Noise and Hearing Loss Prevention

Amanda Azman
November 15, 2011

The findings and conclusions in this report are those of the author and do not necessarily represent the views of the National Institute for Occupational Safety and Health.
Objectives

Introduction

Anatomy of the ear

The noise problem

Noise controls

Administrative controls

Hearing protection

What’s coming next?
Objectives

Introduction

The ear and hearing loss
Noise and mining
Noise controls
Administrative controls
Hearing protection
What’s coming next?
NIOSH Office of Mine Safety and Health Research
Originated in 1910 with the U.S. Bureau of Mines
NIOSH Office of Mine Safety and Health Research
A century of solutions for miners
OMSHR is an office within NIOSH

HHS
Department of Health and Human Services

CDC
Centers for Disease Control and Prevention

NIOSH
National Institute for Occupational Safety and Health

OMSHR
Office of Mine Safety and Health Research

MSHA
Mine Safety and Health Administration

DOL
Department of Labor
Organization of HLPB

HLPB

Noise Control Team
- Noise source identification
- Development of noise controls
- Implementation of noise controls
- Laboratory testing
- In-mine testing

Hearing Interventions Team
- Noise control evaluation
- Surveillance:
  - Audiometric
  - Noise exposure
- Technology dissemination
OMSHR strategic research areas

- Ground control
- Mine disasters
- Respiratory diseases
- Hearing loss prevention
- Surveillance and training
- Cumulative injuries
Hearing Loss Prevention Facilities

Hemi-anechoic chamber
*Pinpoint noise source identification*

Auditory Research Laboratory
*Hearing protector evaluation and subject testing*

Acoustic Test Chamber
*Precision measurement of total sound power*
Hearing Loss Prevention Unit

Hemi-anechoic chamber

Pinpoint noise source identification
Objectives

Introduction

The ear and hearing loss

Noise and mining

Noise controls

Administrative controls

Hearing protection

What’s coming next?
Our office is on the twelfth floor
Wavelength and Frequency

- **Wavelength**: physical distance between successive crests of a sound wave
- **Frequency**: number of wavelengths that occur within one second (Hz)
- **Pitch**: subjective perception of frequency
Ear Sensitivity

- Average healthy adult ear can perceive frequencies from 20 to 20,000 Hz
- The important frequencies for understanding speech are between 300-4000Hz
Intensity

• Intensity: amplitude or height of its sound wave
• Large range of pressures that the ear can perceive
  – 20 to 200,000,000 μPa
  – Logarithmic scale (dB)
• Loudness: subjective perception of the amplitude of a sound wave
The Ossicular Chain

Acts as a lever system
Structures of the Inner Ear

Cochlea - snail-shaped organ with a series of fluid-filled tunnels; converts mechanical energy into hydraulic and electrical energy.
**Hair Cells**

- Frequency-specific:
  - High pitch sounds = base of cochlea
  - Low pitch sounds = apex of cochlea
- Fluid movement within the cochlea causes membranes in the Organ of Corti to shear against the hair cells
Types of Hearing Loss

- **Conductive Hearing Loss:**
  - Obstruction of the ear canal
  - Ear infections
  - Ear wax impaction
  - Certain medical conditions

- **Sensorineural Hearing Loss:**
  - Overexposure to noise
  - Chemically induced
  - Auditory nerve malfunction
  - Presbycusis (age-related)
  - Other medical conditions
Noise-Induced Hearing Loss

- PAINLESS
- PROGRESSIVE
- PERMANENT
- PREVENTABLE
Tinnitus

Ringing, buzzing, chirping
Common with hearing loss
Also from certain medical conditions

NO single treatment for all causes of tinnitus
Hearing is tested with an audiogram

Pure tone test frequencies: 500 – 8000 Hz

Subjects respond to quietest audible level (hearing threshold)

Results are in hearing level decibels (dB HL)
An audiogram can show a “noise notch” of impairment at 4000 – 6000 Hz

Audiogram of an equipment operator tested in NIOSH mobile laboratory

- High frequency hearing loss “notch” at 4K
- Lower limit of normal
- Left and Right ears comparison

Frequency (Hz)

Hearing Level (dB)
NIOSH Hearing Loss Simulator shows what a noise-induced hearing loss sounds like.

