

Do sound restoration hearing protectors provide adequate attenuation for gunfire noise?

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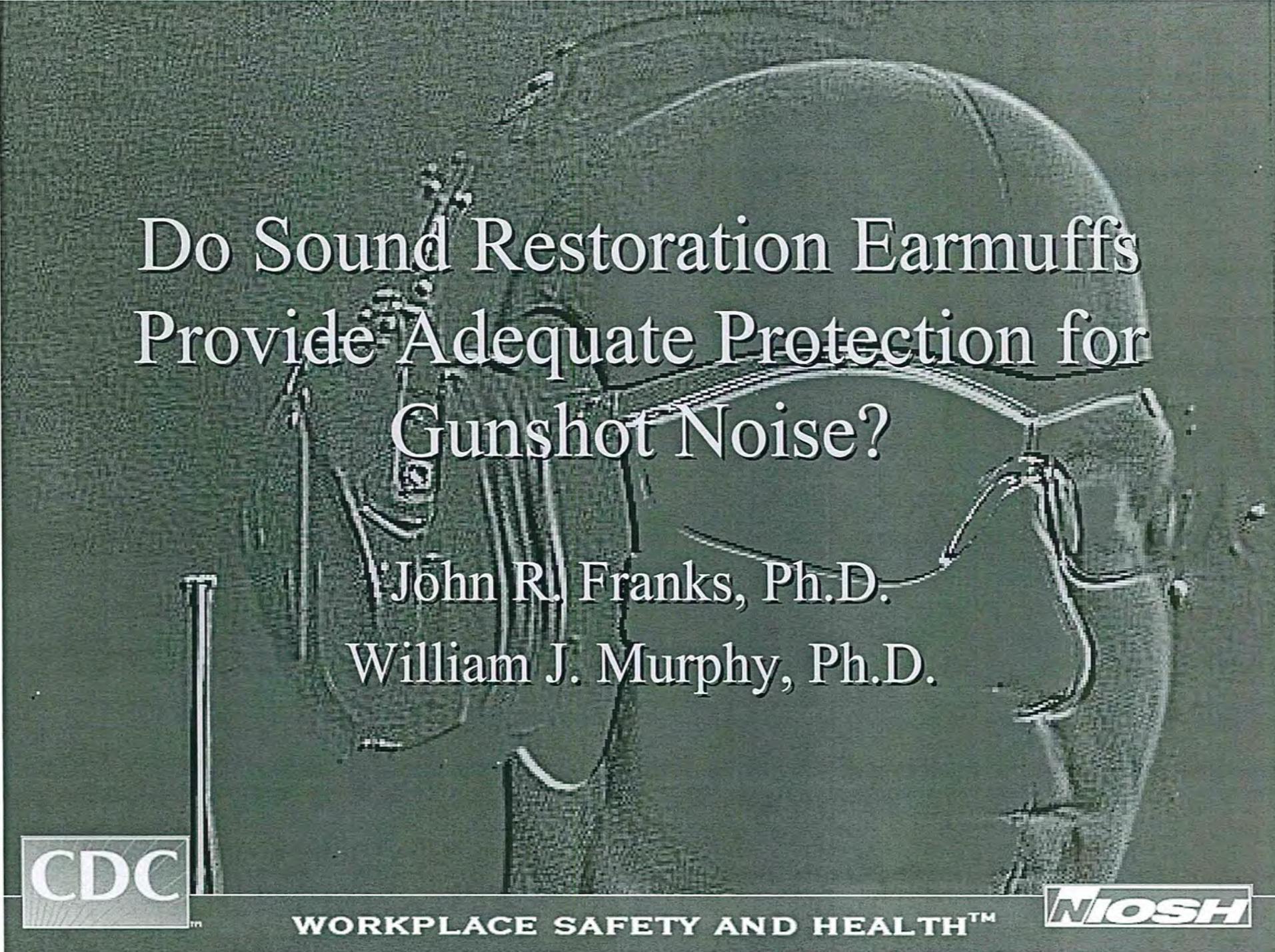
Sound restoration earmuffs have an electronics package installed in a passive earmuff shell or earplug body. The electronics package consists of a microphone placed on the outside of the ear cup or earplug and a limiting amplifier driving a loudspeaker placed inside the ear cup or the earplug. The devices are designed to provide unity gain or better to low-level signals and to shut off when sound exceeds a given level. The effects of several sound restoration earmuffs and two nonlinear orifice earplugs on gunfire for several different weapon types were analyzed. In general, the nature of the electronics packages was such that the studied devices provided the same attenuation when turned on as when turned off. However, as with passive devices, a single protector, be it by earplug or earmuff, appears to be inadequate for gunfire when more than just a few shots are fired. Sound restoration earmuffs are best used with a well-fitted earplug, since the electronics can compensate for both the insertion loss of the earmuff and the earplug. However, nonlinear orifice earplugs may not provide sufficient protection for extended sessions of target practice.

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Do Sound Restoration Earmuffs Provide Adequate Protection for Gunshot Noise?

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Background

- Electroacoustic protectors currently have no ANSI standard for protection assessment.
- ISO has proposed standard for sound restoration earmuffs.
 - Measure earmuffs with HATS or ATF.
 - Third-octave band input/output functions.
 - Yields only information about compression.

Research Question

- Do the Electroacoustic earmuffs have sufficiently fast attack times to effectively reduce impulse and impact noise?

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Methods

- Generate impulsive signals with gunshots
- Measure the protected and unprotected signals
 - 1/4" B&K 4136 microphone outside HPD
 - ISL mannequin with 4165 B&K 1/2" under HPD
- Record signals with Tascam DA-P1 digital audio tape (DAT) recorder.
 - 48000 samples/second.

ISL Mannequin Measurements

Bruel & Kjaer 4136
1/4" microphone

4165 1/2" B&K microphone
4157 B&K ear simulator
Head Acoustics pinna and ear canal
Isolated housing for 4157 assembly

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Methods

- Measured ten weapons
 - 0.357 Smith & Wesson 586 and 686 pistols
 - 0.450 Colt 1991A1, Para-ordinance pistols
 - 0.400 Glock 22 and 27 pistols
 - 9mm Pocket 9 and Sig Sauer P228 pistols
 - 12 gauge Remington 870 and 11-87 shotguns
- Five shots per condition and weapon

Methods

- Six Electroacoustic Earmuffs
 - Bilsom 707 Impact II
 - Bilsom Targo Electronic
 - Howard Leight Thunder
 - Howard Leight Lightning
 - Peltor Tactical 6S
 - Peltor Tactical 7
- Three Volume Settings
 - Off, Unity and Maximum Gain

