Best Practices In Effective Hearing Conservation
Introduction

About Us

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Hazardous noise exposures occur

On the Job

Off the Job
Noise + Acoustics

Sound energy and damage risk follow a logarithmic scale.

Small increases in dB level represent enormous increases in noise level.

10 dB = 10x noise
20 dB = 100x noise
Noise + Acoustics

- 95 dB
- 92 dB
- 89 dB
- 86 dB
- 83 dB
Upper Action Level

$L_{8h}$

85 dB

8 hrs
$L_{8h}$

Upper Action Level

88 dB

4 hrs
$L_{8h}$

Upper Action Level

83 dB

12 hrs
EU Directive

87 dB ~ Exposure Limit
- Maximum allowable noise level in the ear with protectors

85 dB ~ Upper Action Level
- Hearing protectors required
- Audiometric evaluation made available to exposed workers
- Warning signs posted in noisy areas

80 dB ~ Lower Action Level
- Hearing protectors made available
- Training program for noise-exposed workers
- Audiometric screening made available to exposed workers
Factors in Achieving Protection

1. FIT

A worker who selects an HPD with an SNR of 30 but then removes that HPD for just … effectively reduced his 8-hour SNR to just …

2. WEAR TIME

30 dB

In noise exposures, small intervals of no protection quickly void large intervals of adequate protection.
Evaluating Noise Reduction

- 30 dB = 1000x
- 20 dB = 100x
- 10 dB = 10x
- 3 dB = 2x

8-Hour Workday
Hearing Protector Fitting
Hearing Protector Fitting

How much protection?
**Hearing Protector Fitting**

**Roll-Down Foam Earplugs**

1. **Roll**
   
   entire earplug into a crease-free cylinder

2. **Pull Back**

   pinna by reaching over head with free hand, gently pull top of ear up and out

3. **Insert**

   earplug well into ear canal and hold until it fully expands
Hearing Protector Fitting

Good Fit vs Bad Fit

Frequency in Hz

Attenuation in dB

Max Good Fit
SNR = 33dB

Max Poor Fit
SNR = 0dB
Exploding a Few Myths About ...

Here are the facts!

- Bigger is **not** necessarily better
- There is **no such thing** as a one-size-fits-all earplug or earmuff
- It is **impossible** to predict individual protection from labeled ratings, even if de-rated
- An earplug inserted only half-way does **not** offer half the protection
Evaluating Noise Reduction
Evaluating Noise Reduction

How much noise is reaching the ear of the worker?

<table>
<thead>
<tr>
<th>Noise Level</th>
<th>100 dBA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Package rating</td>
<td>25 dB</td>
</tr>
</tbody>
</table>

It’s completely UNKNOWN!
Evaluating Noise Reduction

Single Number Rating (SNR)

- A laboratory estimate of the amount of attenuation achievable by most users when properly fit
- A population-based rating — some users will get more attenuation, some will get less

The SNR is only a population estimate, not a predictor of individual attenuation.
Evaluating Noise Reduction

Determining the SNR

- 16 human subjects tested in a simulated industrial room
- Subjects fit their own protectors
- Tested with ears open / occluded at seven frequencies
- SNR calculated to be population average

A test subject in the Howard Leight Acoustical Lab, San Diego, CA, accredited by the National Voluntary Laboratory Accreditation Program (NVLAP)
Evaluating Noise Reduction

Real-World Attenuation ≠ Rating

Retraining and refitting resulted in an average 14 dB improvement for this group.

Real user attenuation <0 to 38 dB

192 Users of a Flanged Multiple-Use Earplug (Rating 27)

From Kevin Michael, PhD and Cindy Bloyer “Hearing Protector Attenuation Measurement on the End-User”
Evaluating Noise Reduction

Effect of De-rating

192 Users of a Flanged Multiple-Use Earplug (Rating 27)

Real user attenuation <0 to 38 dB

OLF credit for all earplugs

From Kevin Michael, PhD and Cindy Bloyer “Hearing Protector Attenuation Measurement on the End-User”
Evaluating Noise Reduction

RECOMMENDED DE-RATINGS

33 dB EARPLUG

France       - 8 dB
Germany      - 13 dB
Norway       - 21 dB
Sweden       - 0 dB
Using Leading Indicators
Lagging Indicators vs. Leading Indicators
Using Leading Indicators

New Measurement Technologies

Earplug Fit Testing

In-Ear Exposure Monitoring
Earplug Fit Testing

Provides an accurate, real-world picture of your employees’ hearing protector effectiveness.

