

Hearing Loss Prevention for Musicians

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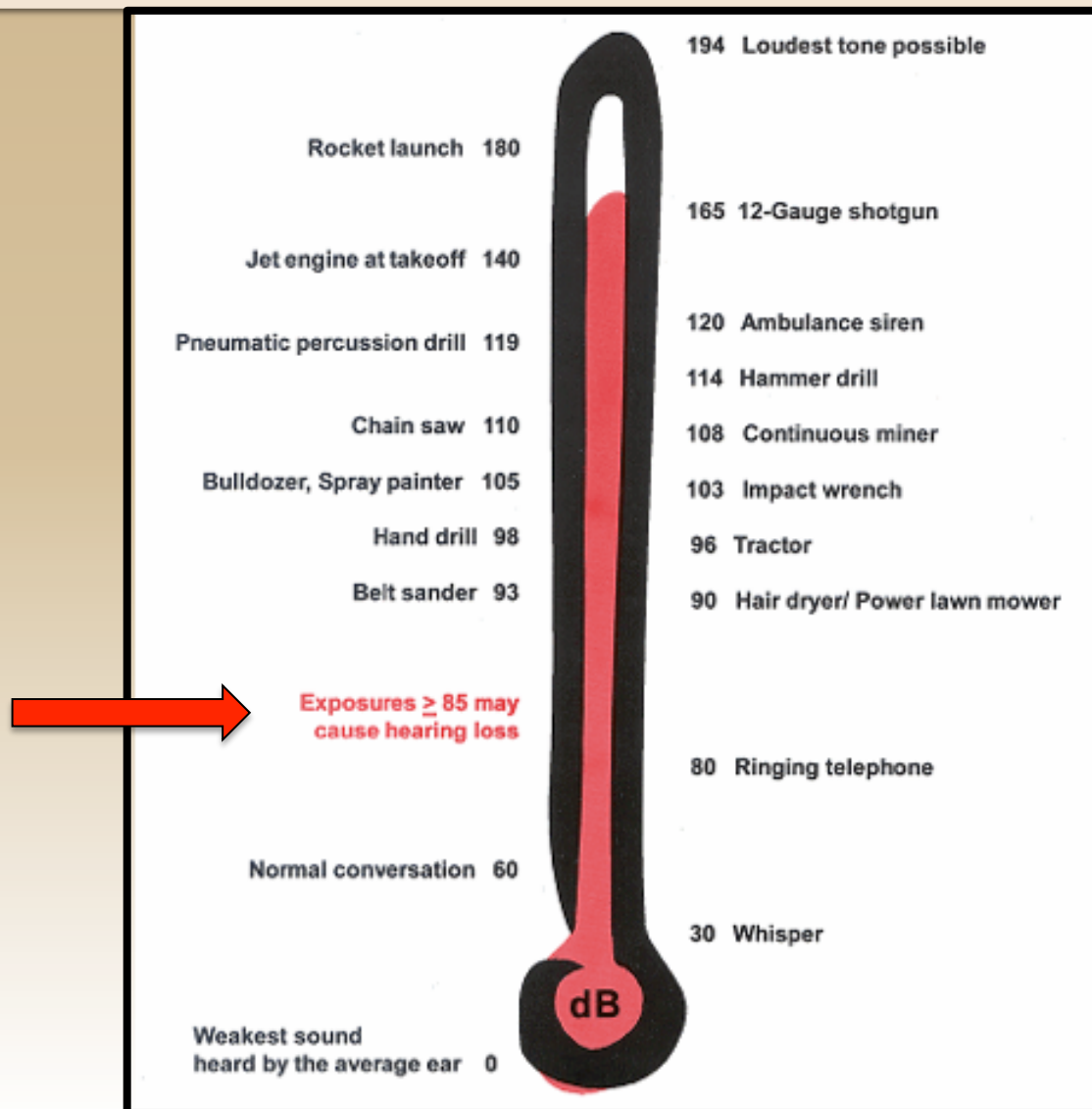
*National Aeronautics and Space Administration
Office of the Chief Health and Medical Officer*



