LIMESTONE MINING – IS IT NOISY OR NOT?

E. R. Bauer, NIOSH, Pittsburgh, PA
D. R. Babich, NIOSH, Pittsburgh, PA

Abstract

National Institute for Occupational Safety and Health (NIOSH) researchers are conducting a cross-sectional survey of equipment noise and worker noise exposures in the mining industry. Surface and underground limestone is one commodity recently surveyed. The sound levels of mining and processing equipment were recorded to identify noise sources. Full-shift worker noise exposures were completed to determine the exposure of various occupations. This paper presents the results of the noise research conducted in both underground and surface limestone mines, detailing the equipment likely to cause worker overexposures, and the occupations experiencing overexposures. Implications for worker noise exposure reduction are also reported.

Introduction

Noise, which is any unwanted sound, is present throughout the mining industry. Continued exposure to high noise levels can cause damage to the inner ear. The eventual result is 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 sound 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 all miners have NIHL great enough to be classified as a hearing disability (NIOSH, 1996b). An analysis of NIHL in miners presents a snapshot of the extent of NIHL in the mining industry (Figure 1) (NIOSH, 1996b). This analysis of a private company's 20,022 audiograms indicates that 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 60 to 90% of the miners had a hearing impairment (NIOSH, 1996b and 1997).

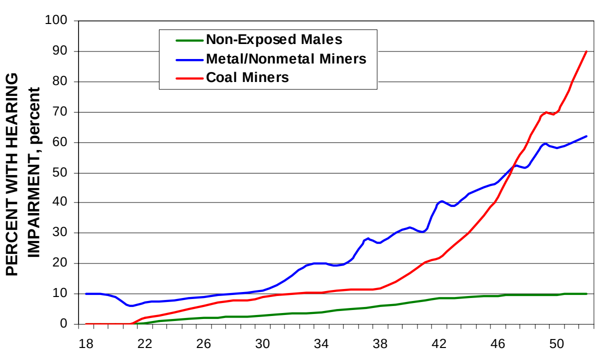

Figure 1. Hearing impairment in coal miners, metal/ nonmetal miners, and non-exposed males (males that never worked in the mining industry) (NIOSH, 1996b, 1997).

Despite 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, the Mine Safety and Health Administration (MSHA) published Health Standards for Occupational Noise Exposure (Federal Register, 1999). Requirements of the new regulation include the adoption of a hearing conservation program similar to that of the Occupational Safety and Health Administration (OSHA), with an "Action Level" of 85 dB(A) eight-hour time weighted average (TWA_8) and a permissible exposure level (PEL) of 90 dB(A) TWA_8. The new regulations also state that a miner's noise exposure measurement shall not be adjusted because of the use of personal hearing protection, and the requirement to use all feasible engineering and administrative controls for noise exposure reduction.

In an attempt to reduce NIHL in the mining industry, the NIOSH researchers have been conducting noise surveys in mining, including the limestone industry. The surveys are designed to monitor worker dose, measure equipment sound levels, and to understand the noise source/worker dose relationship. This was accomplished through full-shift dosimetry readings, equipment noise profiles, and where possible, worker task observations.

Scope of Research

Background

Noise surveys were conducted in one surface and three underground limestone mines located in eastern and western PA, and northern Maryland. In total, 43 worker noise exposures (MSHA PELs) and 71 equipment noise profiles were completed. Noise exposure measurements were taken for equipment operators, crushing plant operators, crusher operators, drill operators, scaler operators, blasters, mechanics, and laborers. The equipment noise profiles included stationary and mobile underground and surface mining equipment, control rooms, and crushing and screening facilities. In addition, the mobile equipment was monitored for noise (dose) inside and outside the cabs.

Instrumentation and Data Collection

The instrumentation consisted of two basic sound monitoring instruments: personal dosimeters and sound level meters (SLM). Worker noise exposure was monitored using Quest[1] Q-400 Noise Dosimeters. The workers donned a dosimeter for their full work shifts. The microphone was located at the middle of the shoulder per MSHA recommendations (CFR, 1998). The dosimeter was set to monitor an MSHA PEL of 100% or a TWA_8 of 90 dB(A) (Specific parameters of this setting include: A-weighting, 90 dB Threshold and Criterion Levels, 5 dB Exchange Rate, Slow Response, and a 140 dB Upper Limit).