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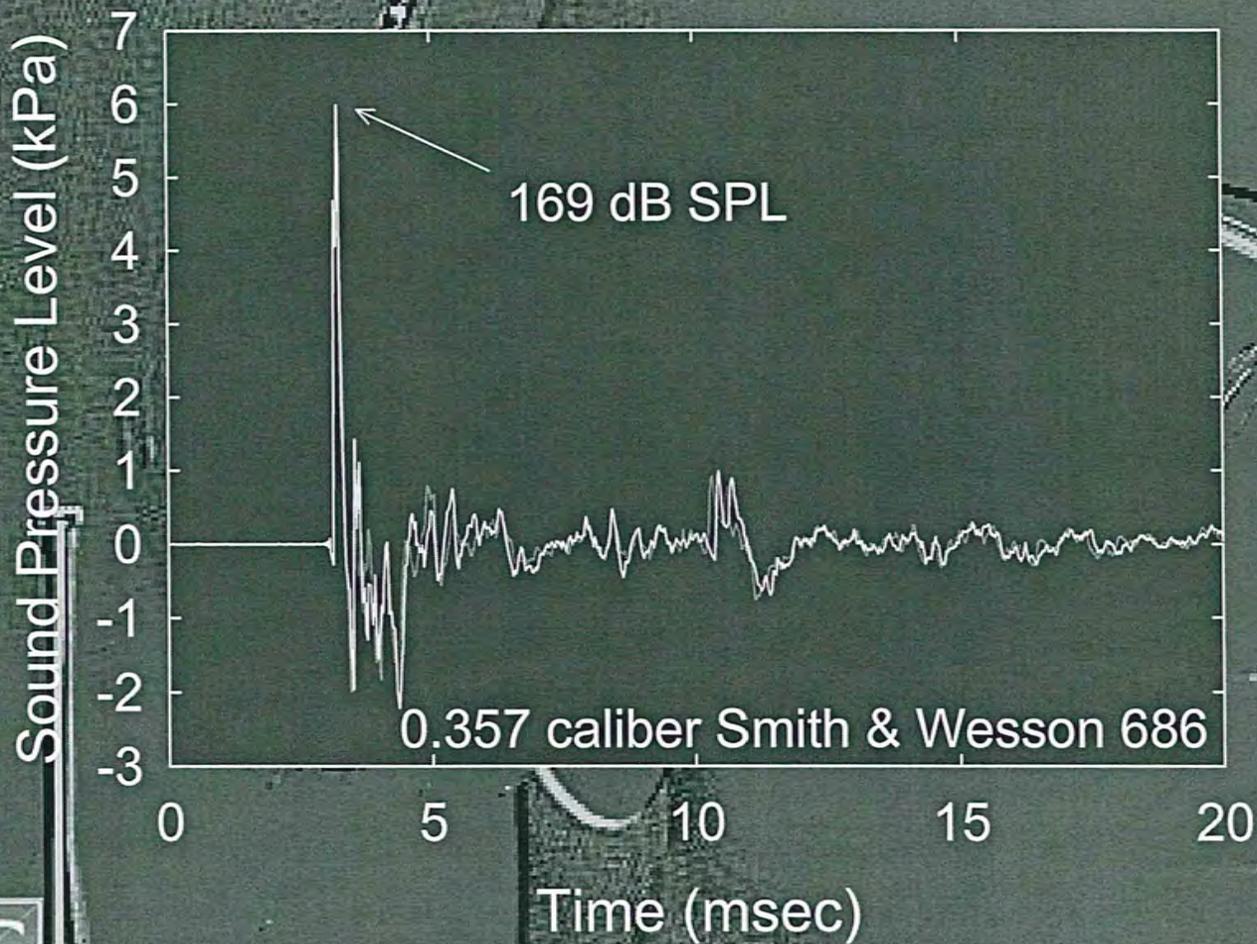
Methods

- One Assistive Listening Device
 - Electronic Shooter Protection Elite
 - Essentially a hearing aid.
- Two nonlinear orifice earplugs
 - Bilsom ISL 655 earplug
 - EAR/Peltor Combat Arms earplug

Gunshot Impulse Analysis

- 42.67 msec analysis window (2048 samples)
- Maximum Impulse Levels,
 - Unprotected & Protected
- Peak Level Reduction
 - Unprotected – Protected
- Third-octave Analysis of Attenuation
 - Unprotected – Protected

