The role of active and passive hearing protection in hearing loss prevention for musicians

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Established in 1983 as a Research & Product Development Company

- Small Company located in NW Suburbs of Chicago
- >100 patents awarded
- Etymotic means "true to the ear"

Components of a hearing loss prevention program

- Recommended sound exposure limits: noise standards
- Musicians' sound exposures: level, duration and dose
- Potential auditory consequences of over-exposure
- High-fidelity active and passive earplugs: benefits & limitations
- Audiologic management

Factors Affecting NIHL, MIHL: It's All About Risk Reduction

- Intensity, duration & frequency of high sound exposures (how loud, how long & how often)
  - Music & other sound exposures
  - Gunfire is the most damaging
- Individual factors that may put an individual at higher risk for hearing disorders
  - Genetic predisposition
  - Environmental (chemicals, solvents)
  - Medical (ototoxic medications)
  - Health status (cardiovascular function, diabetes)

Recommended Exposure Limits

For the Average Person

Source level, dB	85	88	90	92	94	95	97	100	105	110	115	120
OSHA	16		8	6		4	3	2	1	½	¼	1/8
NIOSH	8	4			1	¾	½	¼				

- Exchange rate: NIOSH 3 dB / OSHA 5 dB
  - Exposures shown are assumed to carry equal effect/risk for the auditory system
- Standards were created for industrial exposures, and assume non-occupational quiet (40-hour work week)

Measuring Sound Levels/Exposures

- Sound level meter
  - Measures sound at a single point in time
  - Compare level to standard

- Personal noise dosimetry
  - Measures sound continuously over time
  - Displays noise dose

Why use dosimetry?

- Wide variations in sound exposures, both occupational and non-occupational (leisure)
- SLMs measure at a single point in time
  - complicated to combine exposures
- Potential for greater accuracy
  - Dosimeters measure and integrate sound levels over long durations

Noise Dose Defined

- Exposure level over time, expressed as a percentage of a predetermined "maximum"
- A limit or description of accumulated sound
- A dose of 100% corresponds to exposure at the criterion level and time
  - NIOSH: 85 dBA, 8 hours
  - OSHA: 90 dBA, 8 hours
- Noise dose never ↓; it only increases

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Level, Duration & Dose: NIOSH vs. OSHA

NIOSH (1998)

Level (dBA)	Duration (Hours)	Dose %
85	8	100
88	4	100
91	2	100
94	1	100
97	30 min	100
100	15 min	100

OSHA (1983)

Level (dBA)	Duration (Hours)	Dose %
90	8	100
95	4	100
100	2	100
105	1	100
110	30 min	100
115*	15 min	100

*NIOSH 115 → 30 seconds

Noise Dose: Recommended Limits

- 500% per week (I'm assuming NIOSH)
  - 100% per day x 5 days
  - (NOT 100% per day x 7 days!)
- ~2,000% per month
  - 500% per week x four weeks
- 26,000% per year
  - 500% per week x 52 weeks

"Safe" Sound Exposures

- Neither NIOSH nor OSHA protects 100% of people
  - Concept of excess risk and risk reduction
  - Genetic predisposition (tough vs. tender ears)
  - Environment (chemicals, solvents)
  - Medications (chemotherapy, painkillers, etc.)
  - Health (cardiovascular, diabetes)
- Risk is negligible for noise exposures <75 dBA $_{Leq8}$
- Median avg daily sound exposures: 77-79 dBA $_{Leq8}$ (Flamme et al., IJA 2012)

What are typical exposures in the music industry?

- Instrument/s played
- Type of music being played
- Acoustics of the venue
- Amplification
- Location relative to other instruments and amplifiers
- Asymmetrical exposures are common

Musical Instruments

Alto Sax	110 – 113 dB	Piccolo	102 – 112 dB
Bass Drum	100 – 122 dB	Snare Drum	102 – 113 dB
Bassoon	80 – 93 dB	Tenor Sax	110 – 115 dB
Clarinet	93 – 119 dB	Trombone	106 – 113 dB
Cymbals	118 – 121 dB	Trumpet	109 – 120 dB
Flute	100 – 112 dB	Tuba	110 – 117 dB
French Horn	92 – 104 dB	Violin	85 – 105 dB
Oboe	74 – 102 dB	Viola	85 – 105 dB

