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Selection of passive hearing protection

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Selection of Passive Hearing Protection

1.0 Introduction

The purpose of this guidebook is to explain elements of the Evaluated Passive Hearing Protection Device (HPD) poster to enable hearing health professionals, industrial hygienists, and safety professionals to better select hearing protection appropriate for the noise environment and hearing critical tasks Service Members perform. The HPDs listed in this guidebook have been thoroughly evaluated for performance but do not constitute an approved HPD list.

Good hearing is critical to warfighter performance. All warfighters rely on hearing to communicate among individuals, within and between units, with higher headquarters, and often between battle spaces and other Services. Warfighters also rely on hearing for situational awareness, such as determining the direction of gunfire or whether an enemy is approaching. Many warfighters work in hazardous noise environments every day of their military career. Exposure to hazardous noise, continuous and/or impulsive, may cause significant hearing loss and/or hearing related disabilities. Reducing the risk of hearing loss is essential; when engineering and administrative controls are not possible, HPDs are required.

Traditional passive HPDs are designed to reduce the amount of hazardous noise reaching the inner ear. While protecting hearing is an essential quality of all HPDs, some warfighters require HPDs that allow critical sounds to pass through the device to allow for communication capabilities and situational awareness. For example, force protection personnel must be able to communicate with approaching people, detect and identify sounds, localize the direction of the sound, and work with intermittent noise from approaching vehicles or even gunfire. As such, researchers designed assessment methods to determine how well HPDs function on three fronts: continuous noise suppression; impulsive noise suppression; and sound localization.

The poster provides an overview of performance characteristics of passive hearing protective devices that includes attenuation for continuous and impulsive noise and the effect the HPD has on the user's sound localization performance. In this guide, section 2 has background information, section 3 reviews the poster elements, and section 4 provides guidance on selecting proper hearing protection.

2.0 Background

When selecting HPDs, the working environment, type of work performed, and the hearing critical tasks of the work must be considered. First, HPDs must provide the appropriate level of protection for the noise level. Louder environments demand greater levels of attenuation, but over protection may make the user feel isolated from the environment and decrease the user's situational awareness. When selecting hearing protection, factors other than noise attenuation may be considered such as how a device affects hearing critical tasks, comfort, compatibility with other equipment and other non-acoustical factors like ease of use and cost.

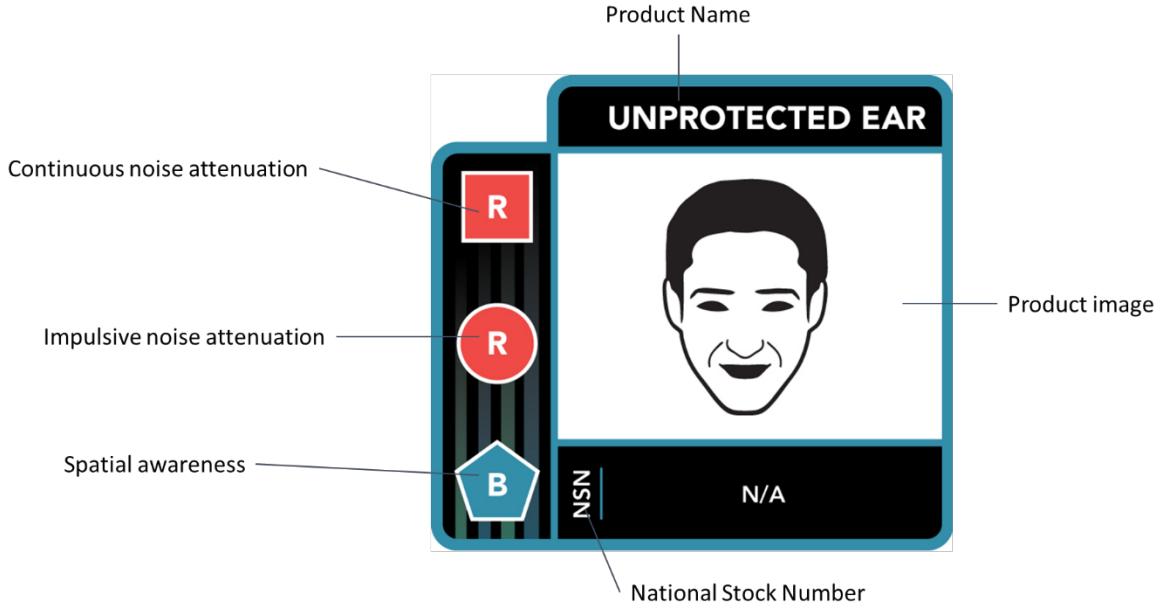
Hearing critical tasks are tasks in which hearing is the only sense that can perform those tasks. Response to the detection, identification, location of sound, or understanding speech is often time sensitive, is usually related to the safety of an operation, and leads to the successful completion of an operation. Examples of hearing critical tasks are talking over the telephone or radio, detecting enemy

presence in low visibility environments or when vision is obscured, and determining the direction of enemy gunfire.

The Evaluated Passive Hearing Protection Devices poster presents passive HPDs that do not contain nor allow connection to electronics that can suppress noise, connect to radio systems, or enhance hearing critical sounds. HPDs have been developed with those capabilities; however, these devices are not necessary for many jobs in the military. Audiologists, industrial hygienists, and safety professionals can assess workplaces and make recommendations for appropriate HPDs for each task. The most expensive or most technologically advanced HPD is not always necessary. The best HPD provides the necessary level of protection, fits well, is comfortable to wear, and allows users to hear critical sounds necessary for the job. Most importantly, it is used by the employee and worn correctly.