Repeated long-term exposure to high sound levels causes hearing loss

- Industrial (workplace) noise
- Shop equipment and power hand tools
- Lawn care equipment
- Sporting events
- Motor sports events
- Recreation (snowmobiles, ATVs)
- Bars and clubs
- Exercise-related noise (group classes, mp3 player)

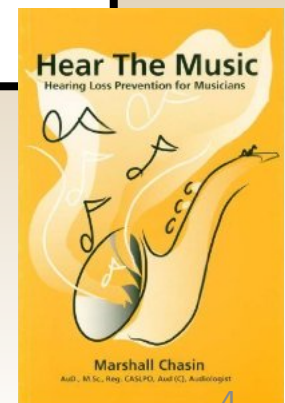
Sound levels of common sources



Can music cause NIHL?

Loudness Level	dB SPL
ppp	40 - 50
pp	45 - 55
p	50 - 60
mf	55 - 70
f	70 - 80
ff	80 - 90
fff	90 - 110

From Marshall Chasin's Hear the Music (2010)
< \$10 from Amazon.com




Damage-risk criteria for noise-induced hearing loss (NIHL)

- Hearing loss risk is based on cumulative “dose”
 - Sound level (in dBA)
 - Duration of exposure
 - Different mechanism from acoustic trauma due to single extreme exposures (e.g., blast noise)
- As level increases, allowable level decreases
- Accepted criteria based on industrial noise data
 - 85 dBA for 8 hours (40 hours/week)
 - 3 dB Exchange Rate: 85 dBA TWA (referred to as 85/3)
 - All sources of noise 24/7 contribute

85 dBA/3 equivalent exposures

Continuous dB	Permissible Exposure Time
85 dB	8 Hours
88 dB	4 hours
91 dB	2 hours
94 dB	1 hour
97 dB	30 minutes
100 dB	15 minutes
103 dB	7.5 minutes
106 dB	3.75 minutes (< 4 min)
109 dB	1.875 minutes (< 2 min)
112 dB	.9375 min (~ 1 min)
115 dB	.46875 min (~ 30 sec)




<http://www.dangerousdecibels.org/education/information-center/decibel-exposure-time-guidelines/>

Every instrument can produce hazardous sound levels!

Musical Instrument (at 3 meters)*	dB (A-weighted)	dB SPL (peak)
Normal piano practice	60-90	105
Loud piano	70-105	110
Keyboards (electric)	60-110	118
Vocalist	70-85	94
Chamber music (classical)	70-92	99
Violin/viola (near left ear)	85-105	116
Violin/viola	80-90	104
Cello	80-104	112
Acoustic bass	70-94	98
Clarinet	68-82	112
Oboe	74-102	116
Saxophone	75-110	113
Flute	92-105	109
Flute (near right ear)	98-114	118
Piccolo	96-112	120
Piccolo (near right ear)	102-118	126 [†]
French Horn	92-104	107
Trombone	90-106	109
Trumpet	88-108	113
Tympani and Bass drum	74-94	106
Percussion (high hat near left ear)	68-94	125
Amplified guitar (on stage using ear-monitors)	100-106	118
Amplified guitar (on stage with wedge monitors)	105-112	124
Symphonic music	86-102	120-137
Amplified rock music	102-108	140+
Portable music (eg, iPod) in ear canal (vol = 6)	94	110-130**
iPod in ear canal (vol = full)	105	110-142**

http://www.hearingreview.com/issues/articles/2006-03_02.asp

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What musical activities can be hazardous?

