Reducing Hearing Loss in the Oilfield

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Director of Hearing Conservation
Noise & Acoustics
Noise-Induced Hearing Loss ...

Causes no pain
Causes no visible trauma
Leaves no visible scars
Unnoticeable in earliest stages
Accumulates with each overexposure
Takes years to notice a change

Is Permanent + 100% Preventable
## Noise + Acoustics

<table>
<thead>
<tr>
<th>Non-Occupational</th>
<th>Occupational</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="170dB" alt="Image" /></td>
<td><img src="140dB" alt="Image" /></td>
</tr>
<tr>
<td><img src="120dB" alt="Image" /></td>
<td><img src="112dB" alt="Image" /></td>
</tr>
<tr>
<td><img src="94dB" alt="Image" /></td>
<td><img src="100dB" alt="Image" /></td>
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<tr>
<td><img src="74dB" alt="Image" /></td>
<td><img src="85dB" alt="Image" /></td>
</tr>
<tr>
<td><img src="58dB" alt="Image" /></td>
<td><img src="60dB" alt="Image" /></td>
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</table>

- **160 dB** - Instant damage
- **120 dB** - Pain threshold
- **85 dB** - Action Level
- **60 dB** - Comfortable level

Painless Hearing Loss

Hearing damage possible
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
If you must **SHOUT** to be understood over background noise ... 

...when standing one arm-length away, that background noise is **HAZARDOUS**.
**Ototoxic Chemical Exposures**

**Confirmed Ototoxics**
- Ethyl Benzene, Lead and Inorganic Compounds (Pb)
- Styrene, Toluene, Trichloroethylene

**Possible**
- Carbon disulfide, n-Hexane, Xylene

**Synergistic Ototoxics**
- Carbon Monoxide
- Hydrogen Cyanide

- Synergistic effect with noise
- Large differences in sensitivity
- Recommend increased frequency of audiometric testing

*Image of workers wearing protective gear.*
How We Hear

The Auditory System

- **Sound waves** cause the eardrum to vibrate
- **Bones in middle ear** transmit vibrations to cochlea
- **Receptors** (hair cells) in cochlea convert vibrations to electrical energy
- **Brain interprets these electrical impulses as sound**
How We Hear

The Auditory System

• Nerve cells in the cochlea are tuned to specific frequencies

• Base of the cochlea is sensitive to high frequency sounds

• Tip of the cochlea is sensitive to low frequency sounds
How We Hear

The Human Cochlea

17-year old girl
• Low noise exposure
• Normal cochlea
• Receptors intact

76-year old man
• Low noise exposure
• Fewer receptors but still intact

59-year old man
• High noise exposure
• Damaged cochlea
• Receptors destroyed
How We Hear

High Frequency Sounds of Speech

TH
SH
S
F
H
CH
T
K
P
Normal Hearing is Understandable

LOUDNESS
How We Hear

NIHL Lacks Clarity

CLEARNESS
Noise in the Oilfield

Why is Oil & Gas Different?
Special Considerations for Oil & Gas

- 12-hour workshifts common
  - More susceptible to noise damage
- Intermittent high noise
- Ototoxic chemical exposures
- Communication is critical …
  "I’m safer without earplugs on my job"
- HPD cleanliness / ease of insertion critical
- Higher claims than most industries
- High off-the-job noise exposures
- Contractor compliance
- Different regulatory requirements
OSHA Noise Regulation - 29 CFR 1910.95

§

a-b Protection against the effects of noise shall be provided for exposures over 90 dB TWA (8 hour)
- Feasible engineering or administrative controls
- Personal Protective Equipment

1970’s

c-n Hearing Cons. Program instituted at 85 dB Action Level
- Noise monitoring
- Annual audiometric testing
- Determination of Threshold Shift
- Provision of Hearing Protectors
- Training
- Recordkeeping

1983

Oil & gas well drilling and servicing: exempt from c-n
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>
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<tr>
<td>Package rating</td>
<td>25 dB</td>
</tr>
</tbody>
</table>

It's completely UNKNOWN!
Hearing Protector Fitting

How much protection?

0 dB

0 dB

>33 dB
Evaluating Noise Reduction

NRR Rating

- 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 NRR is only a population estimate, not a predictor of individual attenuation.
Determining the NRR

- 10 human subjects tested in a simulated industrial room
- Earplugs fit by tester
- Tested with ears open / occluded at seven frequencies
- NRR 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)
Real-World Attenuation ≠ Rating

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

Real user attenuation <0 to 38 dB

From Kevin Michael, PhD and Cindy Bloyer “Hearing Protector Attenuation Measurement on the End-User”
Case Studies
Case Studies

Lagging Indicators vs. Leading Indicators
Case Studies

Beerenberg

**Operation**
- 2,000 employees
- North Sea / Houston

**Key Challenges**
- Hearing protectors required, but protection levels unknown
- Validate good protection
- Avoid overprotection (communication hazard)
Case Studies

Fit-Testing

Test worker with usual earplug
“Fit the way you normally wear it.”

Pass
>16 dB

Retrain with same earplug
Try a different earplug

Photo courtesy of Gulfstream Aerospace

by Honeywell
‘Fit the earplugs the way you normally wear them.’
- Protection levels from 4 – 40 dB
- 30% of workers obtain inadequate protection (15dB or less)

Post Training

95% good protection

Overall
20 > 26 dB

Low performers
9 > 22 dB
95% of workers protected by providing three different models of conventional earplugs

Custom-molded earplugs = no better protection than conventional

“A number of workers were astonished to experience the difference between a poor fit and a good fit of their hearing protector.”

“Positive long-term effect in … reducing or eliminating noise-induced hearing loss at the worksite.”

2012 HSE Annual Report
Case Studies

Linjebygg Offshore (LBO)

Operation

- 500 employees
- North Sea / Houston

Key Challenges

- Unacceptable high noise levels
- Limitations regarding maximum daily noise level doses
- Hard to find “Silent Work”
- Increase in hearing loss cases.
Case Studies

Intelligent Hearing Protection

**PRO**
- Clear communication in high, changing noise levels
- Active noise reduction, speech enhancement, impact noise reduction
- Increased situational awareness
- Connect with radios
- In-ear noise dosimetry

**CON**
- High cost
- Appropriate for specific applications or environments (ATEX)
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
Case Studies

Sample Personal Exposure

Employee Exposure
n = 433 samples

Full Shift Dose in %

Date
(30 months)
Case Studies

In-Ear Dosimetry

Sandblasting

- L - int
- R - int
- L - ext
- R - ext

Time (5 min intervals)

[Graph showing noise levels over time for different earplugs during sandblasting.]
Case Studies

In-Ear Dosimetry

- External mic: 2 minutes of sandblasting = max daily noise dose exceeded
- Internal mic (under hearing protector): after 20 minutes of sandblasting, exposure did not exceed 3% of max. daily noise dose
Case Studies

In-ear dosimetry can differentiate off-job exposures

Off-job + On-job = NIHL
Hearing Loss Due to Noise Exposure Is...

- Painless
- Permanent
- Progressive

PREVENTABLE!

Honeywell