
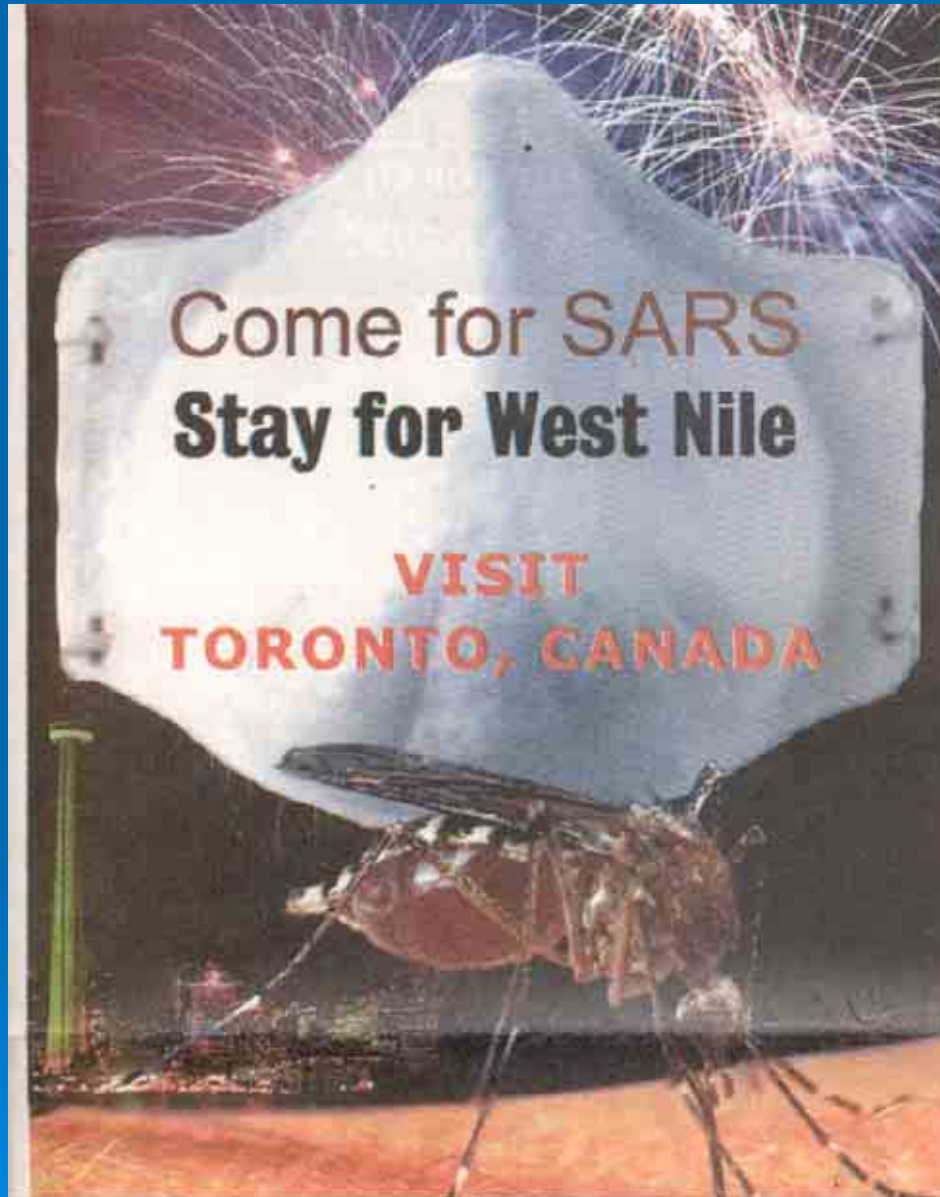


Strategies to minimize the potential for music induced hearing loss

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Musicians' Clinics of Canada
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Musicians' Clinics of Canada



Special issue on musicians

- Hearing Review, March 2006
 - (guest edited by Marshall Chasin)
 - www.hearingreview.com



Rock On!

Get your earplugs

- **Fitting Hearing Aids on Musicians**

- **Portable Music Players and Hearing Conservation**

- **How Outsiders Use**

www.musiciansclinics.com

Sections on:

Hearing loss FAQs

Hearing loss prevention articles

Summary fact sheets (instruments)

Performing arts injuries

Links section

Maximum Levels for Instruments

(Wagner Ring Cycle: Camp and Horstman, 1992)

<i>Instrument</i>	<i>Peak Level (dB SPL)</i>
French Horn	107
Bassoon	102
Trombone	108
Tuba	110
Trumpet	111
Violin	109
Clarinet	108
Percussion	>120
(Amplified Guitar	>115)

Chasin (2006)

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**

The Big Five....

- Hearing protection
- Moderation
- Hum
- Improved monitoring
- Four simple environmental changes

Hearing Protection Alternatives

ER-15: (1988+, Etymotic Research)

Custom made uniform attenuator provides 15 dB of attenuation up to 8000 Hz. It uses an element that interacts with an inductance to provide a 3000 Hz resonance, thus off-setting the loss of the ear canal resonance.

ER-25: (1992+)

Custom made uniform attenuator provides 25 dB of attenuation up to 6000 Hz.

Hearing Protection Alternatives

ER-15 SP:

Similar to ER-15 but LESS attenuation above 4000 Hz.

ER-9:

Custom made uniform attenuator provides 9 dB of attenuation.

ER-20: (HI-FI)

Non-custom earplug with a slight high-frequency roll-off.
Costs about \$10-\$12.

Hearing Protection Alternatives

Vented/tuned earplugs:

Similar to filtered earplugs, except uses a SAV down the main sound bore. In its most open position is acoustically transparent below 1500 Hz.... almost....