- Listening to music
 - Live
 - Recorded, in a room
 - Recorded, with mp3 player
- Performing music
 - Rehearsals with ensembles
 - Practicing alone
 - Aggravated by small practice rooms

NIHL is sensorineural hearing loss

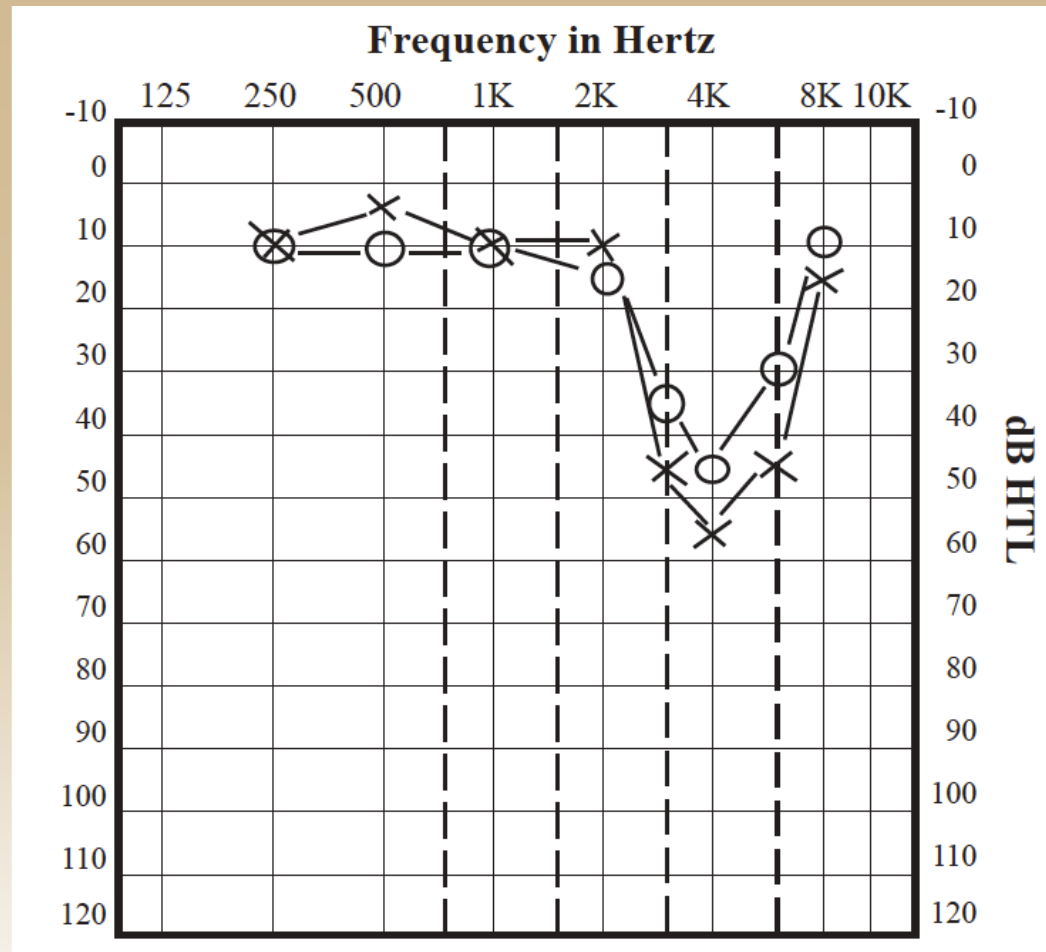
- Damages inner ear
- **Permanent and irreversible**
- Progressive, as long as exposure continues
- May be combined with conductive hearing loss from other causes
 - Impacted wax, foreign bodies in ear canal
 - Otosclerosis, otitis media
- Influenced by various individual risk factors

Individual risk factors

- Smoking
- Level of physical fitness
 - Benefit increases with age
- Genetic pre-disposition
- Ototoxin exposure (alone and with noise)
 - “Workplace” chemicals (heavy metals, solvents)
 - Medications
 - Chemotherapy side effect drugs
 - Aminoglycoside antibiotics