**Normal**

Click on picture for sound

![Normal Frequency Bands](image)

Click to play sound

**Impaired**

25 years of 95 dB(A) exposure, 55-year old worker – noise “notch” at 4,000Hz

Click to play sound

**Severely Impaired**

25 years of 105 dB(A) exposure, 55-year old worker – noise “notch” at 4,000Hz

Click to play sound

Simulated effects of exposure, age, sex based on ANSI S3.44 method
Audiograms can be part of worker empowerment

- Confusing
- Misunderstood
- Lost

Audiometry (standard hearing test)
Fact sheet for hearing test subjects

Purposes of audiograms
Explanation of test frequencies and hearing levels
Do I have a hearing loss? How severe?
Causes of hearing loss
Basic prevention
Value of retaining test records

On the web:
http://www.cdc.gov/niosh/mining/pubs/pubreference/outputid2573.htm
Objectives

Introduction

The ear and hearing loss

Noise and mining

Noise controls

Administrative controls

Hearing protection

What’s coming next
NHANES survey: Mining has the highest prevalence of hazardous noise exposure.

- Mining: 76%
- Lumber & wood products
- Rubber, plastics, & leather products
- Utilities
- Repair & maintenance
- Metal industries
- Paper products, printing, publishing
- Construction
- Agriculture, forestry, & fishing
- Transportation equipment

Note: Top 10 industries.
NHIS & NHANES surveys:
Miners have hearing difficulty despite hearing protector use

% Reporting Hearing Protector Use

**Mining**: 87%

% Reporting Hearing Difficulty

**Mining**: 24%

Note: Top 10 industries
Objectives

Introduction

The ear and hearing loss

Noise and mining

Noise controls

Administrative controls

Hearing Protectors

What’s coming next
Hierarchy of Controls

1. **Control** noise at the source
   (Engineering Controls)

2. **Avoid** noise sources
   (Administrative Controls)

3. **Protect** your ears
   (Hearing Protection Devices)
“CAP the Noise” materials teach hierarchy of controls

CAP the NOISE
CONTROL noise at the source
AVOID noise sources
PROTECT your ears

WHAT MINERS CAN DO WHEN THEY ARE EXPOSED TO HAZARDOUS NOISE
CAP the NOISE
To Save Your Hearing

More than 150,000 miners have some degree of hearing loss. By age 60, more than 75% of coal miners have hearing loss from exposure to noise.

Once you have lost hearing due to noise, it’s permanent and cannot be reversed. Hearing loss is often not noticed right away because there is no pain or visible damage. Your risk of hearing loss increases every time you are exposed to too much noise.

Miners with hearing loss may experience:
- Difficulty hearing warning signals and equipment sounds
- Inability to understand what someone is saying
- Lost productivity and accidents
- Ringing or buzzing in the ears
- Sounds seeming dull or flat after leaving a noisy area
- Headaches, tinnitus, stress, and a feeling of isolation

Although mining is noisy, you don’t have to lose your hearing.

CAP the NOISE with the 3 part process:
1. CONTROL the noise at its source (Engineering Controls)
2. AVOID the noise source (Administrative Controls) then...
3. PROTECT your ears (Hearing Protection Devices)
Noise control treatments

• Source
  – Eliminate the source
  – Select quieter equipment
  – Replace or repair

• Path
  – Airborne noise
    • Barriers
    • Absorbers
  – Structure-borne noise
    • Vibration isolators
    • Vibration dampers
Analysis techniques

Source Path Contribution

Noise source identification with beamforming array
Continuous mining machine
Continuous mining machine coated chain reduces sound pressure level by 4 dB(A)