Other Hearing Protection Alternatives

- Other alternatives exist:
 - Bilsom “Natural Sound Technology” (NST)
 - (Digital) signal processing approaches
 - Other vented/tuned approaches
 - Variable venting schemes
 - Variable (acoustic) filtering schemes



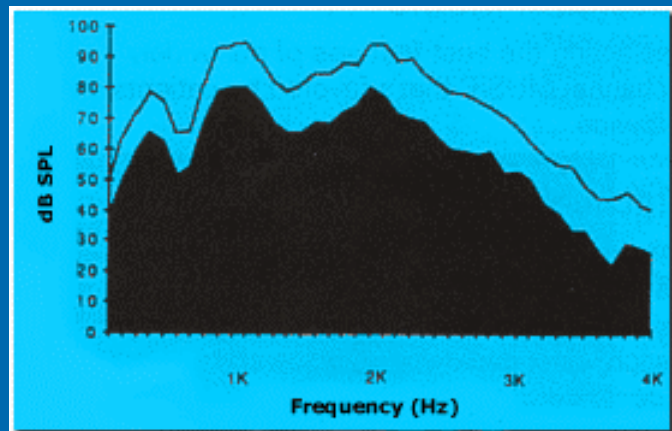


Fig. 1. Spectrum of violin playing A4 (440 Hz) without (top) and with (shaded) the ER-15 earplug. (Reprinted with permission from Chasin and Chong)

Earplugs and Auditory Danger

<i>Instrument</i>	<i>Danger</i>	<i>Earplug</i>
Violin/Viola	Violin/Viola	ER-15
Woodwinds	Percussion	ER-15/ vented-tuned
Brass	Brass/Percussion	ER-15
Percussion	Percussion	ER-25
Amplified Instruments	Loudspeakers/ Drums	ER-15

14 Year Follow-up for ER-Earplugs

Survey of 850 earplug recommendations:

1990: 32% decided to get them

1995: 64% decided to get them

1997: 72% decided to get them

2005: 94% decided to get them

Follow-up for ER-Earplugs

Survey of 425 users:

83% still wearing them

14% changed to a different type (usually less)

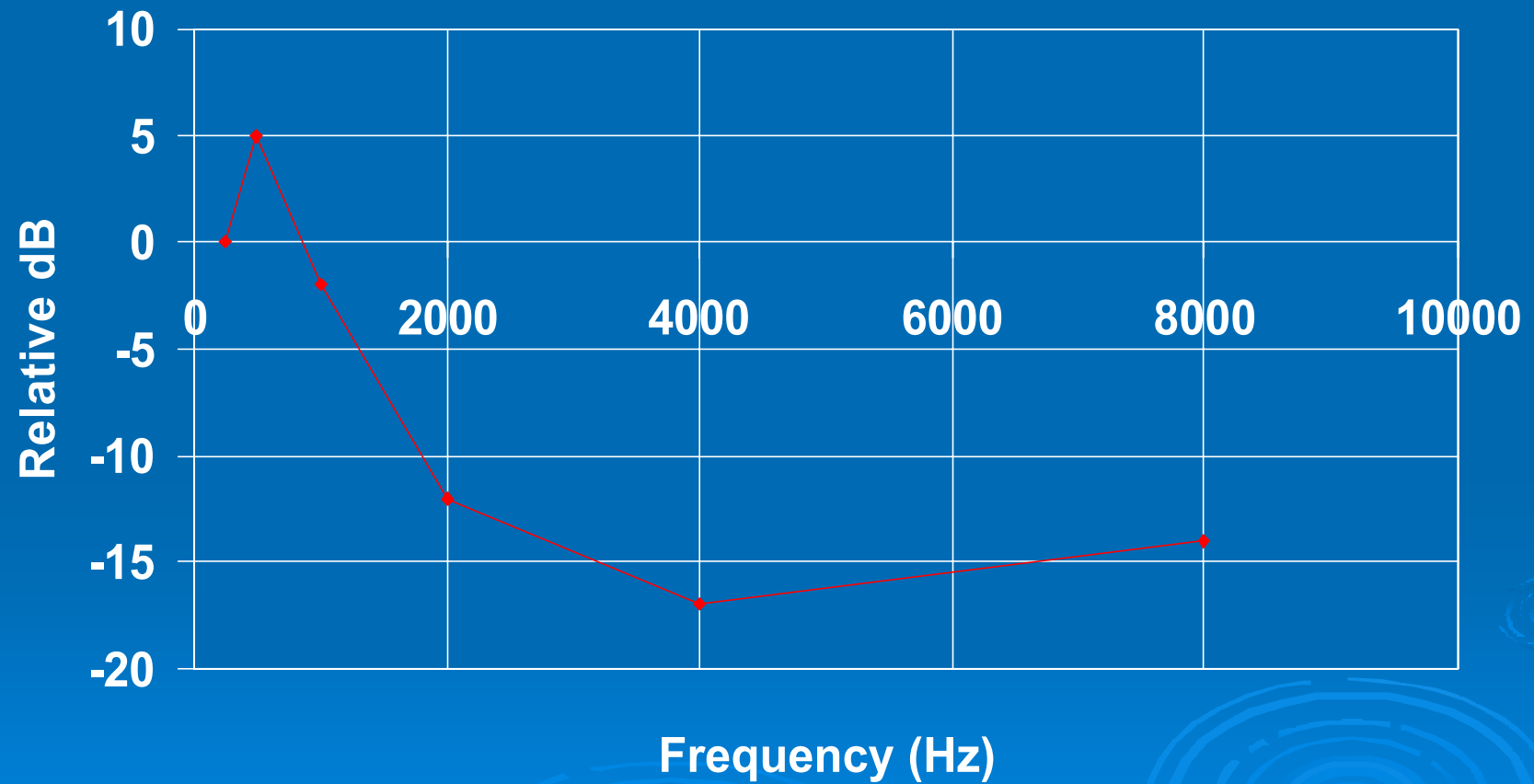
3% did not like them (usually French Horn players)

Vented/tuned earplugs

Resonant Frequency $\propto \frac{\text{area}}{L_o V_e}$

Improved vocal awareness as frequency of the vent resonance is decreased. (decrease area and increase L)

Vented/tuned earplugs



The wrong hearing protection can be worse than none at all...