Classic NIHL audiogram

- Audiogram characterized by “noise notch” at 4 kHz, which widens and deepens with continuing loss
- Impacts high-frequency consonant speech sounds and musical harmonics



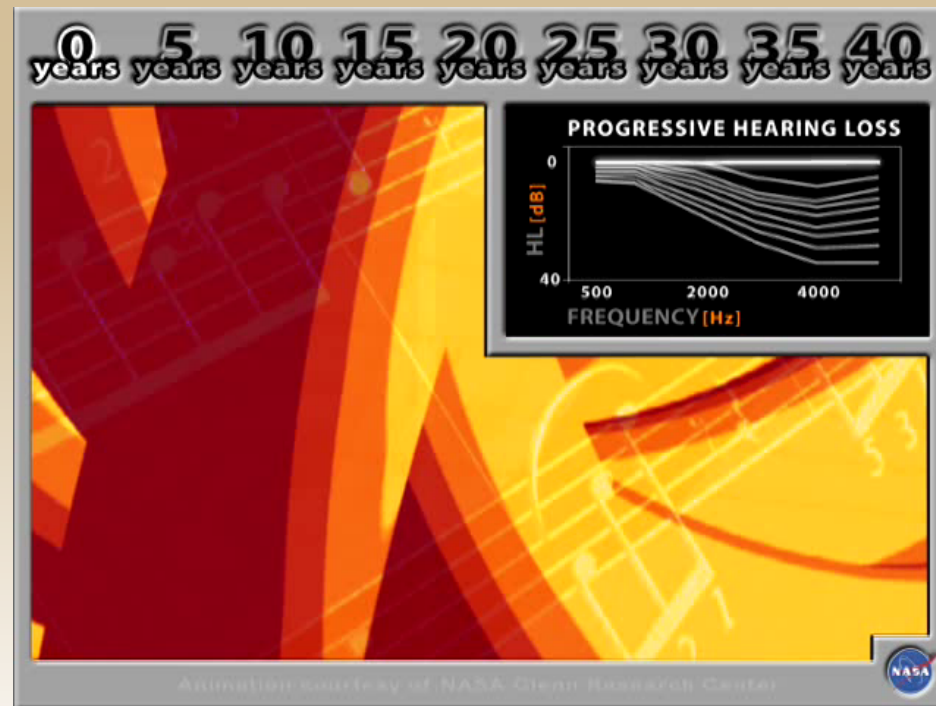
NIHL effects on communication

- Characterized by increasing difficulty understanding speech, especially in noise



NIHL impairs enjoyment of music

- Affects ability to enjoy music because timbre loses brilliance and definition



Noise exposure risks for musicians

- Noise-induced hearing loss
- Tinnitus (ringing or buzzing in the ears)
- Pitch perception problems
- Temporary threshold shift (TTS) after exposure
 - Muffled or dull sound after unprotected exposure
 - Precursor to permanent threshold shift (PTS)
 - After repeated exposure, TTS becomes PTS
 - Always treat TTS as a warning signal

Does it matter whether you like the sound?

- Classical answer is NO
 - Only the level and duration of exposure affect risk
- Various studies have shown that “hating the music” may have a protective effect
- Rock musicians have less hearing loss
 - Singing or grunting along with the music activates protective stapedial reflex
 - Exposure duration is greater for classical musicians

Other factors that affect susceptibility

- Intermittency of music allows stapedial reflex to reset
 - Provides 10 – 30 dB protection from impulse noise
 - Effect only lasts 10-15 seconds
- Industrial noise is more continuous and benefits less from this effect

Strategies for preventing NIHL

- Limit off-hours exposure to hazardous sound levels
- Always wear adequate hearing protection proactively
 - Recreational noise
 - Lawn care, home maintenance
 - Casual music listening (clubs, bars, concerts)
- Lower the volume when listening to recorded music
- Practice at moderate sound levels when possible
- Modify performance/practice environments
 - Reduce reflected sound and direct exposure
- Rest your ears as much as possible

