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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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AudiologyOnline Seminar Series 2012 Noise Induced Hearing Loss Seminar Series

- 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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- Elliot Berger, 3M
- Benj Kanters, Columbia College
- Kris Chesky, PhD, University of North Texas
- Cory Portnuff, AuD, 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)

Bamboozle Road Show, June 2010

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Sound Exposures: Bamboozle Road Show, June 2010

Leq* (dBA)	105
Time (hrs)	4
Noise dose**	5000%

Table 1. Total audience exposure

Leq* (dBA)	99
Time (hrs)	7
Noise dose**	2198%

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"

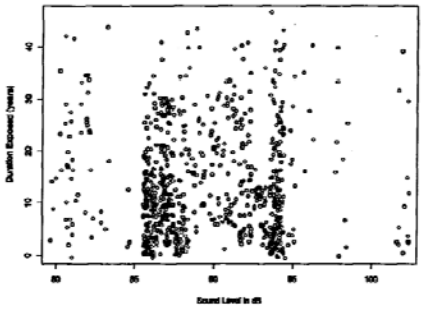
NIPTS (also NITTS):

− Hearing threshold decrease poorest in the 3000 – 6000 Hz range (4000 Hz Notch)

Other injuries in MIHD:

- tinnitus
- abnormal pitch perception (diplacusis)
- 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?

OSHA (1981): **Minimum Standard for Safety**

Organization	TWA Noise Exposure	Estimated % at Risk
ISO	*90 dBA*	*21%*
	85 dBA	*10%*
	80 dBA	*0%*
EPA	*90 dBA*	*22%*
	85 dBA	*12%*
	80 dBA	*5%*
NIOSH	*90 dBA*	*29%*
	85 dBA	*15%*
	80 dBA	*3%*
Prince, et al 1997	85 dBA	8%

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
90 dBA | 8 hrs	85 dBA | 8 hrs	80 dBA | 8 hrs
95 dBA | 4 hrs	88 dBA | 4 hrs	83 dBA | 4 hrs
100 dBA | 2 hrs	91 dBA | 2 hrs	86 dBA | 2 hrs
105 dBA | 1 hr	94 dBA | 1 hr	89 dBA | 1 hr

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Damage Risk Criteria

- NIOSH
  - 85 dBA TWA
  - 3 dB ER

85 dBA | 8 hrs = 100% Noise Dose

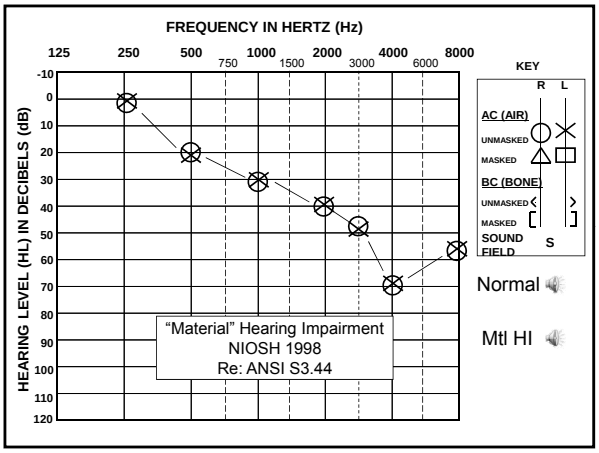
88 dBA | 4 hrs = 100%	88 dBA, 8 hrs = 200%
91 dBA | 2 hrs = 100%	91 dBA, 8 hrs = 400%
94 dBA | 1 hr = 100%	94 dBA, 8 hrs = 800%

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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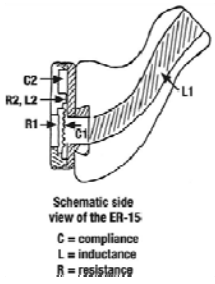
"They told me these were flat, but I don't think they are."

HPD: "Flat Frequency Attenuators"

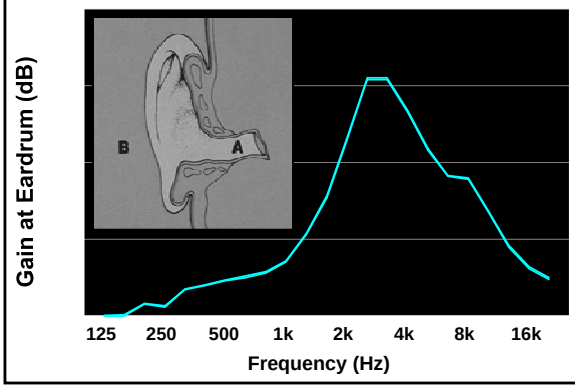


Schematic side view of the ER-15

C = compliance
L = inductance
R = resistance

Musicians Earplugs™ schematic design.