A 25 year old drummer read that he needed to use earplugs.

He started using industrial strength earplugs and 6 months later noted wrist and arm problems.



The wrong hearing protection can be worse than none at all...

No hearing protection	103 dB SPL
“Industrial” protection	113 dB SPL
ER-25 (proper protection)	104 dB SPL

The wrong hearing protection can be worse than none at all...

With the ER-25, wrist and arm strain was reduced

EMG activity returned to normal

Improved monitoring was the key



Moderation

- The two major factors affecting hearing loss are:
 - Intensity (dBA)
 - Duration
- 3 dB exchange rate...
 - 85 dBA for 40 hours = ...
 - 100 dBA for 1.25 hours...

Moderation

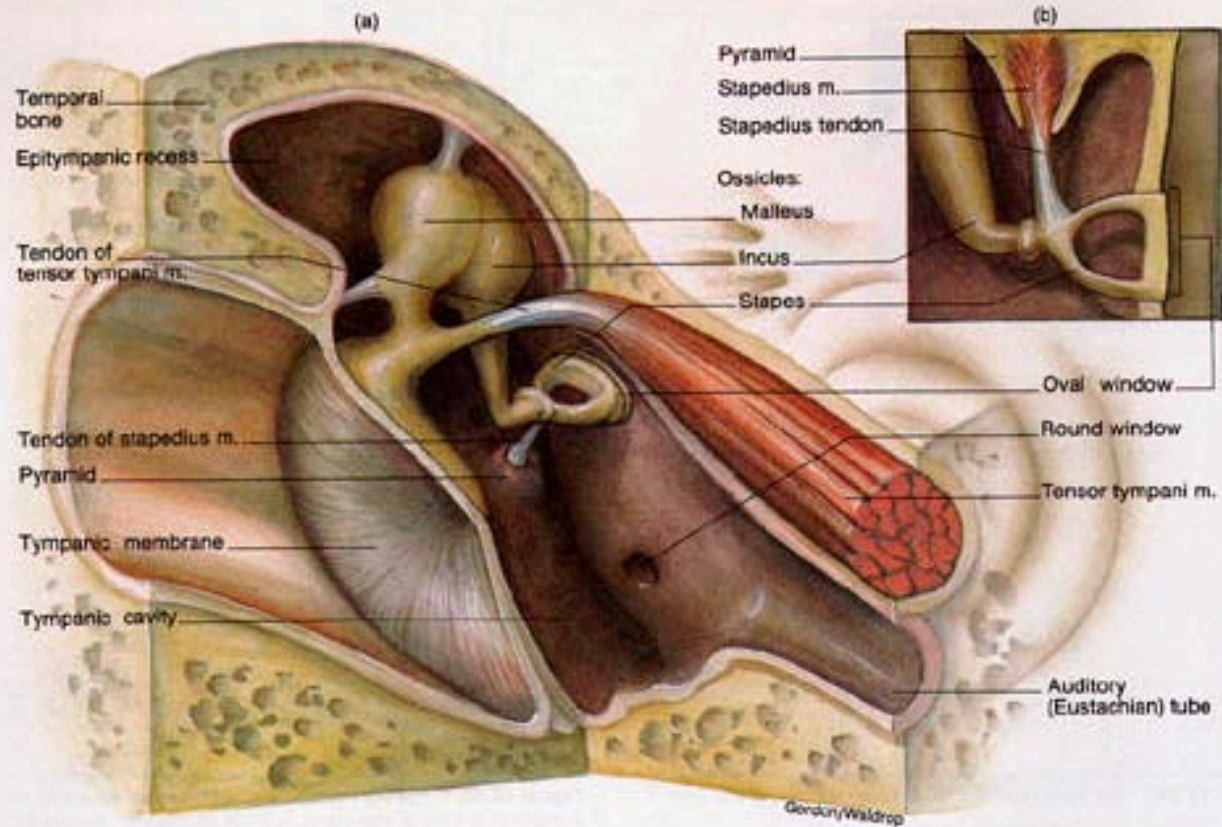
- Nothing wrong with a rock concert... just don't mow your lawn the next day...
- ... or better yet, get someone else to mow it for you!

Humming and the Stapedial Reflex

- A small muscle exists in our middle ear behind the eardrum that contracts upon loud sounds
 - Eg. Our own voice...



The ear ossicles and associated structures within the (a) tympanic cavity; (b) the stapedius muscle arises from a bony protrusion called the pyramid.



Humming and the Stapedial Reflex

- Zakrisson et al. (1980) studied unilateral Bell's Palsy in humans.
- "TTS" was 10 dB greater in the de-innervated side.

Humming and the Stapedial Reflex

- Borg et al. (1983) surgically cut the stapedial muscle on one side of rabbits and created a permanent hearing loss. (PTS).
- There was 30 dB greater hearing loss on the operated ear.