Recommendations for iPod use

- “Fligor Rule”
 - Maximum iPod volume settings to obtain 50% maximum dosage (accommodates other sources)
 - Set at 60% of full volume for 120 minutes/day
 - Set 80% of full volume for 90 minutes/day
- Depends on earphone used
 - “Best” earphone (in-ear) isolates you from environment
- Always use earphones in both ears
 - Volume needs to be 6 dB more intense for one ear

Strategies to reduce noise exposure while performing

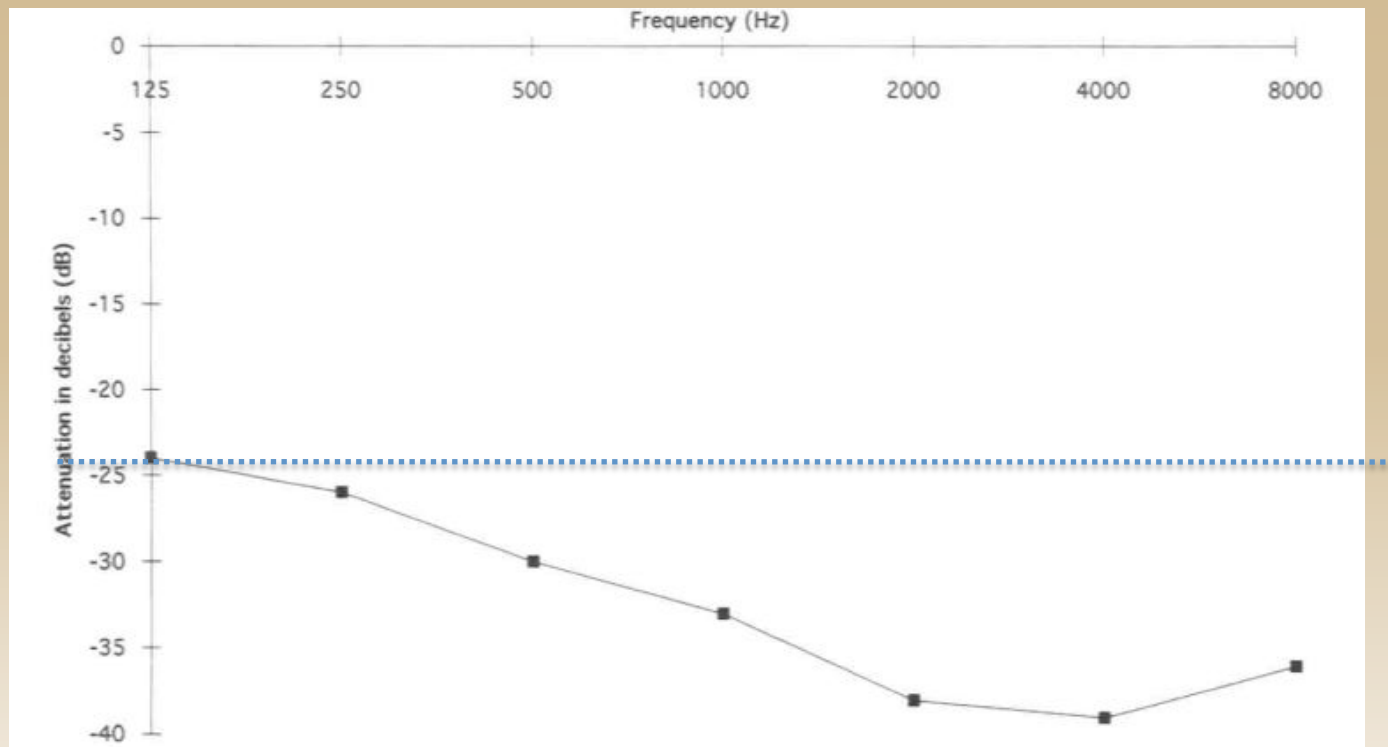
- Recommend consultation with qualified acoustical engineer
 - Performance space architectural treatments
 - Relative placement of musicians (instrument-dependent)
 - Space between musicians
 - Seating heights that direct sound away from ears
 - Baffles to deflect sound
 - Specific devices for individual instruments
 - Acoustic monitors for bass string instruments

What about “industrial” earplugs?