Unprotected Impulses

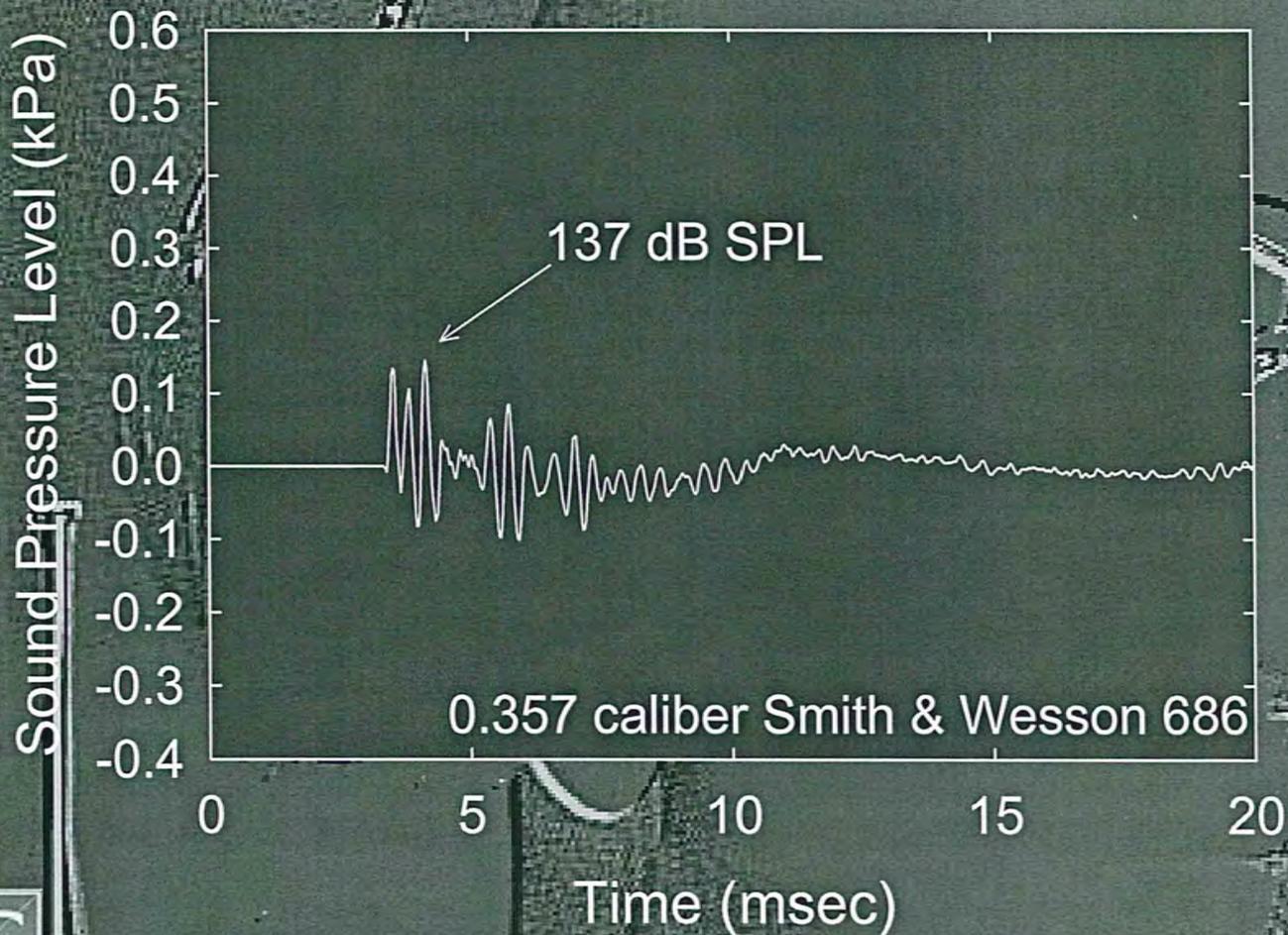


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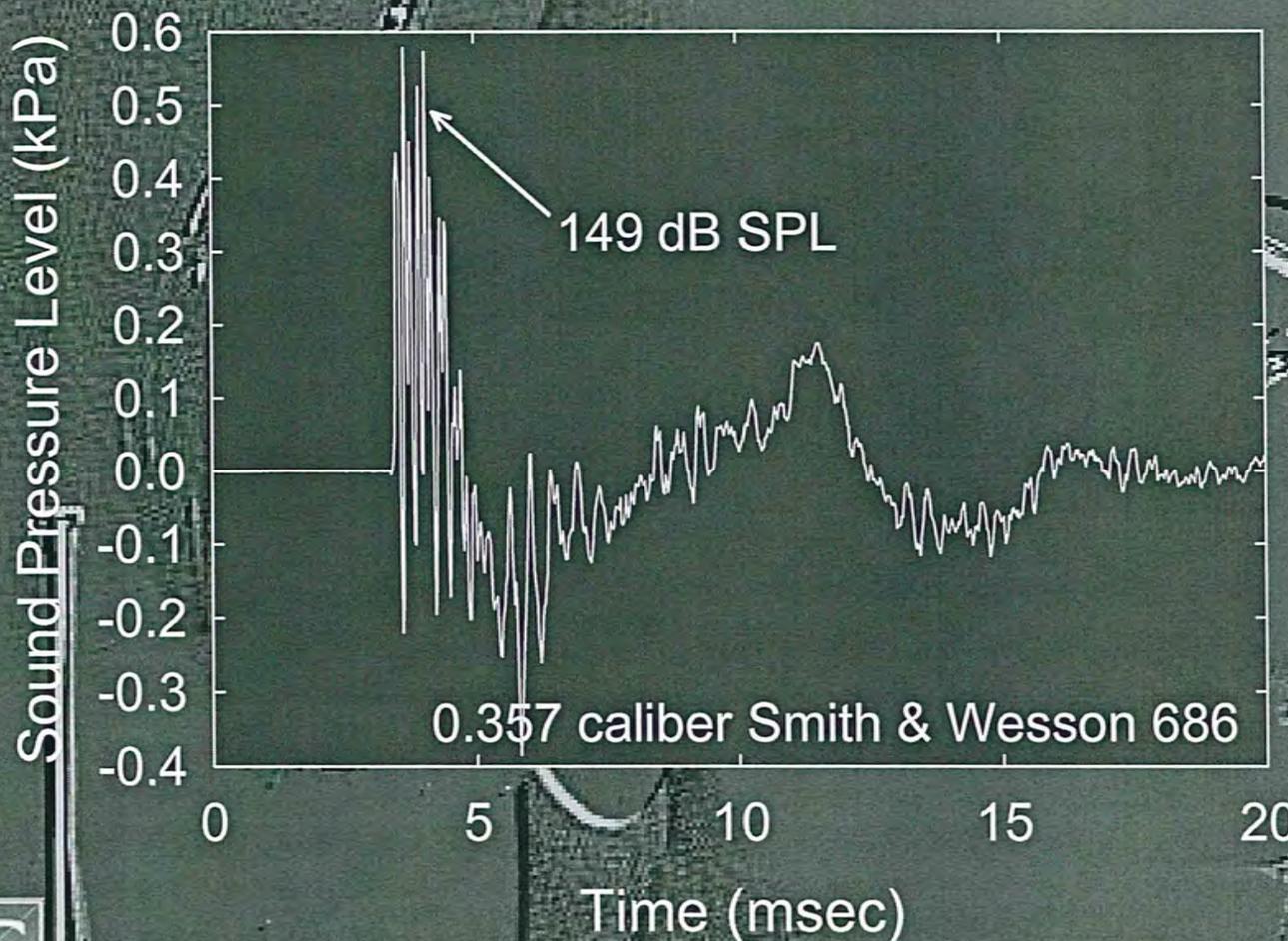
Protected Impulse