Humming and the Stapedial Reflex

- We are not rabbits and TTS is not necessarily a predictor of permanent hearing loss, BUT... if we can even reduce the sound level by 3 dB, we can be exposed for twice as long....
- SO,... hum while you play.
- Hum during a cymbal crash...

Improved Monitoring

- Better awareness of the music means that one does not need to overplay...



Improved Monitoring

- Bass shakers are small sub-woofers (low-frequency) speakers that provide an improved awareness of sound for bass players and drummers.
- Overall playing sound levels are reduced.



Improved Monitoring

➤ A case example:

- a 25 year old drummer read that he needed earplugs and started to wear the industrial foam plugs.
- He came in complaining of arm and wrist problem.

Improved Monitoring

- He was fit with the proper hearing protection (ER-25) and his wrist and arm problems went away.
- His playing intensity was reduced by 11 decibels!

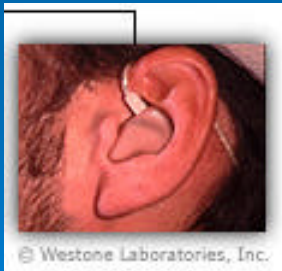
The wrong hearing protection can be worse than none at all...

No hearing protection	103 dB SPL
“Industrial” protection	113 dB SPL
ER-25 (proper protection)	104 dB SPL

Improved Monitoring

- In-ear monitors are miniature loudspeakers that look like hearing aids.
- Replace the large wedge and side monitors up on stage.





© Westone Laboratories, Inc.



In-The-Ear Monitors (in situ)



Improved Monitoring


- In-ear monitors allow the musician to select the mix they want without having to fight with other music sources up on stage...
- The bottom line... lower sound level with less potential for damage- (6 dB lower).

Acoustic Monitor

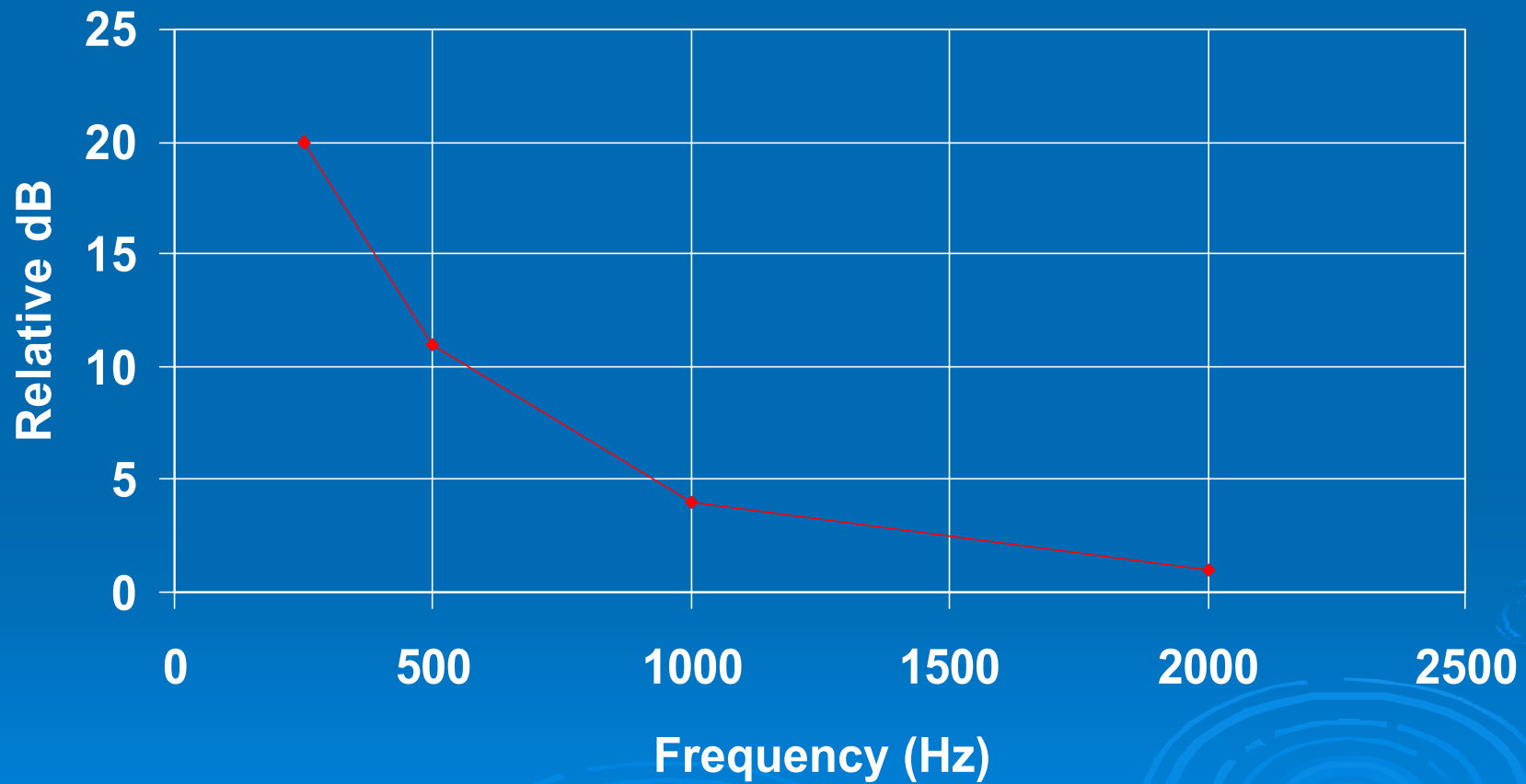
Useful for bass string instruments such as the cello and acoustic bass.

