Clinical Verification of Custom-Fitted Musicians Earplugs
Brian Fligor, ScD, Director of Diagnostic Audiology, Children’s Hospital Boston, Instructor in Otology and Laryngology, Harvard Medical School

Welcome

Moderator:
Carolyn Smaka, Au.D., Editor-In-Chief

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Wednesday, July 11th
Clinical Verification of Custom-Fitted Musicians Earplugs
Presented by Brian Fligor, ScD

Wednesday, July 18th
Protecting Musicians with Hearing Loss Against Employment Discrimination
Presented by Paul Morenberg, Esq., Attorney-at-Law

Wednesday, July 25th
Longitudinal Study of iPod Use with Field Dosimetry: Getting Closer to the Truth about Risky Listening
Presented by Cory Portnuff, Au.D., Ph.D.

Recorded Course Available July 2nd
It’s a Noisy World: Holistic Perspective of Noise Burden in Urban Populations
Presented by Rick Neitzel, PhD, CIH
Verification of Flat Attenuation Characteristics of Musicians Earplugs™

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Director of Diagnostic Audiology, Children’s Hospital Boston
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Paul Morenberg, Esq.
"Protecting Musicians With Hearing Loss Against Employment Discrimination" July 18: 12-1pm EST

Cory Portnuff, Au.D., Ph.D.
"Longitudinal Study of iPod Use With Field Dosimetry: Getting Closer to the Truth About Risky Listening" July 25: 12-1pm EST

Rick Neitzel, Ph.D., CIH
"It’s a Noisy World: Holistic Perspective of Noise Burden in Urban Populations” Recorded, On-demand

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- Kris Chesky, PhD, University of North Texas
- Cory Portnuff, Au.D, PhD, University of Colorado, ENT of Denver
- Frank Wartinger, AuD, All Children’s Health System/Johns Hopkins Medicine

Presented at 47th AES Conference, Music Induced Hearing Disorders: New Technologies for Measurement and Prevention (June 20-22, 2012 Chicago, IL)
Sound Exposures: Bamboozle Road Show, June 2010

<table>
<thead>
<tr>
<th>Leq* (dBA)</th>
<th>105</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time (hrs)</td>
<td>4</td>
</tr>
<tr>
<td>Noise dose**</td>
<td>5000%</td>
</tr>
</tbody>
</table>

Table 1. Total audience exposure

<table>
<thead>
<tr>
<th>Leq* (dBA)</th>
<th>99</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time (hrs)</td>
<td>7</td>
</tr>
<tr>
<td>Noise dose**</td>
<td>2198%</td>
</tr>
</tbody>
</table>

Table 2. Total crew exposure (4 hours show + sound check and setup)

* Leq is the typical 5-minute equivalent continuous sound level in A-weighted decibels
** DRC for determining “Noise dose” = 85 dBA for 8-hr Leq, 3dB exchange rate

Audiology Today MayJune 2011: pp 30-40

Noise-Induced Hearing Loss
Gradually Developing Noise-Induced Permanent Threshold Shift (NIPTS)
- 78 dBA - 130 something (?) dBA
- Outer hair cells
- Metabolic overload after duration of exposure
- Gradual loss in sensory hearing
- NITTS: recovery after a rest period

Acoustic Trauma (AT)
- 140 dB Peak SPL (132 dB SPL - Price, 1981)
- Usually from impulse: brief, fast rise time
- Can result from marked “overdose”
- Mechanical Damage after single exposure
- Immediate loss of sensory hearing

Injury from Chronic Noise Exposure:
- $F$(time & intensity)
- $F$(frequency) – A-weighting “network”

NIPTS (also NITTS):
- Hearing threshold decrease poorest in the 3000 – 6000 Hz range (4000 Hz Notch)

Other injuries in MIHD:
- tinnitus
- abnormal pitch perception (dipacusis)
- loudness intolerance (hyperacusis)
ONHS 1968-1972, NIOSH

Scatter Plot of Noise Exposure (level and years) of 792 workers

Risk for a “Material Hearing Impairment”
Max Noise Dose 85 dBA trade 3 vs. 90 dBA trade 5?

