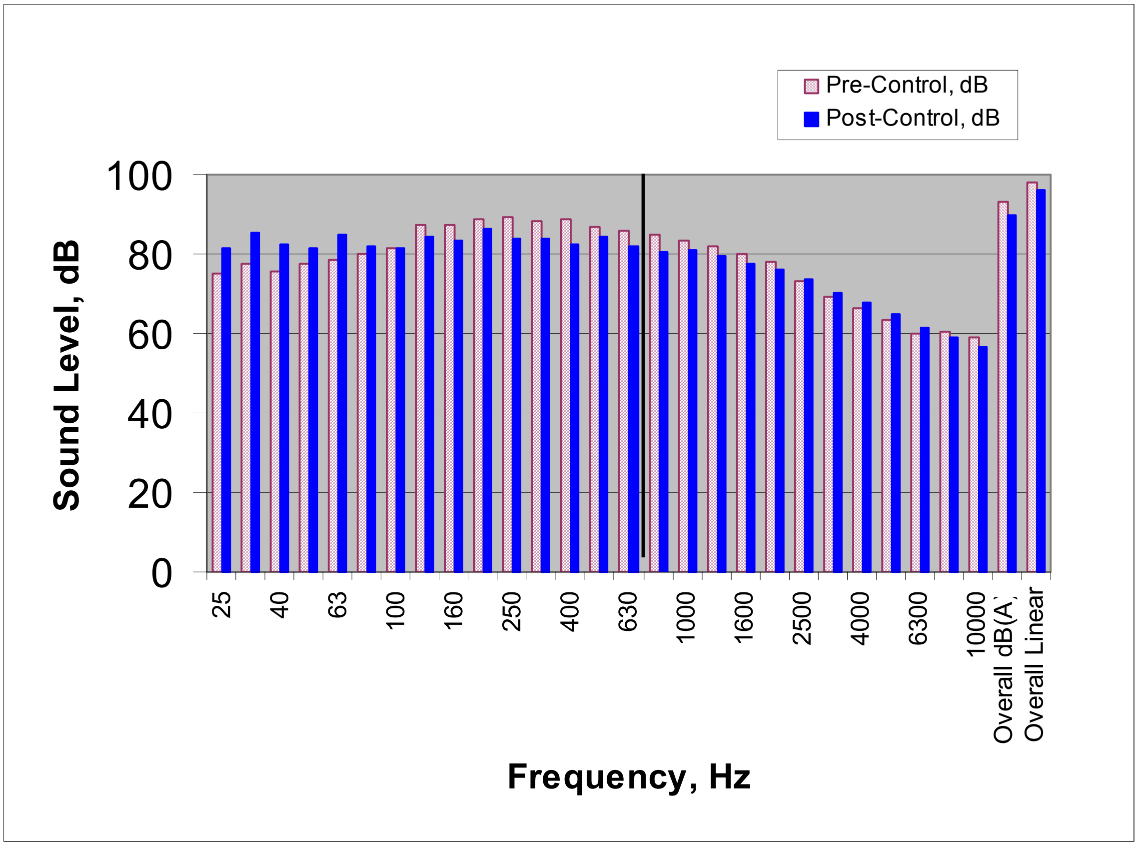

Figure 15. One-third octave plot of stageloader sound levels with and without the noise control.

Production Level

Production level fluctuations can lead to variations in sound level. The sound levels produced while operating at full capacity may be different than the sound levels produced during half-full or empty operation since conveyor chain noise generally increases as the amount of product being conveyed decreases. At this study site, production levels varied greatly because of problems associated with H_2S. This resulted in widely varying amounts of coal in the stageloader because production was slowed or stopped when the concentration of H_2S in the environment reached a certain level.

Equipment Operation

The presence of toxic/hazardous gases, rock, or an uneven face can necessitate changing the way the equipment is operated. Different operators can also change how equipment is operated. A change in equipment operation could cause production levels to vary or the equipment to work harder. Both of these conditions will result in varying sound levels, independent of any engineering noise controls. Even so, equipment operation is not an important consideration in the case of a longwall stageloader, since it essentially operates on its own. However, the stageloader sound levels are dependent upon the operation of the shearer and the production level.

Equipment Position

The position of equipment with respect to the face or crosscuts can affect sound levels. For instance, since the stageloader moves during face extraction each section of the stageloader is adjacent to either a rib or a crosscut at varying times. When next to a rib, less than 1 m (3 ft) of space (walkway) is present. Alternatively, when adjacent to a crosscut, the nearest rib is 30 m (100 ft) or more away. Therefore, the sound field with respect to any point on the stageloader can change depending on the position of the stageloader with respect to the mine opening.