Four feet of #13 hearing aid tubing with an adaptor. One end plugs in to the left Vented/tuned earplug and the other is inserted in the “*f*”-hole of the cello or bass.

Similar to an acoustic stethoscope
(only less than \$10 in parts!)



Acoustic Monitor

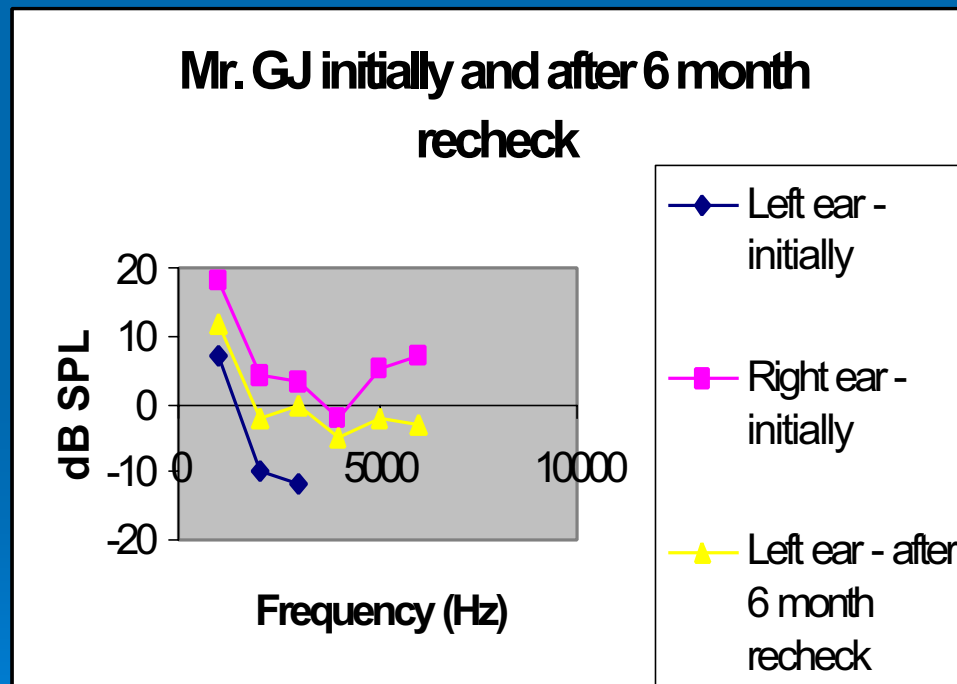


Environmental Changes

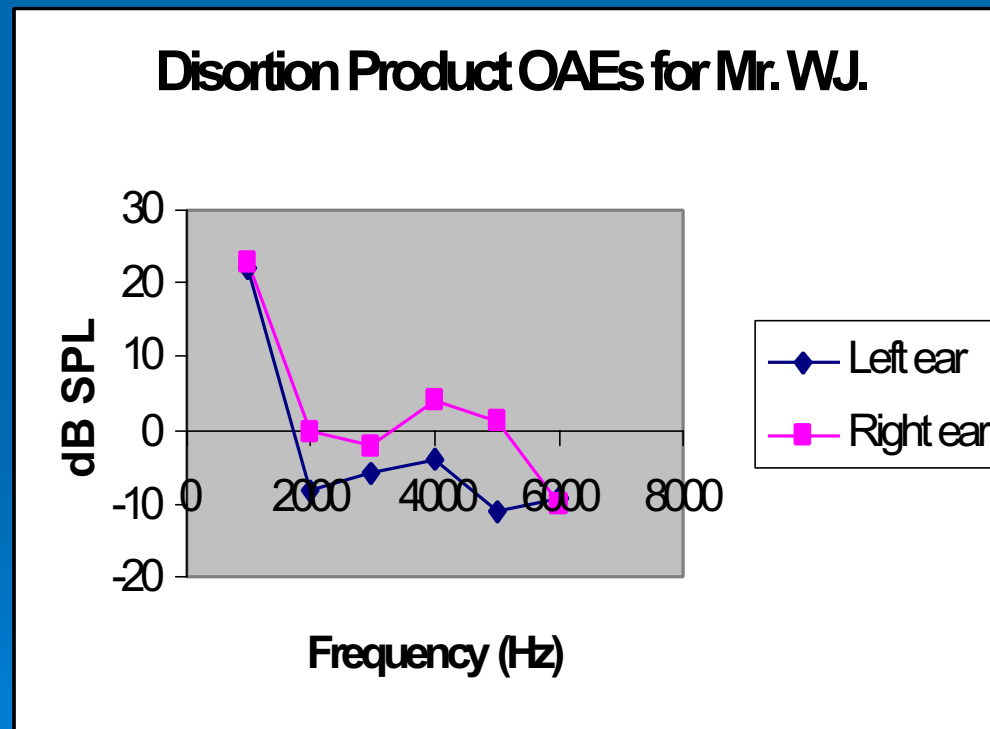
- Move away from an offending source.
- eg. Move away from the high hat of the drummer (left side of drummer).
 - Lead singer is typically in front of drummer such that the high hat cymbals are to the left-rear of the singer....