- Selecting the right protector
- One-on-one training
- Makes published rating obsolete
**Complete Check**
- 5 freqs in each ear
- Best for new users, reliability checks
- ↑ accuracy, ↑ test time

**Quick Check**
- 1 critical freq in each ear
- ↓ accuracy, ↓ test time
- Can use with severe hrg loss

**Report Mode**
- Individual
- Historical
- Results by freq

**Fit Training**
- Videos
Earplug Selection

Please click the product buttons to select the earplug that you will use during the check.
Your safe exposure level with this type of earplugs is **105 dB**

**Extreme Noise**
Short, unprotected exposures cause hearing damage.

**Hazardous Noise**
Frequent, unprotected exposures can cause hearing damage.

**Required Protection Level**
Hearing protection recommended or required in most areas.

**Recommended Protection Level**
Protected noise exposures in this range are generally safe.

**Risk of Overprotection**
The earplugs you are using may be too protective, blocking sounds you need to hear such as warning signals and co-workers' voices.
Using Leading Indicators

Variation from Published Rating

Distribution of PARs

Published Rating

Distribution of PARs

Variation from Published NRR
Using Leading Indicators

**Personal Factors**
- Gender
- Age
- Years in Noise
- Ear Canal Size
- Familiarity
- Model of Earplug

**Program Factors**
- # Group Trainings
- # Personal Trainings

Result: One-on-one training was the only predictor of good protection
Result: Trying a second earplug often improves attenuation
# PROs & CONs of Fit Testing

<table>
<thead>
<tr>
<th>PRO</th>
<th>CON</th>
</tr>
</thead>
<tbody>
<tr>
<td>Estimate / Measure</td>
<td>Cost</td>
</tr>
<tr>
<td>Ratings Obsolete</td>
<td>Time Investment</td>
</tr>
<tr>
<td>Regulatory Compliance</td>
<td>Not Standardized</td>
</tr>
<tr>
<td>Eliminate De-Ratings</td>
<td></td>
</tr>
<tr>
<td>Medico-Legal Cases</td>
<td></td>
</tr>
<tr>
<td>Work-Relatedness</td>
<td></td>
</tr>
<tr>
<td>No Dual Protection</td>
<td></td>
</tr>
<tr>
<td>Employee Feedback</td>
<td></td>
</tr>
</tbody>
</table>

Using Leading Indicators
Using Leading Indicators

New Measurement Technologies

Earplug Fit Testing

In-Ear Exposure Monitoring
In-ear dosimetry measures/records worker’s actual noise dose, with/without protection.

Provides real-time monitoring and alerts when worker approaches safe limits.

Only leading indicator that directly prevents NIHL in real-time.
Using Leading Indicators

Dosimeter records …

• Good fit
• Bad fit
• No fit

Immediate feedback if exposure >95% limit
Using Leading Indicators

Sample Personal Exposure

Employee Exposure
n = 433 samples

Date
(30 months)
Preventive Action After NIHL

In practice, audiometric testing is *not* a preventive action ....

*It is documentation of a hearing loss after the fact.*

How soon will an employee suffering NIHL be re-fit / re-trained?

“Best case scenario” per Hearing Conservation regulations ...

In-ear exposure monitor “worst case” scenario ...

1 Day

- Audiometric test

- Retest • Notification

Years
Using Leading Indicators

Off-job + On-job = NIHL

Employee Exposure
n = 433 samples

Date
(30 months)
Intelligent Hearing Protection

- Fit verification of earplug
- Active Noise Reduction
- Impulse Noise Protection
- Speech Enhancement
- ComRadio Connection
- Personal exposure monitoring
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Bringing It Together
# Case Study #1: Flooring Manufacturer

## Noise Levels
- 105-112 dBA

## HPD Requirements
- 30+ dB protectors required!
- Dual Protection

## Key Challenges
- Reduce noise levels through engineering controls
- Diverse workforce
- Ensure workers wear hearing protection properly, especially in extreme heat/humidity
- Validate amount of attenuation each worker achieves

[www.safeinsound.us](http://www.safeinsound.us)
Tactic #1: Engineering Controls

<table>
<thead>
<tr>
<th>Location</th>
<th>Pre-Enclosure dBA</th>
<th>Post-Enclosure dBA</th>
<th>Hood Insulation dBA</th>
<th>Total Reduction dB</th>
</tr>
</thead>
<tbody>
<tr>
<td>F/16 #2</td>
<td>111.4</td>
<td>104.9</td>
<td>103.9</td>
<td>7.5</td>
</tr>
<tr>
<td>F/16 #6</td>
<td>110.8</td>
<td>102.7</td>
<td>101.8</td>
<td>9.0</td>
</tr>
<tr>
<td>F/16 #11</td>
<td>107.3</td>
<td>100.2</td>
<td>99.7</td>
<td>7.6</td>
</tr>
<tr>
<td>Packout Table</td>
<td>106.4</td>
<td>98.6</td>
<td>96.8</td>
<td>9.6</td>
</tr>
</tbody>
</table>

