OMSHR
Office of Mine Safety and Health Research

Reducing Miner’s Noise Exposure by Controlling the Noise at the Source

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• Introduction
• Noise exposure in the mining industry
• Noise control alternatives
• Noise Reduction at the Source: Case Studies
• Lessons learned
• Conclusion
Despite 30+ years of regulation, NIHL is still prevalent in mining.

Approximately 80% of miners have hearing impairment by retiring age.
Noise in the Mining Industry

Various noise sources underground:
1. Steel panel vibration.
2. Drills.
3. Conveyor chains.
4. Hydraulic pumps.
5. Ore/coal crushing machines.
6. Diesel engines and electric motors.
7. Scrubber and ventilation fans.
8. Dust control water sprays.

Conditions that contribute to the miner’s noise exposure:
1. Confined environments.
2. Powerful heavy duty equipment.
3. Close proximity of the miners to the machines.
Noise in the Mining Industry

% Reporting Hearing Protector Use

- **Mining**: 87%
- Food & kindred products
- Metal industries
- Furniture, lumber, & wood
- Utilities
- Paper products & printing
- Rubber, plastics, & leather
- Agriculture, forestry, & fishing
- Chemicals, petroleum, & coal products
- Transportation equipment

Note: Top 10 industries

% Reporting Hearing Difficulty

- **Mining**: 24%
- Railroads
- Primary metal
- Furniture, lumber, & wood
- Utilities & sanitary
- Transportation equipment
- Repair services
- Other non-durable goods
- Fabricated metal
- Machinery, except electrical

Note: Top 10 industries

NHIS & NHANES studies
Three different approaches to reduce miner’s noise exposure:

1. Noise control at the source.
2. Controls in the noise path:
   - Acoustic barriers
   - Acoustic absorbers
3. Controls at the receiver.
NIOSH Noise Reduction Process

Reduction in NIHL

- Long-Term Effectiveness
- Industry Usage

Technology Transfer

- Short-Term Effectiveness
- Development
- Needs Assessment
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Laboratory Facilities

Hemi-anechoic chamber
*Pinpoint noise source identification*

Auditory Research Lab

Acoustic Test Chamber
*Precision measurement of total sound power*

Hearing Loss Prevention Unit
Case 1: Roof Bolting Machine

- Roof Bolting Machines (RBM) are used to drill holes and install bolts in the roof of coal mines to provide roof support.
- Operated by two drillers and one helper.
- Typical noise levels measured at operator’s location are 96-100 dB(A).
Case 1: Roof Bolting Machine

Experimental Setup

- NSID test was conducted at the Hemi-anechoic chamber of NIOSH.
- A granite block was used to drill holes.
- A 42-microphone array was used to collect data.
Two noise sources were identified:

- At 4 to 8 inches below the drill steel media interface
- Above the drill chuck.

As the drill steel advances during drilling, the lower drill steel noise source advances with it, while the upper source essentially remains the same.
Developed Noise Controls

Noise controls at the source:
- Bit isolator – commercially available
- Chuck isolator – in development

The Bit Isolator:
- Consists of two steel cylinders with a rubber layer in between.
- Inserted between the bit and the steel.
- Provides 3-5 dB(A) noise reduction.
Case 1: Roof Bolting Machine

Developed Noise Controls

Control for the noise path:

- Bit isolator is an effective control but is not applicable in certain situations.
- For these situations a Collapsible drill steel enclosure was developed.
- Barrier between the source and receiver.
- Reduces operator noise exposure by 2-5 dB(A).
- Beginning with manufacturers for technology transfer.