Otoacoustic Emissions

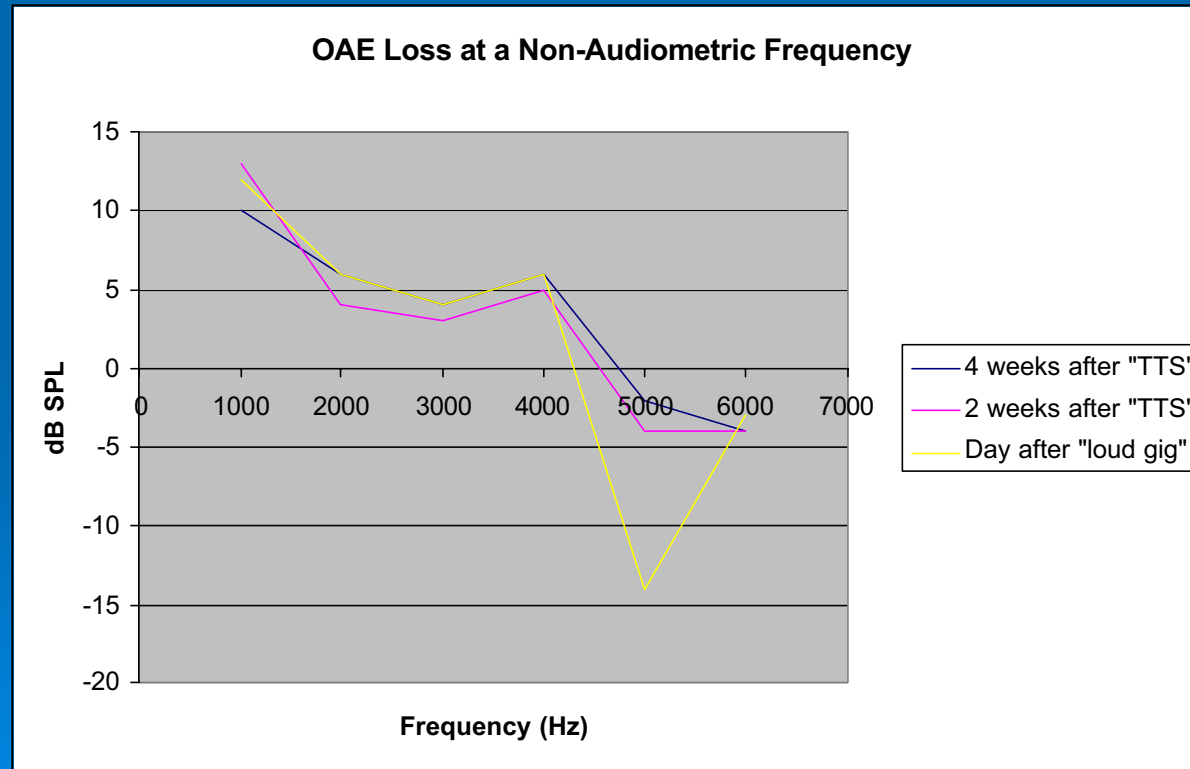
(Lead singer moved away from drummer)



Otoacoustic Emissions (Drummer - symmetrical “hearing”)



OAE “notch” at 5000 Hz and not measured on audiometry...



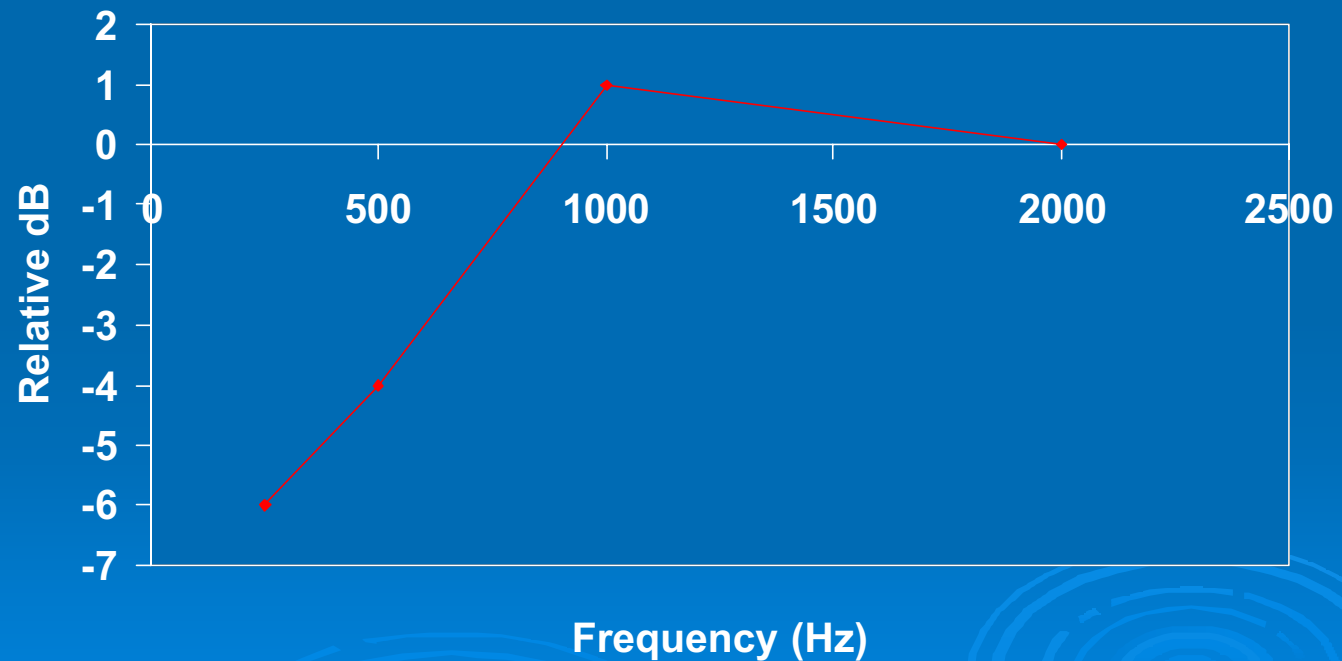
Four inexpensive
environmental changes
to minimize exposure to
music...