<table>
<thead>
<tr>
<th>Organization</th>
<th>TWA Noise Exposure</th>
<th>Estimated % at Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>ISO</td>
<td>90 dBA</td>
<td>21%</td>
</tr>
<tr>
<td></td>
<td>85 dBA</td>
<td>10%</td>
</tr>
<tr>
<td></td>
<td>80 dBA</td>
<td>0%</td>
</tr>
<tr>
<td>EPA</td>
<td>90 dBA</td>
<td>22%</td>
</tr>
<tr>
<td></td>
<td>85 dBA</td>
<td>12%</td>
</tr>
<tr>
<td></td>
<td>80 dBA</td>
<td>5%</td>
</tr>
<tr>
<td>NIOSH</td>
<td>90 dBA</td>
<td>29%</td>
</tr>
<tr>
<td></td>
<td>85 dBA</td>
<td>15%</td>
</tr>
<tr>
<td></td>
<td>80 dBA</td>
<td>3%</td>
</tr>
<tr>
<td>Prince, et al 1997</td>
<td>85 dBA</td>
<td>8%</td>
</tr>
</tbody>
</table>

Damage Risk Criteria

- OSHA
  - 90 dBA, 8-hr TWA
  - 5 dB Exchange rate

- NIOSH
  - 85 dBA TWA
  - 3 dB ER

- EPA / WHO
  - 80 dBA TWA
  - 3 dB ER

<table>
<thead>
<tr>
<th>90 dBA</th>
<th>8 hrs</th>
<th>85 dBA</th>
<th>8 hrs</th>
<th>80 dBA</th>
<th>8 hrs</th>
</tr>
</thead>
<tbody>
<tr>
<td>95 dBA</td>
<td>4 hrs</td>
<td>88 dBA</td>
<td>4 hrs</td>
<td>83 dBA</td>
<td>4 hrs</td>
</tr>
<tr>
<td>100 dBA</td>
<td>2 hrs</td>
<td>91 dBA</td>
<td>2 hrs</td>
<td>86 dBA</td>
<td>2 hrs</td>
</tr>
<tr>
<td>105 dBA</td>
<td>1 hr</td>
<td>94 dBA</td>
<td>1 hr</td>
<td>89 dBA</td>
<td>1 hr</td>
</tr>
</tbody>
</table>

LIBERAL → CONSERVATIVE
Damage Risk Criteria

- NIOSH
  - 85 dBA TWA
  - 3 dB ER

85 dBA | 8 hrs = 100% Noise Dose
88 dBA | 4 hrs = 100% 88 dBA, 8 hrs = 200%
91 dBA | 2 hrs = 100% 91 dBA, 8 hrs = 400%
94 dBA | 1 hr = 100% 94 dBA, 8 hrs = 800%
97 dBA | 30 min = 100% 97 dBA, 1 hr = 200%

Material Hearing Impairment?

NIOSH 1998 Definition:

> 25 dB HL Avg. 1k, 2k, 3k, and 4kHz

(What’s that like?)
Elements of a Hearing Loss Prevention Program (HLPP)

Application to music exposure

- Noise Survey (assessment)
- Engineering Controls
- Audiometric Monitoring
- Education and Motivation
- Hearing Protection Devices (HPD)

HPD: “Flat Frequency Attenuators”

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HPD: “Flat Frequency Attenuators”

“They told me these were flat, but I don’t think they are.”

Musicians Earplugs™ schematic design.
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Transfer Function of the Open Ear

Gain at Eardrum (dB)

Frequency (Hz)
"Real Ear" Probe Microphone sound level measures

Principle Complaint Against HPD

"Muffling"/ "Distortion"
- Change of timbre of music (change of harmonics relative to the fundamental frequency)
- Loss of natural ear canal resonance

Do these look (or sound) flat?
Refitted with ER-15

HPD: “Flat Frequency Attenuators”

“I can tell this is how they were supposed to sound!”

Verification of Flat Attenuation
Verification of Flat Attenuation

M. Killion, 6/22/12: used with permission

Table 3. Total audience exposure with hypothetical reduction in exposure from use of different HPD

Table 4. Total crew exposure with hypothetical reduction in exposure from use of different HPD

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