Other Typical Sound Levels

65 dB SPL	Conversation
88 dB SPL	Rug shampooer
93 dB SPL	Subway
98 dB SPL	Nightclub
105 dB SPL	Motorcycle, FF helmet, 60 mph
103-108 dB SPL	Sporting event, NASCAR
112 dB SPL	Rock concert

Berger et. al, 2011: Noise Navigator v1.5

Noise Dosimetry Examples:

- Quads (Orchestra): 1 hour = 220%
- Cymbals (Orchestra): 30 min = 180%
- Snare drum (Band room): 45 min = 1500%
- Quads – (Drumline): 2 hours = 5200%

Music-Induced Hearing Disorders

- TTS, PTS
- Tinnitus*
- Hyperacusis
- Diplacusis

Kujawa and Liberman:
"Age Related Hearing Loss: Evidence of a Misspent Youth" (2006)
"Adding Insult to Injury: Cochlear Nerve Degeneration After 'Temporary' Noise-Induced Hearing Loss" (2009)

Mice experiments summary:

- 2 hours @100 dB (producing 40 dB TTS 2 hours post exposure)
- Threshold, DPOAE, and ABR recovery in 8 days
- Loss of ≈ 50% of cochlear synaptic terminals at one day (!)
- Loss of ≈ 50% of ganglion cells at 64 weeks
- DPOAEs still normal at 64 weeks

"Temporary" noise-induced hearing damage isn't necessarily temporary:

- OHCs recover; normal thresholds, OAEs, ABRs
- Dramatic, irreversible degeneration of pre & post synaptic elements of the inner hair cells and spiral ganglion cells
- These changes aren't seen until weeks or months post-exposure
- NIHL has progressive consequences that we can't measure and that don't manifest until long after the exposure
- Noise-exposed ears age differently (worse!)

Reducing Musical Exposures

Source	Environment	Listener
Mute	Risers	Location
Practice Pad	Shields	Reduce Time
Play Softer	Absorption	Earplugs

Earplugs play a critical role in reducing noise exposures for those in the music industry

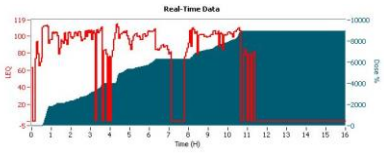
How much protection is needed?

(Ideally, enough to acceptably reduce risk of MIHD)

- More isn't necessarily better; sometimes more is worse
  - Overplaying
  - Misuse or nonuse
- Those in the music industry need to hear clearly
- Choose the least amount that will adequately protect
- 10 dB of actual protection extends allowable exposure time by a factor of 10
- 20 dB of actual protection extends allowable exposure time by a factor of 100

Noise Dosimetry: Examples

Phantom Regiment, Center Snare
Rehearsal Day (11 hours): 8900%



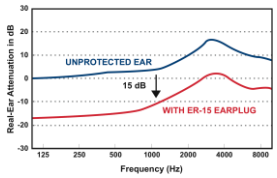
Noise Dosimetry: Examples

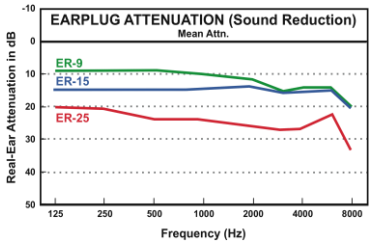
Cuban Rumba (Drums)
4 hours: 280% Dose

High fidelity: reproduces the same response as the original, just quieter

- Wiener & Ross, 1946:
  - Sound entering the ear is amplified by approximately 15 dB at 2800 Hz
  - TFOE, REUG
- Placing an earplug into the ear removes this resonance, making music sound muffled or unclear
- High-fidelity earplugs reproduce normal average pinna/canal resonance
- Flat attenuation earplugs provide the same amount of sound reduction across frequency

High fidelity earplugs maintain the average canal resonance (TFOE, REUG)