Equipment noise profiles and area sound levels were recorded using a Quest Model 2900 SLM in combination with a Bruel & Kjaer 2260 Investigator. The SLM and Investigator were mounted side-by-side on a tripod (Figure 2), with the microphone 1.5 m (5 ft) from the mine floor (approximate ear height), angled at 70° from the source (per manufacturer

[1]Reference to brand names does not imply endorsement by NIOSH.

recommendations), and facing the sound source. Measurements were made on a 1- to 2-m (3- to 6-ft) grid, at a distance of approximately 1 to 2 m (3 to 6 ft) from the equipment. Sufficient measurements were made to delineate the sound levels both near and far from the equipment. The instruments were set up to monitor the A weighted Linear Equivalent Continuous Sound Pressure Level (Leq), a Linear 1/3-octave band frequency noise spectrum, a Linear Leq, and a C-weighted sound level. Of most importance was the Leq sound level, in decibels (dB), which is the average sound level for a measurement period based on a 3-dB Exchange Rate, which reflects the human ear's auditory capabilities. A slow response rate with an averaging time of 10 seconds was employed, with most readings being recorded over a 30-sec period.

Figure 2. Sound level meters.

Mine Characteristics

The four limestone mines surveyed included one surface and three underground mines. A similar mining sequence was used at all the mines which included drilling the face or bench, blasting the rock, and extraction using front-end loaders and haul trucks. The blasted material was transported to the crushing and screening facilities where it was processed into various sized aggregate for use in concrete and asphalt production, or for sale to end users. Mine production ranged from 318,000 to 1,360,000 t/a (350,000 to 1,500,000 tpy) of raw product, or 1270 to 8165 t/d (1400 to 9000 stpd). Employment at the mine sites ranged from 10 to 43 employees. The underground mines would be considered large opening, with heights in excess of 6 m (20 ft) and widths in excess of 12 m (40 ft). Underground equipment was both diesel and electric powered. No belts or crushers were located underground, but all mine sites had crushers, screens and surface belt facilities.

Results

Worker Noise Exposure

Workers at each site wore dosimeters for a full shift to provide noise exposure data. Table 1 lists the worker doses measured, including the outside cab doses for evaluation of cab effectiveness in preventing exposures from engine noise and equipment operation. A typical dosimeter location for outside cab measurements is shown in Figure 3.

Two general conclusions can be made from these data. First, all worker doses were below the MSHA PEL except for one of the laborers who spent the shift using an air wrench to tighten bolts while installing a sheet metal protective canopy at the drift mouth. Secondly, a comparison of the interior and exterior mobile equipment doses indicates that the equipment cabs are providing sufficient protection from noise for the operators.

Equipment/Area Noise Measurements

Sound level measurements were taken around all stationary equipment such as belts and belt drives, crushers, screens, ventilation fans, and around semi-stationary mobile equipment including scalers, and face and floor drills. Table 2 lists the results of the sound level measurements for both the surface and underground equipment. For convenience, equipment such as screens, crushers, and belt drives are lumped together by category even though they varied widely in size and product throughput.

Figure 3. Location of dosimeter outside of haul truck.

Table 1. MSHA PEL noise dose for limestone mine workers.

Occupation	No. of Recorded Doses	Worker Range MSHA PEL Dose, %	Outside Cab Range of MSHA PEL Dose, %
Haul Truck Operator	11	0.59 to 49.69	65.92 to 187.54
FEL Operator	9	0.34 to 64.21	59.04 to 262.79
Drill Operator	3	24.57 to 31.38	293.74 to 487.26
Scaler	3	1.18 to 50.23	162.32 to 208.96
Water Truck Operator	1	35.81	ND[1]
Crusher Operator	3	5.85 to 13.36	ND
Blaster/Blaster Helper	4	13.27 to 28.64	ND
Crushing Plant Operator	3	0.90 to 32.30	ND
Plant Helper/Laborer	5	17.50 to 119.27	ND
Mechanic	1	8.94	ND

[1]ND – Not determined.

Table 2. Sound level measurements at limestone mines surveyed.

Equipment	Location	Range Leq, dB(A)
Fans, Main and Auxiliary	UG[1]	75 to 109
Tamrock Ranger 500 Floor Drill	UG	91 to 102
Oldenburg Cannon Face Drill	UG	93 to 103
Gardner Denver MK45H Face Drill	UG	86 to 109
Gradall 5110 Scaler	UG	89 to 98
Gradall XL4300 II Scaler	UG	89 to 94
Blasters Bucket Truck	UG	76 to 81
Gorman-Rupp Diesel Water Pump	UG	89 to 98
Jaw Crushers	S[2]	72 to 102
Jaw Crusher Control Rooms	S	67 to 82
Cone Crushers	S	82 to 107
Plant Control Rooms	S	65 to 72
Screens, Single Deck	S	90 to 103
Screens, Double Deck	S	86 to 111
Screening Towers	S	86 to 107
Belt Drives	S	81 to 101
Surge Tunnels with Belts	S	87 to 101
Compressor Building	S	89 to 91
Plant Area Noise	S	67 to 101

[1]UG – Underground
[2]S – Surface

Figure 4. JOY axivane fan in underground limestone mine.