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Protected Impulse with Leak

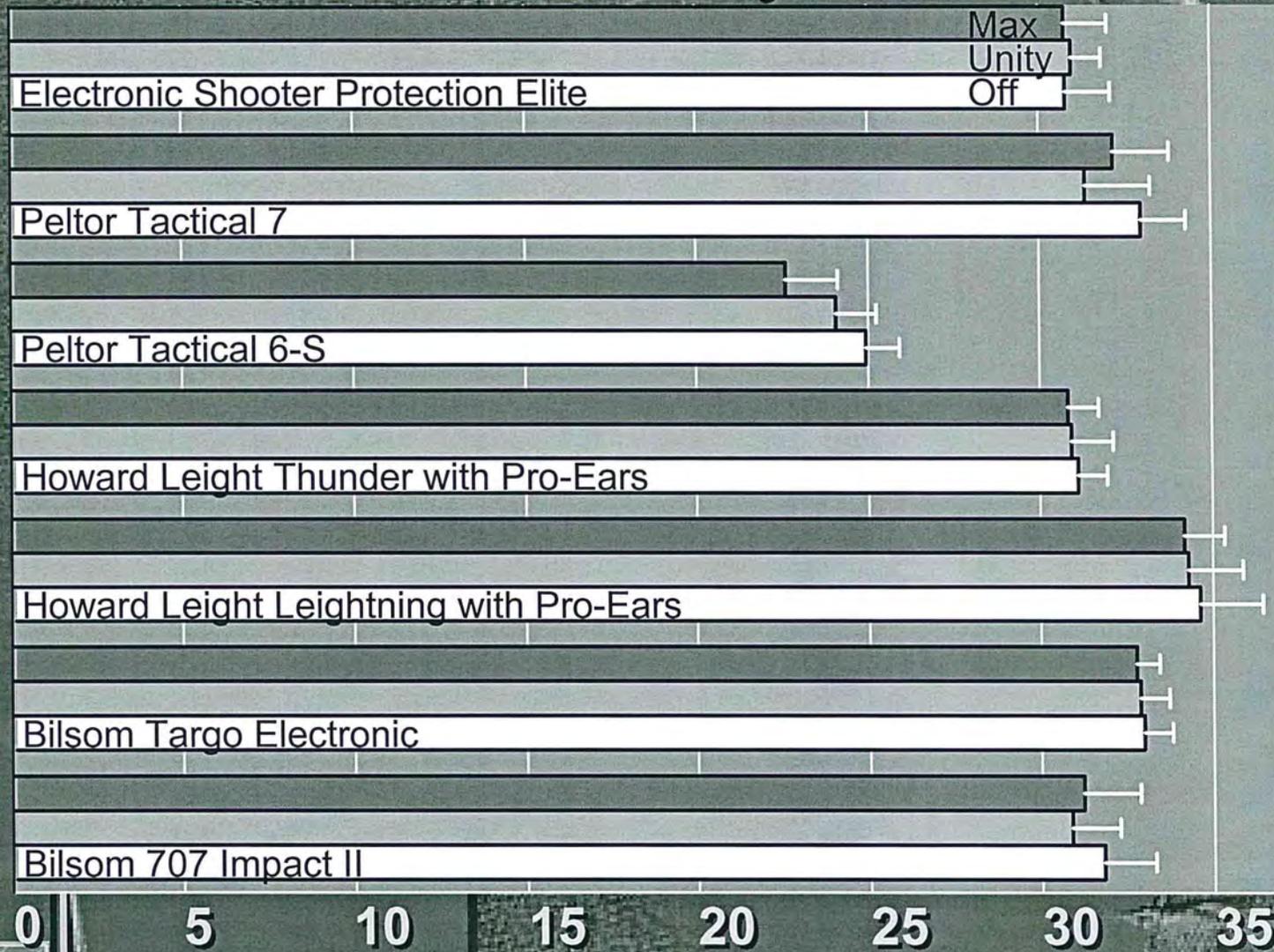


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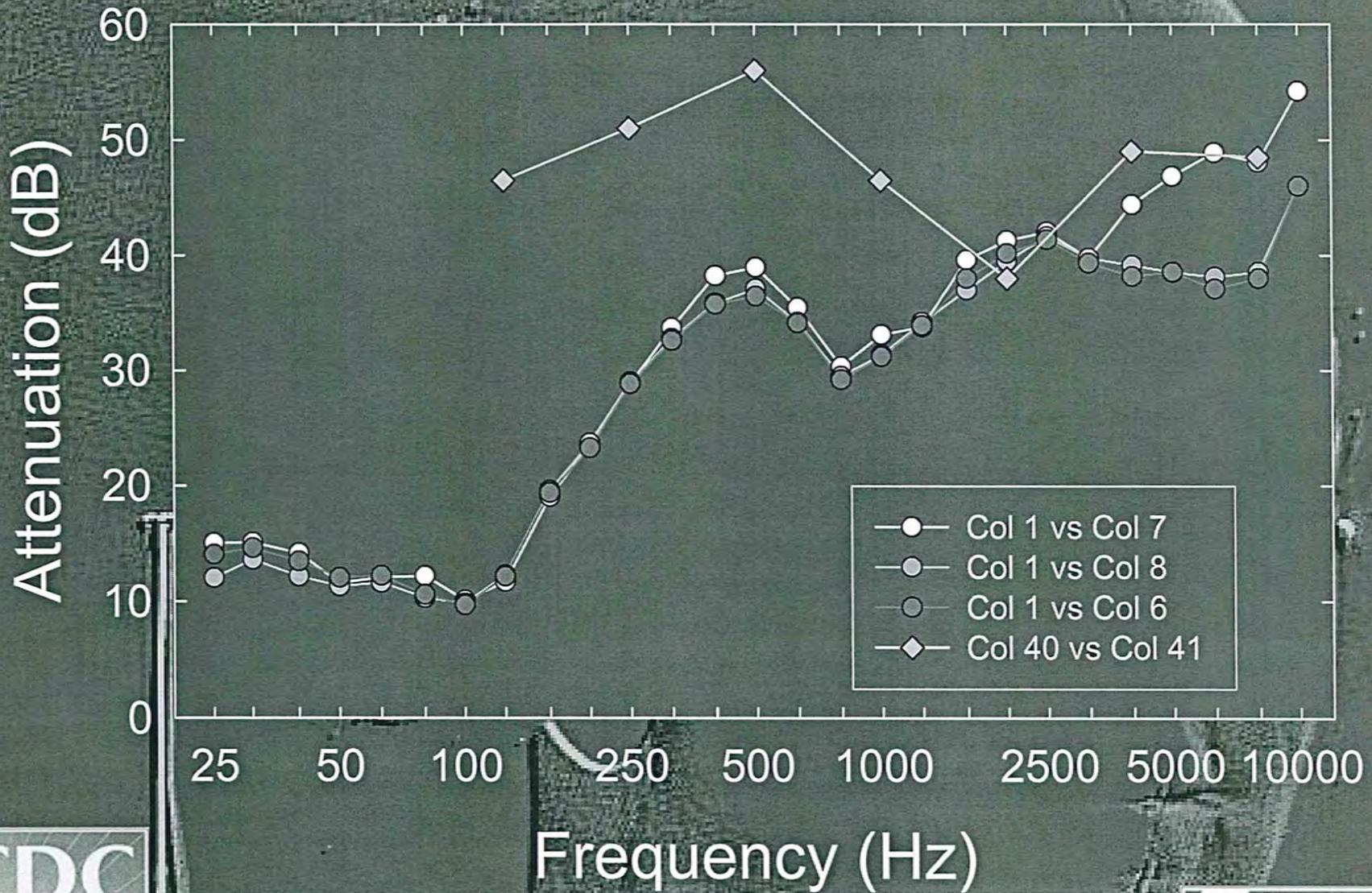
Peak Reduction by Protector



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Bilsom 707 Impact II Earmuffs