- Not suitable for use when performing
 - Attenuation is too high; can result in overplaying and stress/strain (e.g., percussionists)
 - Attenuation is not flat; distorts spectrum
- Not ideal for critical listening
- Acceptable hearing protection in casual music venues and for other sources of noise exposure (e.g., recreational noise)

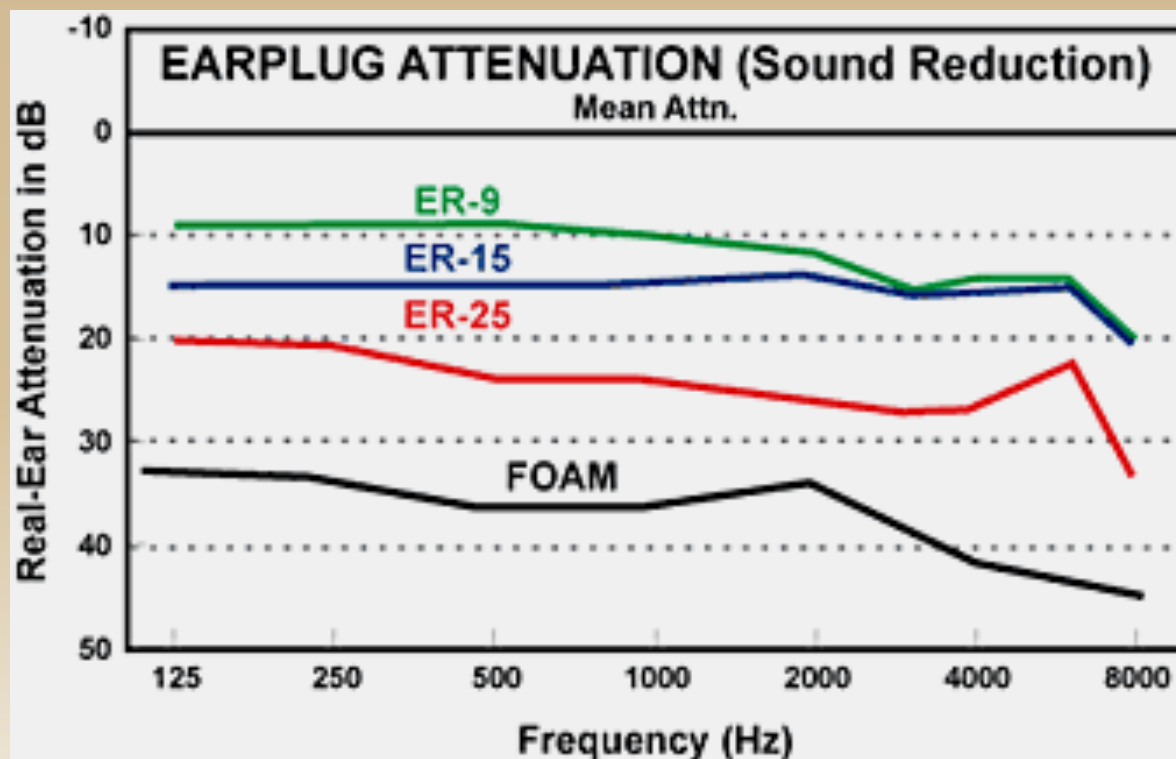


Attenuation of classic (industrial) earplugs



Chasin, Marshall. Musicians and the Prevention of Hearing Loss. San Diego: Singular Publishing Group, Inc., 1996. p. 86.