The background of the slide is a solid blue color. In the lower right quadrant, there are several faint, concentric circular patterns that resemble ripples in water, creating a subtle decorative effect.

Environmental Changes

- 1. Speaker/amplifier combinations should be elevated from the floor.
 - Low-frequency bass notes will be lost to the room so the volume will have to be needlessly turned up.

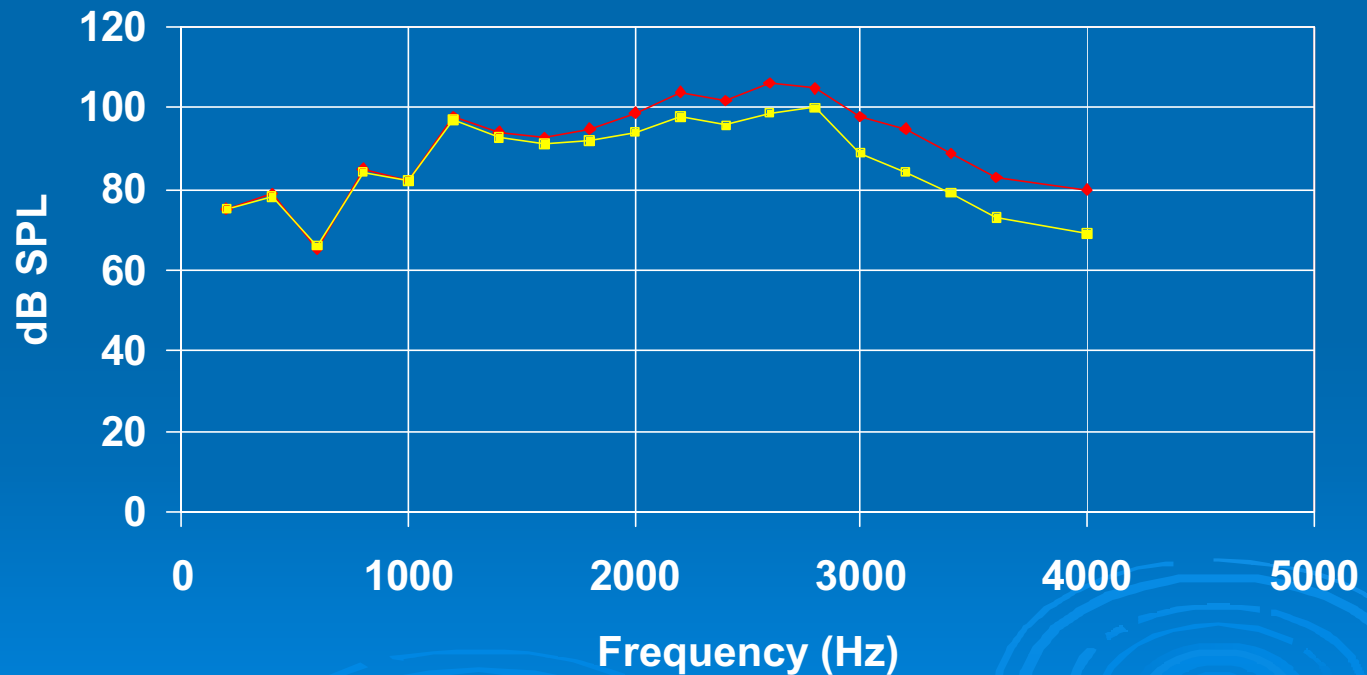
Energy lost due to speaker contact with the floor ...



Environmental Changes

- 2. Stringed instruments should always have at least two meters of unobstructed space above them.
 - The pit overhang will “eat up” the higher frequency components of the violins and violas...

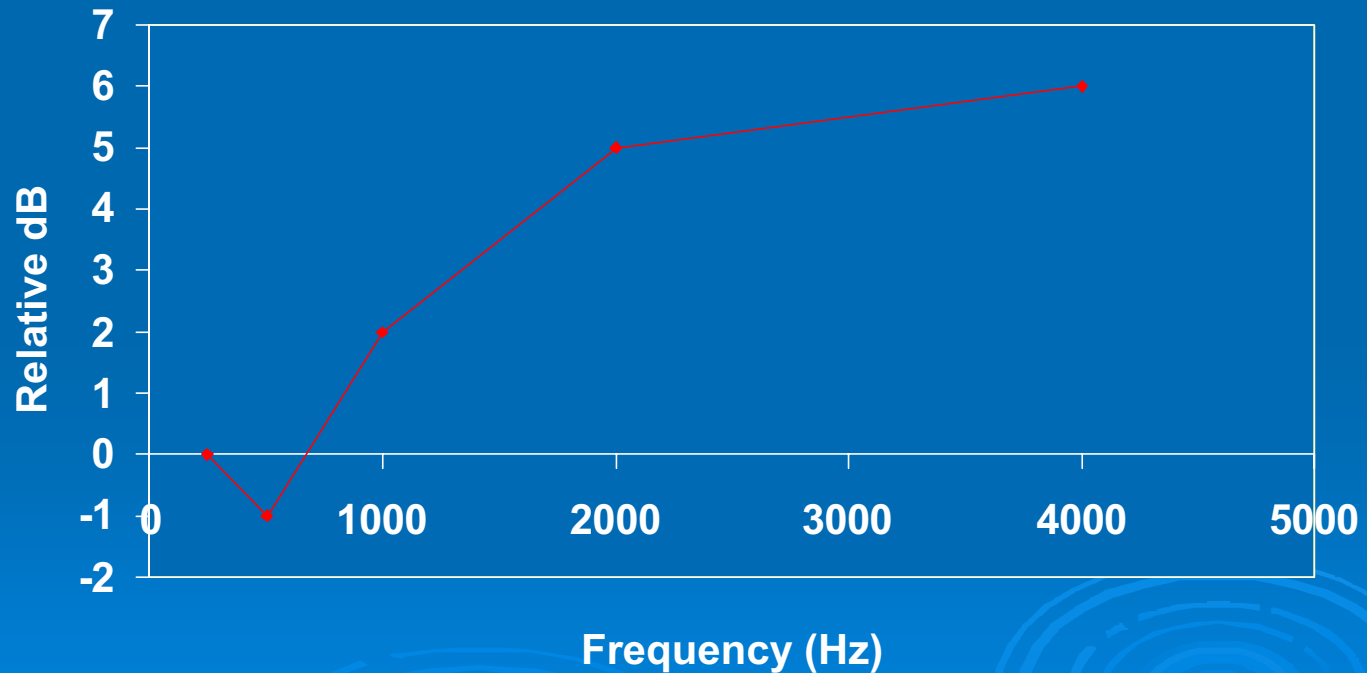
High frequency loss due to poorly constructed overhang...