Fully extended CDSE- 48 inches

Fully compressed CDSE- 11 inches

Collapsible Drill Steel Enclosure Around the drill steel
Case 2: Continuous Mining Machine

- Continuous Mining Machines (CMMs) are used to extract coal in room-and-pillar operations.
- Controlled by one operator and one helper.
- Typical noise levels measured at operator’s location are 101–103 dB(A).
Case 2: Continuous Mining Machine

Experimental Setup

Microphone Phased Array

- NSID was conducted at the Hemi-anechoic chamber of NIOSH.
- The conveyor chain and the scrubber fan were run simultaneously.
- A 42-microphone array was used for the test.
Case 2: Continuous Mining Machine

1/3-Octave Band Acoustic Maps: 1000 Hz

Most significant noise sources
Case 2: Continuous Mining Machine

Effect of Urethane Coated Chain

**Standard** Conveyor Chain at 1250 Hz

**Urethane Coated** Conveyor Chain at 1250 Hz
## Case 2: Continuous Mining Machine

Noise Reduction Obtained with the various Noise Controls

<table>
<thead>
<tr>
<th>Noise Control</th>
<th>dB(A)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard Chain</td>
<td>101</td>
</tr>
<tr>
<td>Dual Sprocket Chain</td>
<td>98</td>
</tr>
<tr>
<td>Urethane Coated Chain</td>
<td>95</td>
</tr>
<tr>
<td>Soft Urethane Coated Tail Roller</td>
<td>93</td>
</tr>
</tbody>
</table>

*All measurements taken in Hemi-Anechoic Chamber with Joy 14CM-9 at the Operators Position*
Case 2: Continuous Mining Machine

Industry Usage

- Manufacturer (Joy Global) redesigned conveyor chain.
- The dual sprocket chain is now the standard version offered.
- Latest sales indicate roughly 400 units in place representing 36% of the market.
- Outstanding success on such a large problem.

*322 chains installed and in service worldwide by 4/4/2012*

*311 installed in U.S. mines: 30% of all CMMs*
Case 3: Longwall Mining System

- Longwall Systems are sets of machines used to extract 50% of the national underground coal production.
- Controlled by three operators and one helper.
- Typical noise levels at operator’s location range from 100 to 105 dB(A).
- Two major noise sources are the shearer and the stageloader.
Case 3: Longwall Mining System

Approach

Experimental Modal Analysis

Operational Force Data → Input

Finite Element Model

Structural / Acoustic Response

Validated Output

Structural Modifications (Noise Controls)
Stiffening the face ring, outer vanes and bit assemblies

Measured coal cutting force cases

- Stiffeners on vanes and the face ring can lead to a 3 dBA noise reduction approximately
- We recommend this modification

Overall sound power level reduction


dB

2.7

3.5

3.7

0

0.5

1

1.5

2

2.5

3

3.5

4

Bit on vane at the discharge side

Bit on vane near face ring

Bit on face ring

Case 3: Longwall Mining System
Lessons Learned

- Effective noise controls can be developed for various mining applications.
- Miner noise exposure can be reduced and allowable exposure time increased with these controls.
- Sophisticated analysis and noise control technology is required to develop effective controls – using belting as a barrier is not effective.
Conclusions

- NIHL remains the second most prevalent disease in the mining industry.
- First line of attack is to reduce miner overexposure: Noise control at the source.
- Noise controls for various mining equipment have been developed and they are commercially available.
- The future of mining noise control is the design of quiet machines which requires cooperation with the equipment manufacturers.
Thank you.

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www.cdc.gov/niosh/mining
Case 2: Continuous Mining Machine

Tail Noise – Development of a Urethane Coated Tail Roller

Standard tail roller at 1000 Hz.

Coated tail roller at 1000 Hz.

Standard tail roller at 1250 Hz.

Coated tail roller at 1250 Hz.

www.cdc.gov/niosh/mining
**Case 3: Longwall Mining System**

**Panel Contribution Analysis**

- **Whole drum**
- **Cylindrical body**
- **Inner vane segments & face ring**
- **Outer vane segments**

Overall energy distribution:
- Cylindrical body
- Inner vane segments & face ring
- Outer vane segments

- The outer vane segments vibration contributes the most to the total noise radiation, and stiffening the outer vanes will lead to noise reduction.

www.cdc.gov/niosh/mining
Case 3: Longwall Mining System

Laboratory Tests

- Modal analysis (vibration) and sound power tests were conducted at NIOSH.
- Results obtained in the lab show potential for the noise controls to reduce the operator’s noise exposure.
- Underground evaluation to be conducted in March 2015.