To illustrate the sound level measurements, several examples are included. Figures 4 and 5 include a photo and contour plot of sound levels around a JOY Axivane fan used for auxiliary ventilation underground. Sound levels up to 105 dB(A) were recorded adjacent to the fan and below 90 dB(A) at a distance of approximately 15 m (50 ft) from the fan.

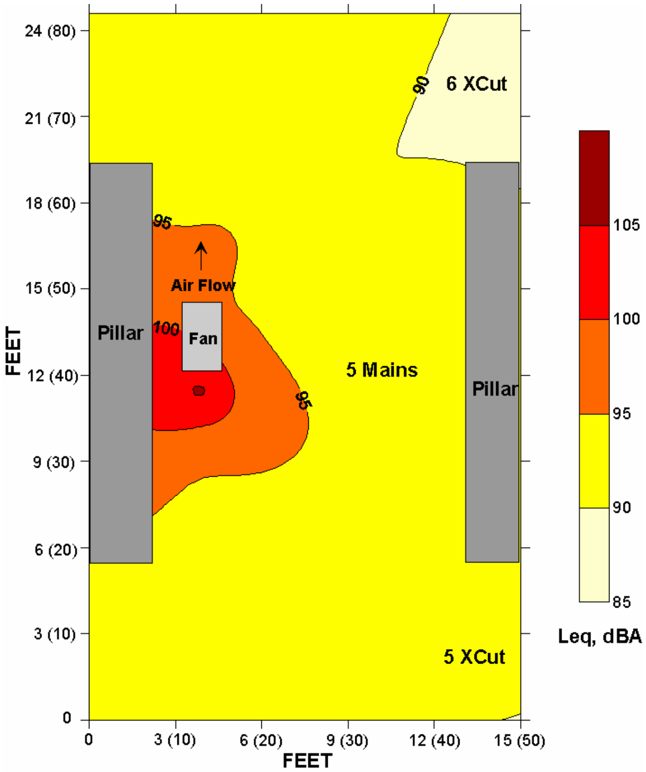

Figure 5. Sound contour plot for JOY axivane fan.

Figure 6 is a sound level contour plot for an Oldenburg Cannon face drill. The plot illustrates that even at a distance of 24 m (app. 80 ft) the sound levels are still 95 dB(A).

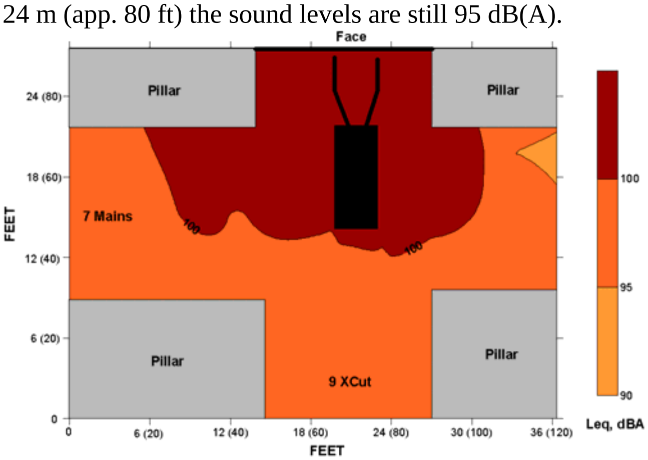

Figure 6. Sound contour plot for face drill.

A Nordberg cone crusher is illustrated in Figure 7. This crusher receives crushed rock from the primary jaw crusher. The contour plot illustrates that sound levels from 100 to 106 dB(A) were present on the platform around the crusher (Figure 8).

Figure 7. Nordberg cone crusher.

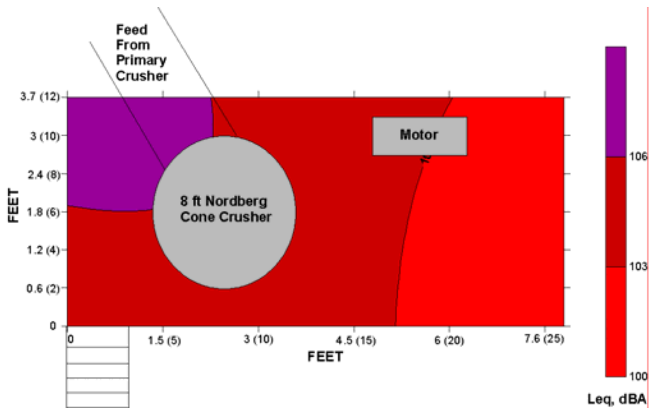

Figure 8. Sound contour plot for cone crusher.

A pair of screens positioned side-by-side is shown in Figure 9. The sound levels around these screens ranged from 85 to 97 dB(A) (Figure 10).