Standard chain: 103 dB(A)  Coated chain: 99 dB(A)
Roof bolting machine
Drill bit isolator developed and lab-tested

7 dB(A) noise reduction in lab testing

- Without isolator
- With isolator
Objectives

Introduction
The ear and hearing loss
Noise and mining
Noise controls

Administrative controls

Hearing protection

What’s coming next
Administrative Controls

- Remove worker from noise
- Relocate work areas
- Reschedule to reduce exposure time
- Rotate tasks
DOSES noise management software

Quickly identifies high-noise tasks, locations

Manual, CD, Technology News, web download released
NIOSH Hearing Loss Simulator

Benefits:

• Positive changes in beliefs
• Increased intention to conserve hearing
• Increased understanding of severity and susceptibility

On the web:
http://www.cdc.gov/niosh/mining/products/product47.htm
Objectives

Introduction
The ear and hearing loss
Noise and mining
Noise controls
Administrative controls

Hearing protection

What’s coming next
Hearing Protection Devices

HPDs reduce the level of noise exposure by attenuating the sound reaching the ear.

Noise Level minus HPD attenuation = Exposure

90 dBA - 20 dB = 70 dBA
Earmuffs

- Create a seal with your head around your ear
- Difficult with safety glasses and hard hats
- Attenuation is less affected by improper fit
- In hot areas, earmuffs can be uncomfortable.
Foam Earplugs

- Rolled and compressed for insertion
- Proper insertion is vital
- Variety of sizes and shapes available
- Hold in place so earplug can expand to fill the ear canal
**Premolded Earplugs**

- Soft flexible device with insertion stem
- Flanges seal against ear canal
- Reusable if kept clean
- May be less comfortable than foam earplugs
Semi-Aural Earplugs

- Earplugs connected by a plastic band.
- Designed to be stored around the neck.
- Convenient when noise is intermittent.
- Seal at the entrance to ear canal—not fully inserted.
Custom Fitted Earplugs

- Individually molded for each ear
- Precise earmold impression is necessary
- More expensive but reusable many times
Dual Protection

- Combination of ear plugs and muffs
  - Generally recommended for exposures of 8hr TWA of 105 dB(A)
  - Add 5 dB to the HPD with the higher NRR
Research has shown that ears are poorly protected due to improper earplug fit.

Source: Berger, Franks, & Lindgren, 1996
Simplified Roll-Pull-Hold instructions

Original

1. Roll
2. Pull
3. Hold

Simplified

1. Roll
   the earplug up into a small, thin "snake" with your fingers. You can use one or both hands.

2. Pull
   the top of your ear up and back with your opposite hand to straighten out your ear canal.
   The rolled-up earplug should slide right in.

3. Hold
   the earplug in with your finger. Count to 20 or 30 out loud while waiting for the plug to expand
   and fill the ear canal. Your voice will sound muffled when the plug has made a good seal.

Result: Better protection

On the web:
http://www.cdc.gov/niosh/mining/topics/hearingloss/earplug.htm
Fit testing is the only accurate way to determine the actual protection from HPDs

- NHCA-OSHA-NIOSH Alliance
  - Best practices document
  - Individual fit testing with hearing conservation program
- Variety of commercial fit test systems
  - Subjective or objective systems
  - Plugs, muffs or probed HPD
NIOSH QuickFit earplug tester

Inexpensive, reliable design uses off-the-shelf components

MP3 player containing test sounds

Housed in earmuff
Objectives

Introduction

The ear and hearing loss

Noise and mining

Noise controls

Administrative controls

Hearing protection

What’s coming next
Summary

• Topics covered
  – Mechanics of the ear
  – NIHL facts and prevention
  – NIOSH’s ongoing program for improved H&S

• Prevent NIHL now, or deal with it forever
Questions?

Amanda Azman
NIOSH/OMSHR/HLPB

AAzman@cdc.gov
412-386-6731

www.cdc.gov/niosh/mining

www.cdc.gov/niosh/topics/noise