Flat attenuation Musicians Earplugs™ vs. deep-inserted foam plugs



http://www.etymotic.com/pdf/er_hearing_protection_brochure.pdf

Custom-Molded Musicians Earplugs™

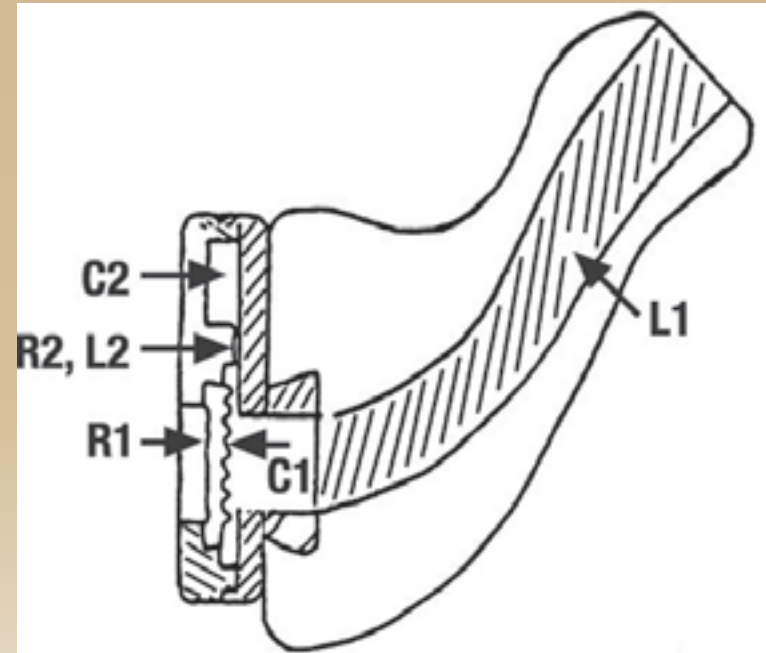
<http://www.etymotic.com/hp/erme.html>

- 3 filter inserts allow choice of attenuation
 - 9 dB
 - 15 dB
 - 25 dB
- Select filter to match each exposure scenario
- Deep insertion to second bend in ear canal reduces “occlusion effect” (plugged, hollow sound)



How Musicians Earplugs™ work

- Diaphragm functions as an acoustic compliance.
- Volume of air in the sound bore of the custom earmold acts as an acoustic mass.
- The combination of the two produces a resonance at approximately 2700 Hz (as in normal ear), which results in smooth, flat attenuation.



**Schematic side
view of the ER-15**

**C = compliance
L = inductance
R = resistance**

Making a custom earplug

- Audiologist makes an impression of the ear canal using soft material injected deep into the canal
- Partially hardened impression is removed and sent to earmold lab to make custom plug



<http://www.earimpressions.com/links/instructions.cfm>

“Off-the-shelf” option

- Etymotic Research ER20
- Provides ~ 20 dB attenuation
- Slight high frequency roll-off
- Cost is ~\$10 - \$12
- Available from Amazon.com and other sources



Custom vented/tuned earplug

- Provides no attenuation below 2000 Hz and 20-28 dB attenuation of high frequencies
- Adjustable vent allows tuning attenuation
- Allows musician to hear lower frequencies (typically own playing) while protecting from loud higher frequency sounds produced by other instruments
- Intended for players of low instruments
- Allows vocalists to better monitor own voice

In-ear monitors for amplified music

- Replaces stage monitor “wedge” speakers
- Reduces minimum acceptable listening level by ~ 6 dB
- Custom-molded earpieces
- “Off-the-shelf” options available