Photos courtesy of Shaw Inc,
Tactic #2: Earplug Fit Testing

• All workers showing a shift in hearing receive a fit-test as part of “retraining”

• All new (or re-hire) employees receive a fit-test prior to beginning work:
  • Find the appropriate earplug
  • Ensure proper fit

• Existing workers are ‘certified’ to a particular earplug, can ‘graduate’ out of double protection

“When an employee walks away, he knows how a good fit feels and sounds.”
Result: Distribution of Protection Levels Shifted

Personal Attenuation Rating (PAR)

PAR (in dBA)

# of Workers

Before

After
Bringing It Together

Result: Protected Exposure Level Shifted

- **Before Training:**
  17% achieve good fit

- **After Training:**
  78% achieve good fit (in-ear exposure 82 dB or below)

- **Two-thirds** of workers changed earplug model
## Result: Reduction in Hearing Loss

<table>
<thead>
<tr>
<th>Year</th>
<th>Confirmed Shift</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>2006</td>
<td>5</td>
<td>Prior to noise control</td>
</tr>
<tr>
<td>2007</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>2008</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>2009</td>
<td>1</td>
<td>Non-production associate</td>
</tr>
<tr>
<td>2010</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

### HC Program Improvements

- Expanded HPD offerings from 3 to 6 choices
- Employees happier with single protection
- Mandated job rotation in departments
- Emphasis on equipment maintenance
# Case Study #2: Aerospace

## Noise Levels
- 87-92 dBA TWA
- 102 dB peak common

## HPD Requirements
- 100% wear time when on plant floor (even walking through)

## Key Challenges
- High number of hearing shifts
- High intermittent noise exposures in enclosed spaces
- Moderately low TWA exposures
- Possible overprotection
Bringing It Together

**Tactic #1: Fit-Testing**

- Test Worker with Usual Earplug
  - "Fit the way you normally wear it."
  - **Pass > 15 dB**
- **Fit Training with Same Earplug**
- **Try a Different Earplug**

*Photo courtesy of Gulfstream Aerospace*
Bringing It Together

Result: Identifying workers with poor fit

One-on-one training until good fit is documented
Bringing It Together

Result: 120% improvement in protection levels

Goal of > 15 dB protection now achieved by nearly all workers
Bringing It Together

Result: Pre / Post Surveys

Pre-Test
How would you rate your ability to fit your earplugs?
73% - ‘Expert or Good’

Post-Test
After this fit-test, are you better able to fit your earplugs?
84% - ‘Yes’

Did you change your choice of earplugs as a result of the fit-test?
65% - ‘No’

“I’ll put a little more effort and get ‘em deeper!”

“I learned I’ve been using my earplugs wrong my whole career.”

“Amazed at difference with proper fit.”

“Just learned how to effectively roll the plug before insert.”

“Found the best ear protection to fit my ears I’ve ever had in 15 years in aviation.”
Bringing It Together

Result: Significant decline in hearing shifts

HC Program Improvements

- Manager buy-in very successful
- Inventory of offered earplugs was decreased / adjusted to fill size gaps
- Continued earplug fit testing in other business units
- Possible development of fit-testing kiosks / workstations throughout facility
- Explore additional opportunities for engineering noise controls
# Case Study #3: Offshore Platform

## Bringing It Together

### Noise Levels
- Frequent peak noise levels >110 dB
- Few engineering options

### HPD Requirements
- High SNR protectors

### Key Challenges
- Few noise control options
- 12-hour workshifts
- Situational awareness (‘I’m safer without my earplugs’)
- Hygiene / ease of insertion
- Compatibility with Com Radios
- Compatibility with other PPE
Bringing It Together

Tactic: Intelligent Protection

- Fit verification of earplug
- Active Noise Reduction
- Impulse Noise Protection
- Speech Enhancement
- ComRadio Connection
Results: Communication + Protection

Clear Two-Way Communication, Even in Extreme Noise

• Connected to two-way comm radios, in-ear microphones
• Users speak at normal level and can be heard without picking up environmental noises or compromising speech intelligibility
• Compatible with other PPE, including full-face respirators, helmets and other head protection
Hearing Loss Due to Noise Exposure Is...

- Painless
- Permanent
- Progressive

PREVENTABLE!