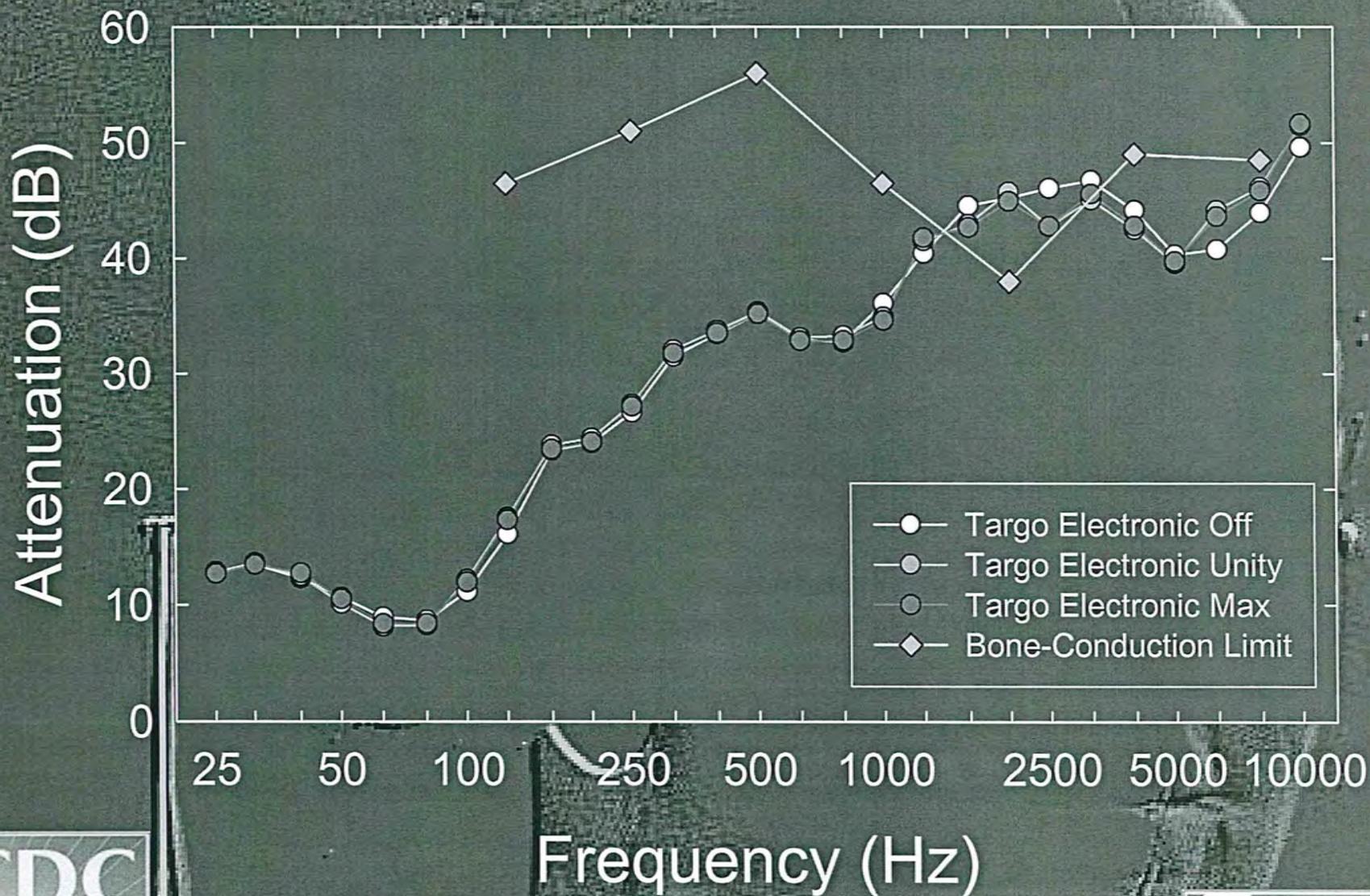


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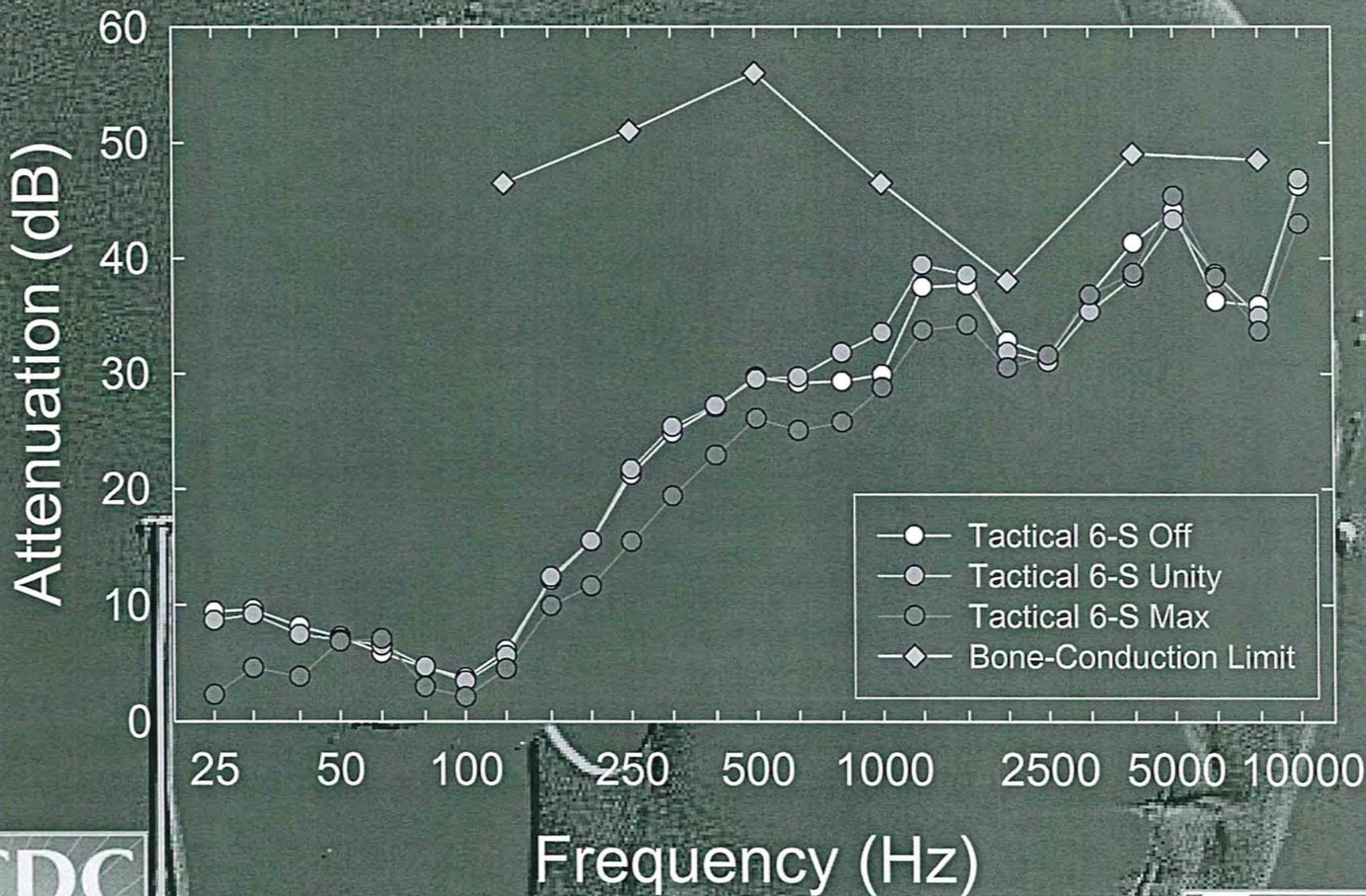
Bilsom Targo Electronic Earmuffs



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Peltor Tactical 6-S Earmuffs