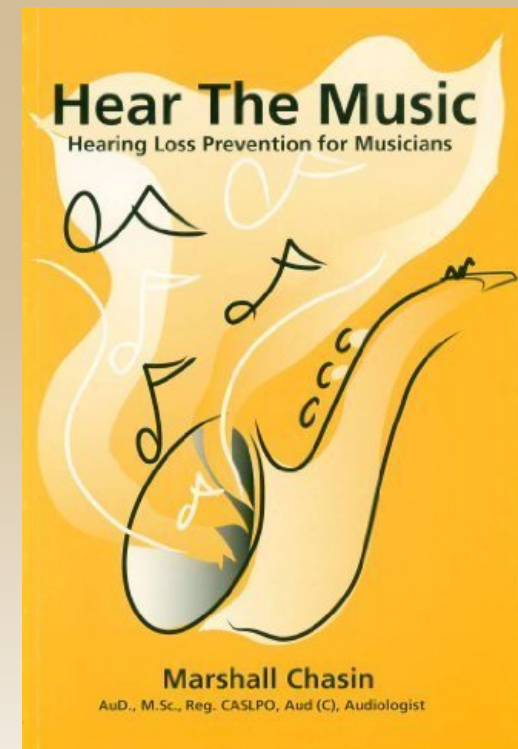


Local Resources for Custom-Molded Musicians Earplugs™

- EMU Speech and Hearing Clinic
John W. Porter Bldg., Ste. 135
Dr. Lidia Lee lidia.lee@emich.edu
- O'Connor Hearing Center
203 S. Zeeb Rd., Suite 207
Ann Arbor, MI 48103
Phone: (734)994-8300
<http://www.oconnorhearing.com/>
- University of Michigan - Audiology Division
1500 E Medical Center Dr., TC 1904
Ann Arbor, MI 48109-0312
Phone: (734)936-7507
<http://www.med.umich.edu/oto/divisions/audioindex.shtml>

To learn more, start here

- Marshall Chasin
 - Director of Research at the Musicians' Clinics of Canada (http://www.musiciansclinics.com/hearing_loss.asp)
 - Blog editor at <http://hearinghealthmatters.org/hearthemusic/>
 - Author of Hear the Music (\$8.50 from Amazon.com)

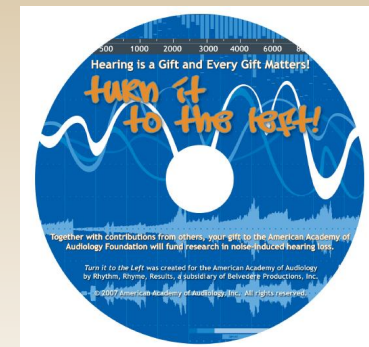


More educational resources

- Dr. Kris Chesky
 - Director of Education and Research at the Texas Center for Music and Medicine, University of North Texas
 - <http://www.unt.edu/untresearch/2007-2008/music.htm>
- Dr. Brian Fligor
 - Director of Diagnostic Audiology for Children's Hospital, Boston and Instructor in Otology and Laryngology at Harvard Medical School
 - Research on noise-induced hearing loss in children and teens, particularly from personal mp3 players
 - Demonstrations of listening with hearing loss and with hearing protectors:
<http://www.childrenshospital.org/clinicalservices/Site2148/mainpageS2148P27.html>

Resources for working with children and teens

- Dangerous Decibels (Oregon Health & Science University)
 - <http://www.dangerousdecibels.org/>
- National Hearing Conservation Association
 - <http://nhca.affiniscape.com/displaycommon.cfm?an=1&subarticlenbr=13>
- National Association for Music Education
 - <http://musiced.nafme.org/about/position-statements/health-in-music-education/>
- American Speech Language Association
 - <http://www.listentoyourbuds.org/>
- American Academy of Audiology
 - <http://www.turnittotheleft.com/default.htm>



NASA EARLAB Resources

- Download Auditory Demonstration collections:
 - <http://buyquietroadmap.com/> and browse collections
- Contact me:
 - Beth.A.Cooper@nasa.gov