Recommended High-Fidelity Earplugs

	ER-9	ER-15	ER-25	ER-20 Extend.	Harmful Sound Comes From:
Small strings	●	●	●		Own instrument, other strings
Large strings	●	●	●		Brass
Woodwinds		●	●		Brass, percussion
Brass		●	●	●	Own instrument, other brass
Flutes		●	●		Percussion
Percussion		●	●	●	Own instruments, other percussion
Vocalists	●	●	●		Own voice, speakers, monitors
Acoustic guitar	●	●	●		Drums, speakers, monitors
Amplified instruments		●	●	●	Speakers, monitors
Marching bands		●	●		Multiple sources
Music teachers		●	●		Multiple sources
Recording engineers		●	●		Speakers, monitors
Sound crews		●	●		Speakers, monitors

Ref: Chasin, M. *Musicians and the Prevention of Hearing Loss*. Singular Publishing Group. 1996.

Earmold Impression Techniques

- Ear canals should be free of cerumen
- Impressions must be deep--past the second bend
- Cotton or vented otoblocks
- Silicone impression material
- Jaw movement and instrument use
- Remake impressions if they're not long & completely filled

Ordering Options: Filters

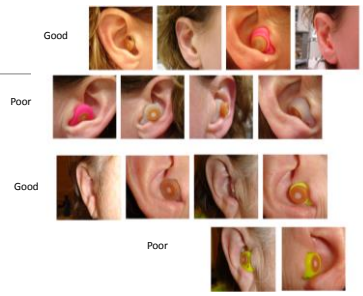
- ER-9, ER-15, ER-25
- Filters are interchangeable
- 100% QC checked by our lab

Musicians Earplug Fitting, Use and Care (This requires an appointment!)

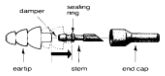
- Musicians Earplugs are one part of a hearing loss prevention program
  - Annual history, audio, OAEs, earmold check
- Lubricant (Otoease), wearing schedule
- Verify earmold fit and attenuation
- Counsel re: adjustment & adaptation
- Care of filters and molds

Visual Inspection of Earmolds

- Sound bores; earmold length and uniformity
- AMM results: 500-750 mV?
- Does the filter fit snugly and not pop out?
- Aesthetics



High-Fidelity ETY-Plugs®



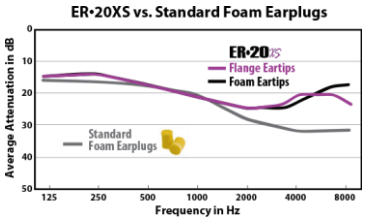
- Low cost, ready-fit
- Two sizes:
  - Standard Fit (blue or frost tips)
  - Large Fit (white tips)
- A tuned resonator and acoustic resistor replicate the response of the open ear

ER-20®xs Universal Fit Earplugs

ETY·Plugs: Fitting and Care

- Insert deeply
- Break seal, then remove
- Clean eartip with a wipe
- Replace as needed (3-6 mos for flange tips)

ER·20XS vs. Standard Foam Earplugs



How do you know you've "done it right?"

- Stable hearing thresholds, OAEs, tinnitus
- The patient wears the earplugs consistently & reports good sound quality
- Performance measures
  - Seal, attenuation
  - Occlusion effect
  - Fit, comfort, cosmetics

Why doesn't everyone use HP?

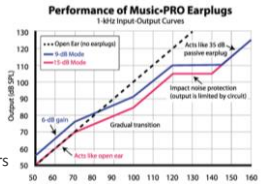
- "Hearing loss" isn't meaningful unless it's sudden and/or severe (focus on tinnitus prevention?)
- Access to high-fidelity earplugs
- Concern about sound quality
- Need to hear quiet sounds
- Being perceived as "different" or "weak"
- HABIT

Electronic Hearing Protection: Preservation and Enhancement

- Some situations require:
  - Normal or enhanced hearing for quiet sounds
  - Ongoing protection from steady loud sound
  - Protection from transient loud sounds
    - Military , Law Enforcement
    - Hunting, Shooting
    - Industry, Construction
    - Music Industry

Music-Pro® 9-15

- Like having two Musicians Earplugs in one
- Handles high inputs without distorting
- Adaptive release time
- High fidelity; tested by the NSO
- Directors, educators, performers



Electronic Hearing Protection: How it Works

- Electronics:
  - Audibility for quiet sounds
  - Protection from loud steady-state sounds
- Peak Clipping:
  - Instantaneously limits transients (109 – 115 dB MPO)
- Eartips:
  - 35-40 dB blast protection
  - Deep insertion reduces "piston" movement in the ear