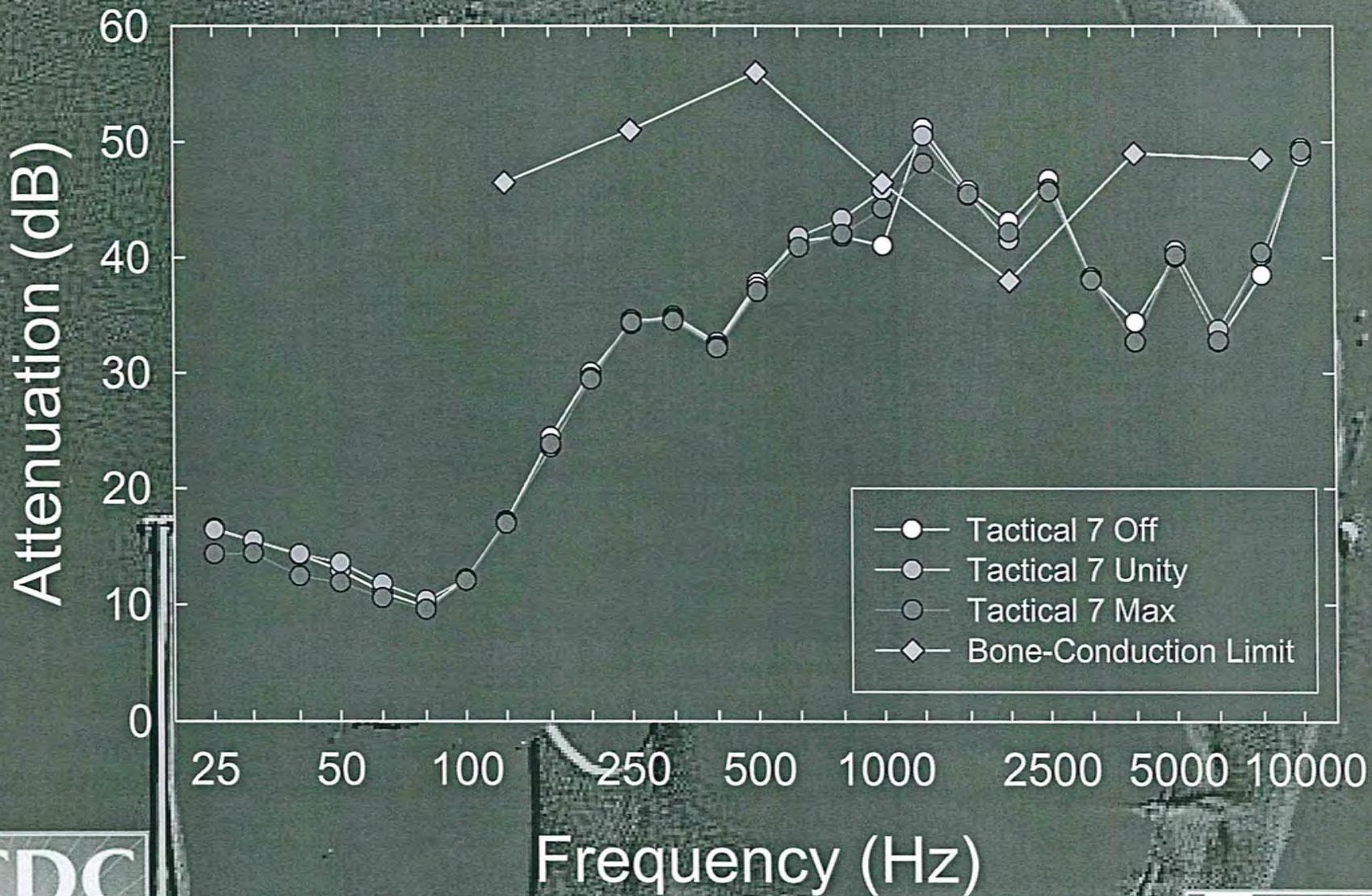


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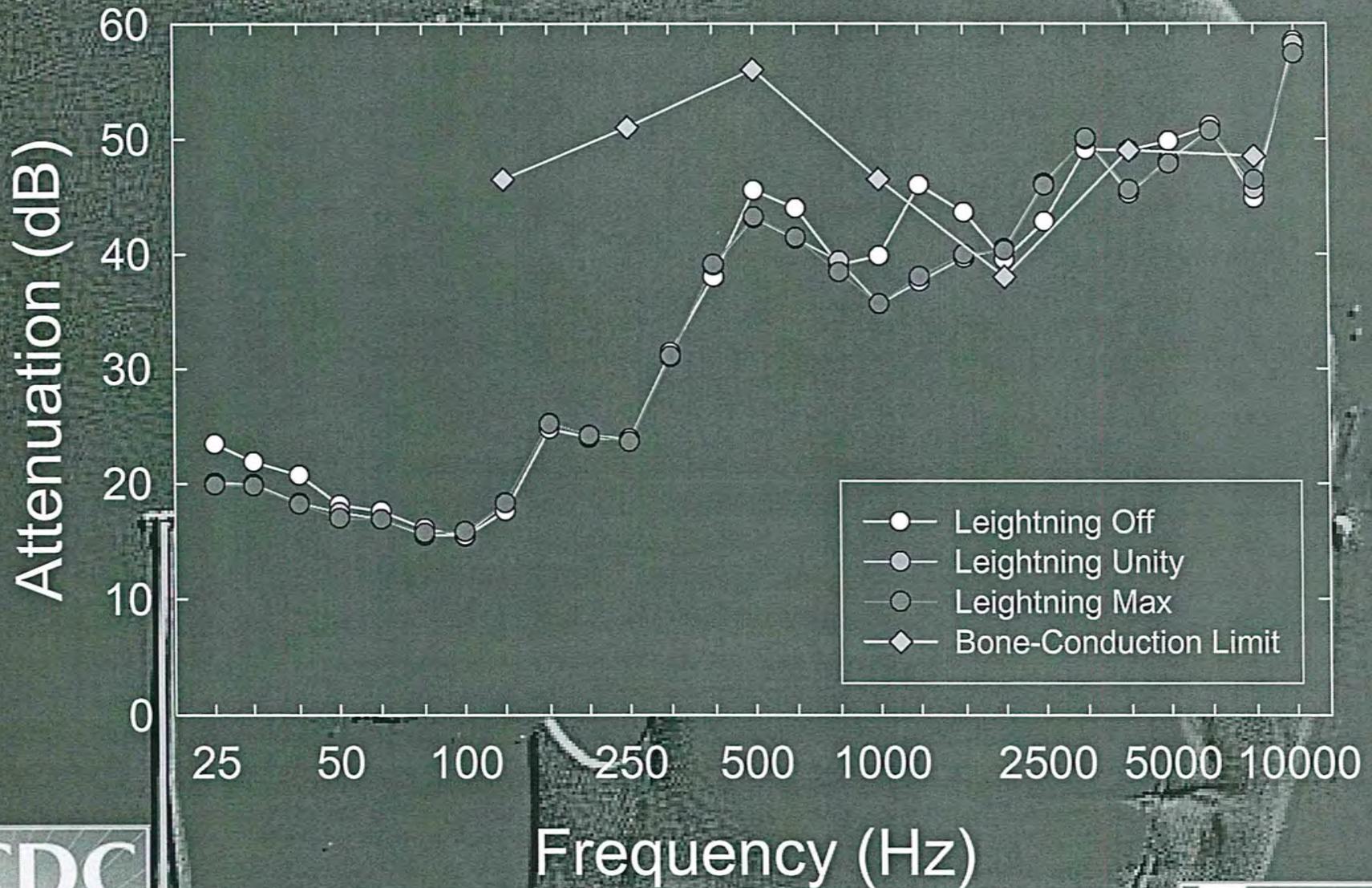
Peltor Tactical 7 Earmuffs