Environmental Changes

- 3. There should be 2 meters of unobstructed floor space in front of orchestra.
 - The floor will act as an “acoustic mirror” reflecting the higher frequency sounds so that the overall level on stage does not need to be as intense....

Two meters of unobstructed floor space (an acoustic mirror)

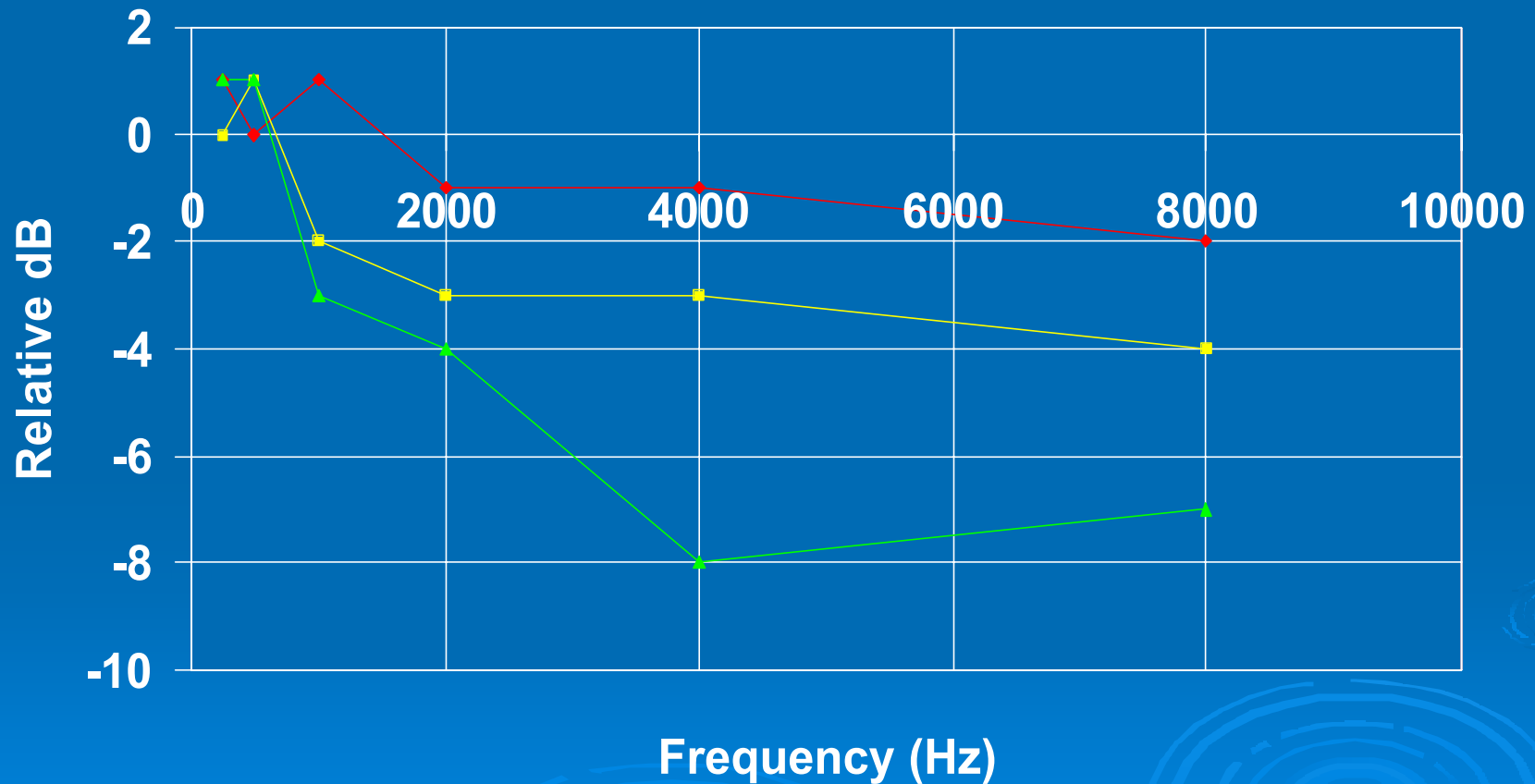


Environmental Changes

- 4. Treble brass instruments should be on risers.
 - The higher frequency (and more intense components) of the trumpets emanate in almost a direct “laser beam” straight line. Elevating trumpets allows the damage to go over the heads of those downwind...

Loss of Energy for Higher Frequencies at -45 Degrees

(low [red], mid [yellow] and high [green] frequency)



Why do you instantly
dislike trumpet players?



Because it saves time!



www.musiciansclinics.com

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