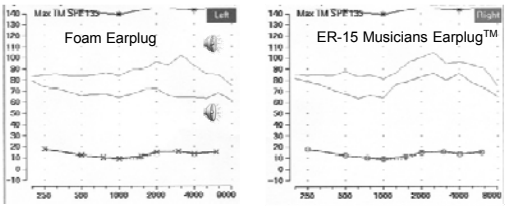
Transfer Function of the Open Ear



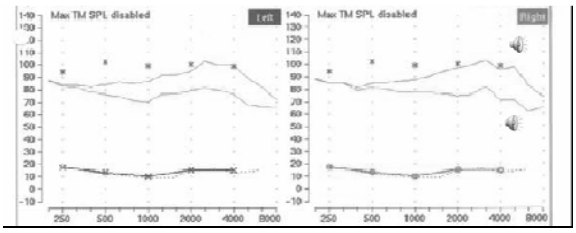
"Real Ear" Probe Microphone sound level measures

Principle Complaint Against HPD

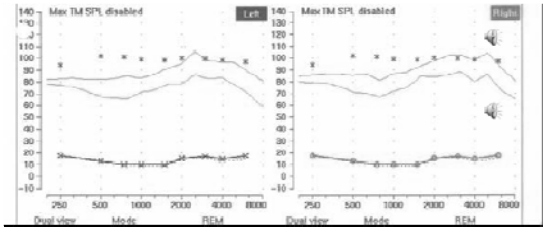
"Muffling"/ "Distortion"
- Change of timbre of music (change of harmonics relative to the fundamental frequency)
- Loss of natural ear canal resonance



Do these look (or sound) flat?



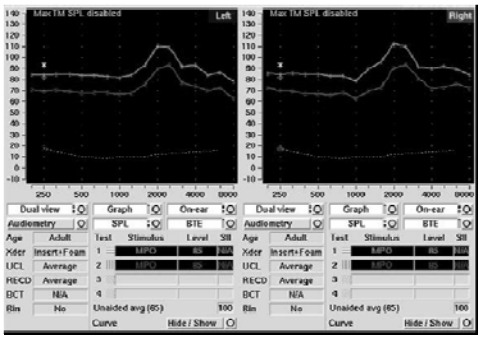
Refitted with ER-15



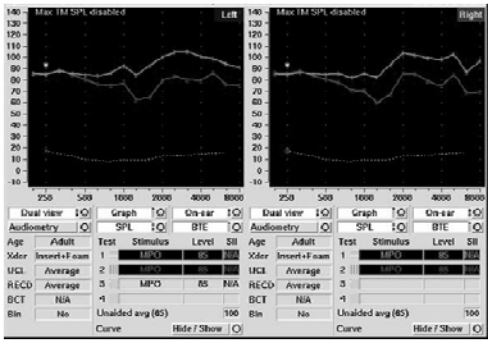
HPD: "Flat Frequency Attenuators"

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

Verification of Flat Attenuation



Verification of Flat Attenuation



Killion, DeVilbiss and Stewart (1988): ER-15 Performance Characteristics

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

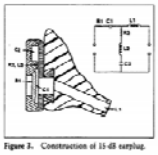


Figure 3. Construction of 15-dB earplug.

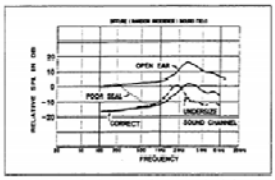


Figure 8. Expected eardrum SPL with ear open and with three constructions of ER-15 earmold.

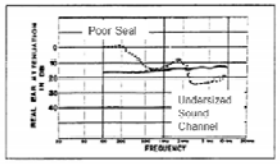


Figure 9. Calculated ER-15 performance vs. earmold construction: (—) correct (3.5 mm) sound channel, well-sealed; (. . .) poor seal, equivalent to 0.028" vent hole; (– – –) undersized sound channel (2 mm dia.).

Hypothetical Protected Sound Exposures: Bamboozle Road Show 2010

Leq (dBA)	105
Time (hrs)	4
Noise dose*	5000%
w/ ER9 (-9dB)	629%
w/ ER15 (-15dB)	158%
w/ ER25 (-25dB)	16%
w/ foam (-20dB)	50%

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

Leq (dBA)	99
Time (hrs)	7
Noise dose*	2198%
w/ ER9 (-9dB)	277%
w/ ER15 (-15dB)	70%
w/ ER25 (-25dB)	7%
w/ foam (-20dB)	22%

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

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