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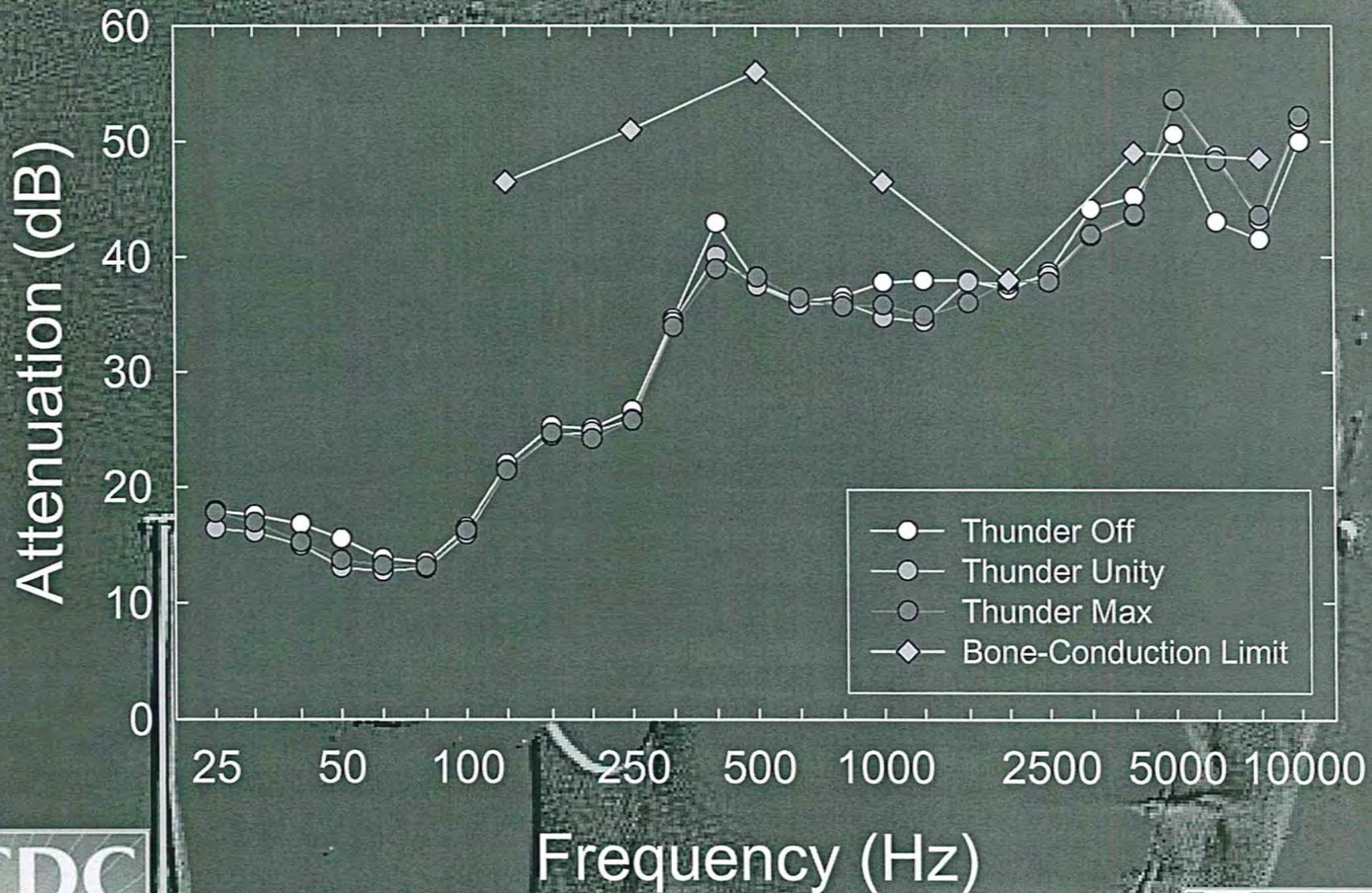
Howard Leight Lightning Earmuffs



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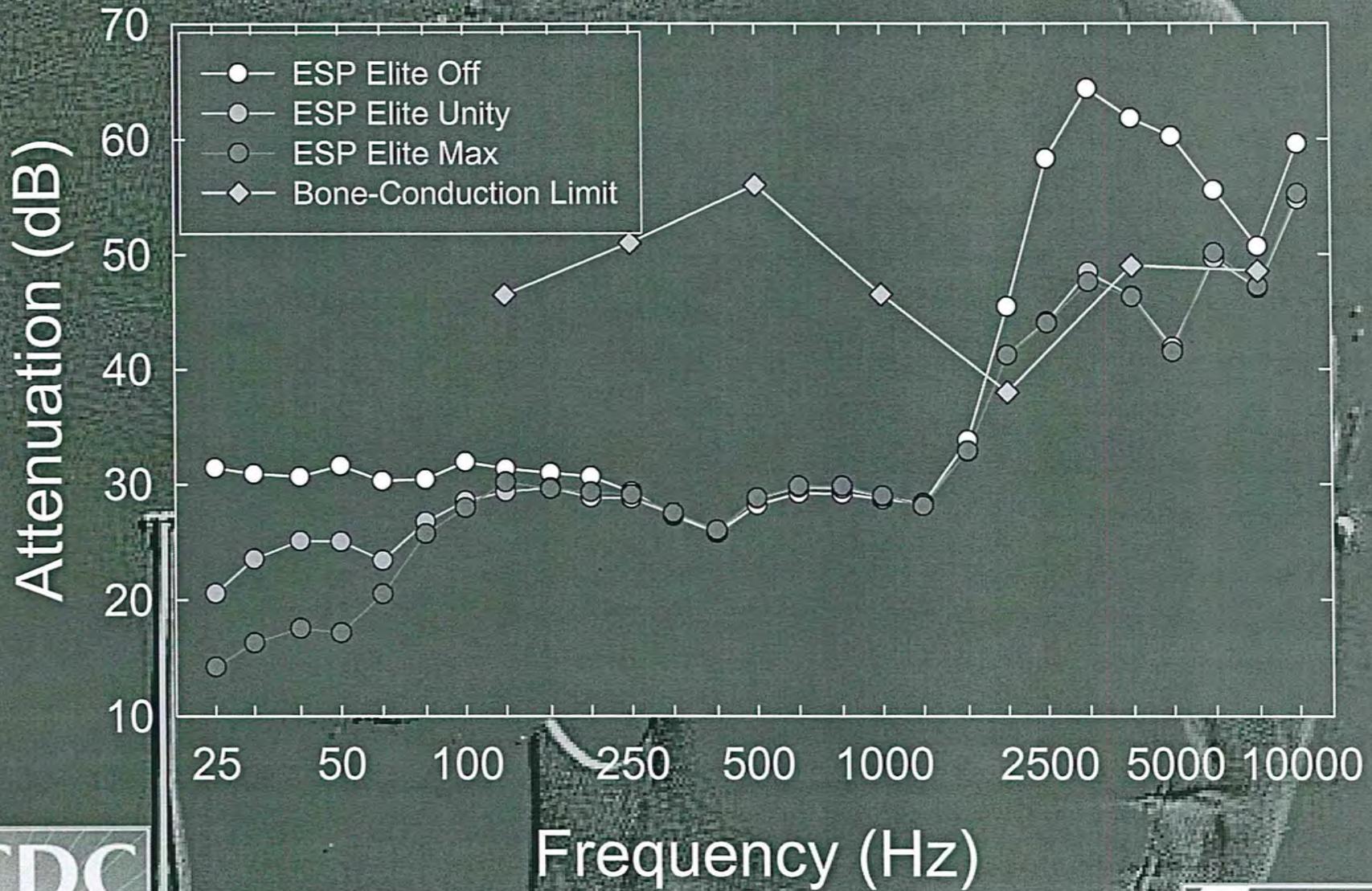
Howard Leight Thunder Earmuffs