Operator Position

Due to the aforementioned reasons it is difficult to be consistent with pre- and post-control sound level measurements. It is also just as difficult to determine the effect of the noise control on worker noise exposure because of changes in operator position. For instance, the stageloader operator can be located anywhere along the stageloader, face, or away from the stageloader for varying periods throughout the shift. In addition, if production levels, equipment operation, or downtime varies, determining if an engineering noise control was effective in reducing worker noise exposure is even more difficult. As seen in the analysis conducted at this mine, the worker noise exposure (dose) was less after noise controls were implemented, even though the post-control stageloader generated higher sound levels than the pre-control stageloader.

Summary and Conclusions

Three mine visits were conducted to evaluate the effectiveness of an engineering noise control on a longwall stageloader. The control consisted of fiberglass insulation in brattice cloth bags, installed in the cavities of the stageloader (mostly the gooseneck/incline section), and covered with bolted-on conveyor belt. The studies, one pre-control and two post-control, involved monitoring stageloader sound levels through the use of stationary dosimeters and sound level profiles, as well as longwall worker dosimetry with task observations. In general, the results from the stationary dosimeters indicated that the highest sound levels occurred at the discharge. In addition, sound levels at the crusher and the crossover locations remained about the same. Further, the levels at the AFC Drive were higher than the crusher/crossover levels but less than those at the discharge. This trend was consistent across visits, with or without the noise control in place, although the actual measured values changed. In addition, the pre- and post-spectral analysis was unable to determine if the noise control was effective in reducing stageloader sound levels.

In spite of the consistent data trend, this study illustrates how difficult it is to conduct evaluations of engineering noise controls in a mine environment. Without maintaining the exact environmental characteristics, production levels, and equipment position, it is difficult to measure the effectiveness of a noise control since all of these parameters will affect the sound levels generated. Overall, it was not possible to determine if the implemented engineering noise control reduced the stageloader sound levels or the stageloader operator noise exposure.

Finally, as opportunities arise, NIOSH, in conjunction with the mining community and longwall equipment manufacturers, will continue to investigate engineering controls designed to reduce longwall worker noise exposures. Future studies will include an improved control selection process that addresses noise source, frequency analyses, and the control's noise reduction characteristics. In-lab studies that better simulate in-mine conditions, and an improved in-mine study that controls the mining and production parameters more closely from study-to-study will also be employed.

Acknowledgements

The authors wish to acknowledge the assistance of Mike Crivaro, MSHA Technical Support, for analysis of the tape recorded data, Shawn Peterson, NIOSH, for analysis of dosimeter data, Scott Jones and Kerry Hales, Longwall Coordinators, Steve Marshall, Longwall Maintenance Foreman, and the longwall miners of San Juan Coal Company, San Juan Mine, for their assistance and cooperation during the research study.

References

1. Armour, D [2003]. New Dosimeter Readings Reveal Better Noise Dosage Data. *Coal Age*, v. 108, No. 9, September, pp. 30-37.
2. Bauer, ER, DJ Podobinski, ER Reeves, and JS Vipperman [2001]. Noise Exposure in Longwall Mining and Engineering Controls Research. Proceedings of Longwall USA 2001 International Exhibition & Conference, June 13-15, Pittsburgh, PA, pp. 51-69.
3. Joy Mining Machinery [2002]. Report on Noise Survey Performed on: December 23, 2002. Internal Company Report, 7 pp. Available from Dan Armour, Joy Mining Machinery, 120 Liberty Street, Franklin, PA, 16323.
4. NIOSH [1996a]. Preventing occupational hearing loss – a practical guide. Edited by Franks, J, MR Stephenson, and CJ Merry. National Institute for Occupational Safety and Health, Cincinnati, OH, DHHS (NIOSH) Publication 96-110, 91 pp.
5. NIOSH [1996b]. Analysis of Audiograms for a Large Cohort of Noise-Exposed Miners. John Franks, National Institute for Occupational Safety and Health, Cincinnati, OH, Internal Report, 7 pp.
6. NIOSH [1997]. Prevalence of Hearing Loss for Noise-Exposed Metal/Nonmetal Miners. John Franks, National Institute for Occupational Safety and Health, Cincinnati, OH, Internal Report, 5 pp.
7. Federal Register [1996]. Health Standards for Occupational Noise Exposure in Coal, Metal, and Nonmetal Mines: Proposed Rule. Department of Labor, Mine Safety and Health Administration, 30 CFR Parts 56, 57, 62, 70, and 71, Vol. 61, No. 243, Tuesday, December 17.
8. Federal Register [1999]. Health Standards for Occupational Noise Exposure; Final Rule. Department of Labor, Mine Safety and Health Administration, 30 CFR Parts 56 and 57 et al., Vol. 64, No. 176, September 13, pp. 49548-49634.
9. Reeves, ER [2004]. Assessment of Noise Controls Commonly Used on Jumbo Drills and Bolters in Western Underground Metal Mines. SME Preprint 04-112, 7 pp.