Figure 9. Double screens.

Finally, Figure 11 is an overall view of the surface crushing and sizing facilities for one of the underground mines. Figure 12 is the sound contour plot for this area, with all measurements made at ground level. It illustrates where the higher sound levels are and where hearing protection devices (HPDs) should be utilized.

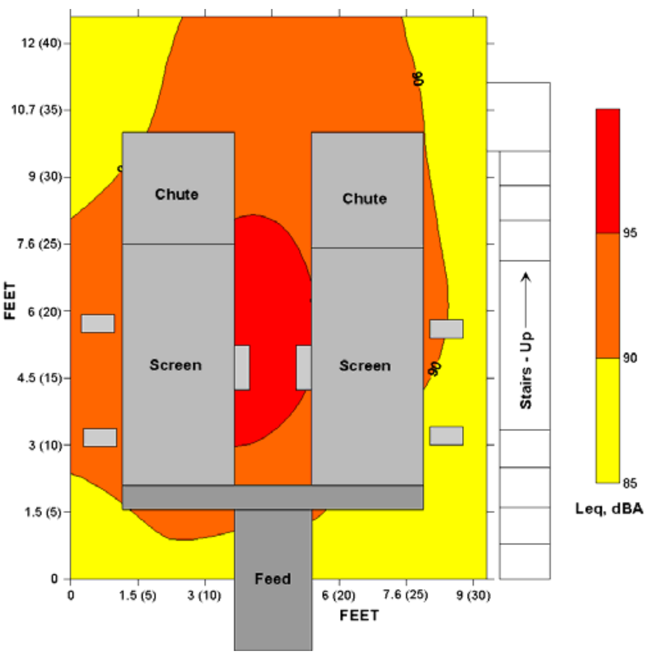

Figure 10. Sound contour plot for double screens.

Figure 11. Surface crushing and sizing facilities.

Research Implications

Even though only one worker overexposure was recorded, there are some important implications of this research with respect to NIHL in the mining industry. The differences between dose measurements inside and outside the mobile equipment cabs suggest that proper maintenance of the cab's noise controls (i.e., windows, door and panel gaskets, acoustical materials, mufflers, etc.) and keeping the doors and windows closed during operation is essential to

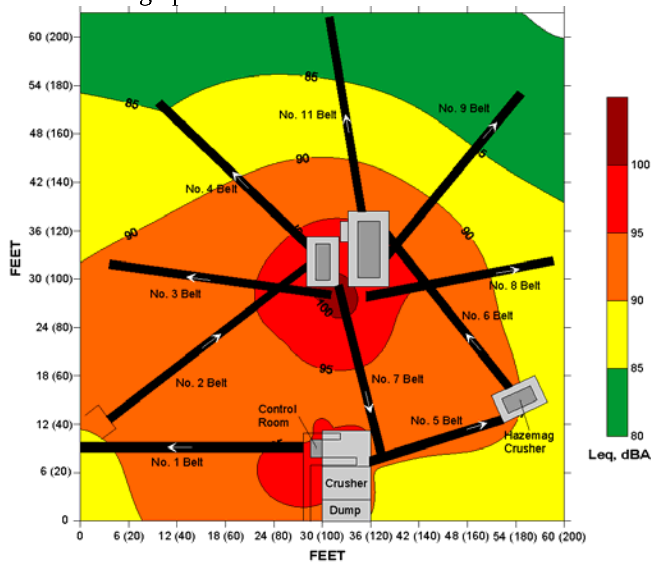

Figure 12. Sound contour plot for surface facilities.

limiting operator exposure. The equipment and area noise measurements confirm that areas of high sound levels are present in both underground and surface limestone mines. As such, high sound areas should be clearly marked, all workers should be made aware of these locations, and workers should be instructed to wear hearing protection at all times when working in these areas. Finally, there is some equipment, especially underground, that would benefit from the application of engineering noise controls. This would help to minimize the potential for exposure of workers in the immediate vicinity during equipment operation.

Summary

The noise measurements indicate that yes, limestone mining can be noisy, but exposure monitoring reported here indicates that the mine operators and workers are avoiding overexposures to noise. The mobile equipment used both underground and on the surface can generate high sound levels, but the cabs are effectively shielding the operators from the noise. The crushing and grinding facilities are also noisy, but workers seem to limit their activity in these areas, thus avoiding overexposure. The highest measured sound levels were near the underground fans and drills. Travel near these pieces of equipment while they are operating should be limited and should include the wearing of appropriate hearing protection.

References

1. Code of Federal Regulations (CFR) [1996]. Title 30, Mineral Resources, Subchapter O, Part 70.506, p. 419.
2. 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.

3. 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.
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 p.
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 p.
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 p.