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ESP Elite Protectors

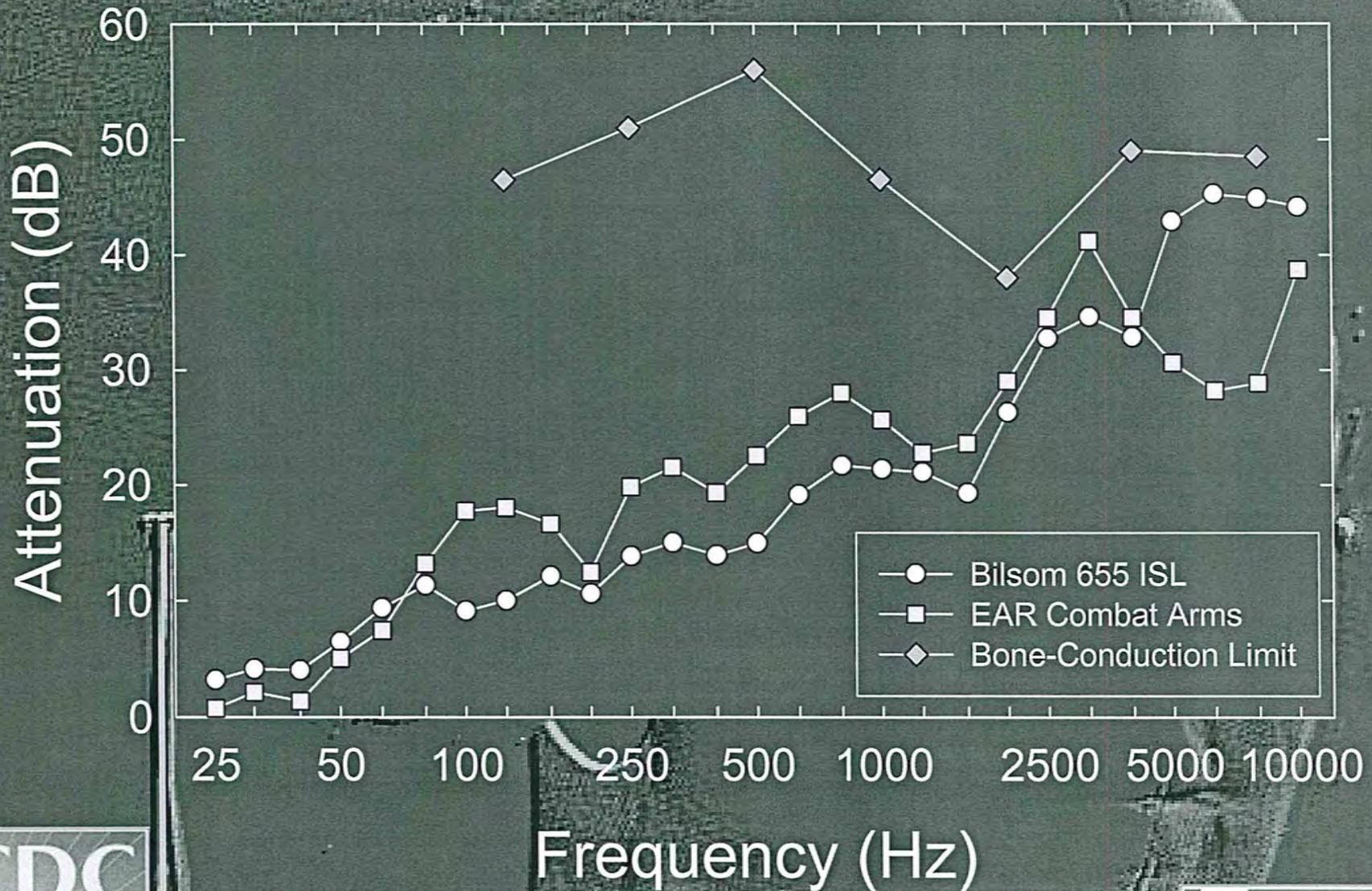


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EAR & Bilson Nonlinear Earplugs



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Electronic Performance

- Most electronic earmuffs do not add additional signal to loud impulses.
- Electronics are sufficiently fast to protect from impulsive noise.
- Electronic earmuffs yield low-pass filter effect that is almost identical with the passive earmuff.

Attenuation Performance

- For most earmuffs, attenuation is not dependent upon the peak impulse level above 159 and below 170 dB SPL.
- Poor attenuation below 500 Hz.
 - Earmuffs typically have poorer low frequency performance due to the volume of the cup.
 - Inconsistent performance below 100 Hz due to analysis.

Recommended Usage

- The Protected Peak Exposure Levels for shooting were about 130-140 dB SPL.
- NIOSH recommends no more than 1 peak at 140, based upon TWA of 85 dBA.

$$N = 10^{(140 - \text{PI dB}) / 10}$$

10 impulses at 130 dB

100 impulses at 120 dB, etc.

Recommended Usage

- Dual protection Earmuffs with Earplug.
 - Use the electronics to overcome the insertion loss of the earplugs.
- If using safety glasses while shooting, use dual protection; the stems cause an acoustic leak that compromise the cushion's seal.



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