Music-PRO® 9-15

- Assortment of noise-isolating eartips
- Neck cord
- 1 pkg 312 batteries
  - Battery life 2-3 weeks continuous use
  - LOBAT
- Filters, filter tool, cleaning tool
- Protective case
- 1-Year Warranty

Music-PRO® 9-15

- 15 dB mode (switch toward battery)
  - Transparent for soft sounds
  - 15 dB reduction for sustained loud sounds
  - Instantaneous impact protection
- 9 dB mode (switch away from battery)
  - 6 dB gain for soft sounds
  - 9 dB reduction for sustained loud sounds
  - Instantaneous impact protection

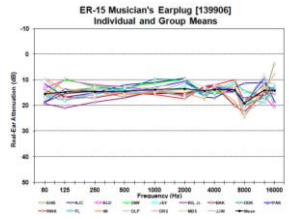
NRR (Noise Reduction Rating) = 25 dB

- NRR doesn't represent protection when worn
  - NRR is calculated with the device OFF
  - Protection depends on the input level, and no single number reflects that
  - NRR doesn't represent safety (awareness)
- Extensive testing revealed better protection, directional hearing, and higher fidelity compared to other earplugs

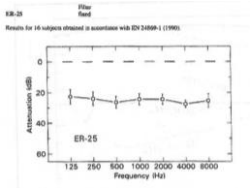
*But do they really work?

AND WILL MUSICIANS USE THEM?

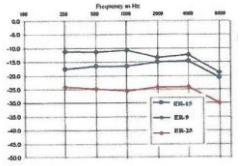
1989 REAT data from EARCAL Lab



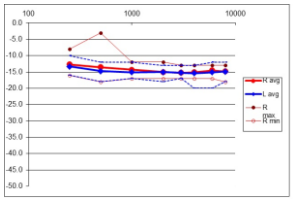
1997: TNO, Holland



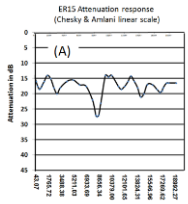
2009: PZT GmbH, Germany



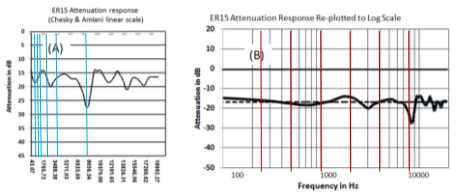
2012 Real-Ear Measures (ER-15): Chasin



Chesky & Amlani, 2015

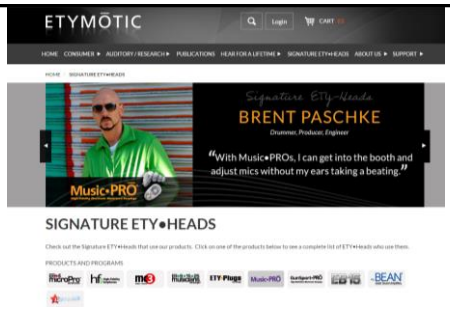


Scale: It Matters



Will Musicians Use Earplugs?

- Fit is critical for custom products
  - Poorly made or poorly fitting earplugs will not perform as advertised
- Some users require adaptation time
  - 10,000 hours required for "expert" performance
  - Musicians develop an internal reference for loudness (how things "should" sound)
  - Younger users tend to adapt more quickly, although many seasoned musicians also adapt quickly
- At high sound levels the ear overloads & distorts; hearing protection can reduce overload distortion and allow the musician to hear the instruments more clearly



Etymotic's Adopt-A-Band Program

- Education, advocacy & hearing protection
  - Educational videos, SoundRules
  - Quantity pricing on earplugs
- Available for any type or size musical group
- Over 400 groups participating
  - DCI award-winning Cavaliers
  - The Ohio State University Marching Band

Resources: www.etymotic.com

Conclusion

- Those in the music industry are often at risk for NIHD/MIHD
- Hearing protection is a necessary component of a prevention/risk reduction program
- Treat musicians with respect; treat the whole person (not just sending them earplugs)
- When fit correctly and with adaptation if needed, musicians can be successful users of hearing protection

Contact information

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