3.0 Poster elements

Marine Corps Systems Command provided funding for the study and selected all the passive insert HPDs. The Air Force Research Laboratory (AFRL) performed the HPD assessment that included continuous noise attenuation, impulsive noise attenuation and sound localization measurements by way of an aurally guided visual search task. Each HPD on the poster is described with a product name, a picture of the device, and a National Stock Number (NSN) when applicable. The performance metrics are also displayed for each HPD by way of a colored rating scale. A square is used to represent the colored rating for continuous noise attenuation; a circle represents the colored rating for impulsive noise attenuation; and a pentagon is used to represent the colored rating for spatial awareness.



A. Continuous noise attenuation

1. Continuous noise attenuation data was collected in accordance with ANSI S12.6-2008 Method A, trained-subject fit.
    a. Noise level reduction statistics for A-weighting (NRS_A) versus Noise Reduction Rating (NRR)
        i. NRR, a single number descriptor, is a well-known way of estimating the noise level under a HPD. EPA regulations require manufacturers to display the NRR on

HPD labels. However, the NRR was designed to be subtracted from C-weighted noise levels and requires a 7-dB spectral adjustment be applied prior to subtracting it from A-weighted noise levels.

ii. Noise level reduction statistics for A-weighting (NRS_A) was designed to be subtracted directly from the measured A-weighted noise level to estimate the level of sound at the ear under the hearing protector. The method offers several advantages over the well-known NRR. As stated above, the NRR was designed to be subtracted from C-weighted noise levels. NRS_A eliminates this problem with the NRR by subtracting from the A-weighted noise levels, which are typically known. NRS_A should not be used with noise environments that have high levels of low frequency content or if the overall sound pressure level exceeds 100 dBA. Another advantage of NRS_A is that it calculates two levels of protection to indicate the range of performance achieved during the evaluation. This range reflects the variation across the subjects in the test panel, providing insight into how hard/easy the device may be to fit. The majority of users (80%) will achieve the performance specified by the lower value in the range, with only the most motivated proficient users (20%) able to achieve or exceed the higher value.

iii. Poster displays the NRS_A via a color code for the majority of users (80%).
    1. Blue – 30 dB or greater
    2. Green – 20-30 dB
    3. Yellow – 10-20 dB
    4. Red – 10 dB or less

Hearing Protector	NRS_A		Poster Ratings
	80%	20%	
3M EAR UltraFit	19	30	Yellow
Allen Sound Sensor	17	30	Yellow
EarPlugz PC with cord	17	31	Yellow
EarPlugz PC without cord	16	29	Yellow
Etymotic ER20 ETY	14	20	Yellow
Hear Defenders DF	19	29	Yellow
Hearing Armor	16	30	Yellow
Howard Leight Max	29	29	Green
Moldex BattlePlugs Closed	19	30	Yellow
Moldex BattlePlugs Open	10	19	Red
Moldex PuraFit	33	41	Blue
SensGard SG26	19	31	Yellow
SensGard SG31	23	33	Green
Combat Arms Gen 4 Closed	23	29	Green
Combat Arms Gen 4 Open	10	17	Yellow
Sonic Defenders EP3 Closed	18	31	Yellow
Sonic Defenders EP3 Open	12	20	Yellow
Sonic Defenders EP4 Closed	23	28	Green
Sonic Defenders EP4 Open	12	20	Yellow

Sonic Defenders EP7 Closed	28	34	Green
Sonic Defenders EP7 Open	16	30	Yellow

2. Consult service guidance when using the NRR.

B. Impulsive noise

1. When anticipating exposure to impulsive noise such as on a firing range, personnel should choose hearing protection that has been evaluated for its capability to protect against impulsive noise hazards. M16s usually generate mid-150 dBP range at the shooter (but higher to the sides) and a 105 mm Howitzer exposes crew to levels from the mid-160 dBP range to the low-180 dBP range depending on firing conditions. When selecting HPDs to protect against impulsive noise, choose the peak sound pressure level closest to the expected exposure.
    a. Note: Impulsive noise is the term used in MIL-STD-1474E, the Department of Defense Design Criteria Standard Noise Limits. The term is more current and is synonymous with impulse noise.
    b. The below table lists devices and the average impulsive peak insertion loss data from blast measurements. ANSI S12.42-2010 was used for the testing methodology. The insertion loss for each ear at impulsive noise levels at 170 dB, 185 dB and 195 dB is contained below.
    c. The poster displays via a color code the impulsive noise attenuation at 170 dB.
        i. Blue – 30 dB or greater
        ii. Green – 20-30 dB
        iii. Yellow – 10-20 dB
        iv. Red – 10 dB or less

Hearing Protector	Peak Sound Pressure Level			Poster Ratings
	170 dB	185 dB	195 dB	
3M EAR UltraFit	36	35	36	Blue
Allen Sound Sensor	10	21	33	Yellow
EarPlugz PC with cord	35	36	33	Blue
EarPlugz PC without cord	34	35	41	Blue
Etymotic ER20 ETY	25	28	32	Green
Hear Defenders DF	41	38	39	Blue
Hearing Armor	35	36	30	Blue
Howard Leight Max	41	41	41	Blue
Moldex BattlePlugs Closed	36			Blue
Moldex BattlePlugs Open	30			Green
Moldex PuraFit	54	41	41	Blue
SensGard SG26	31	27	33	Blue
SensGard SG31	28	20	29	Green
Combat Arms Gen 4 Closed	40			Blue
Combat Arms Gen 4 Open	33			Blue
Sonic Defenders EP3 Closed	28	28	33	Green
Sonic Defenders EP3 Open	26	28	32	Green
Sonic Defenders EP4 Closed	35			Blue

Sonic Defenders EP Open	28			Green
Sonic Defenders EP7 Closed	41	41	41	Blue
Sonic Defenders EP7 Open	28	34	40	Green

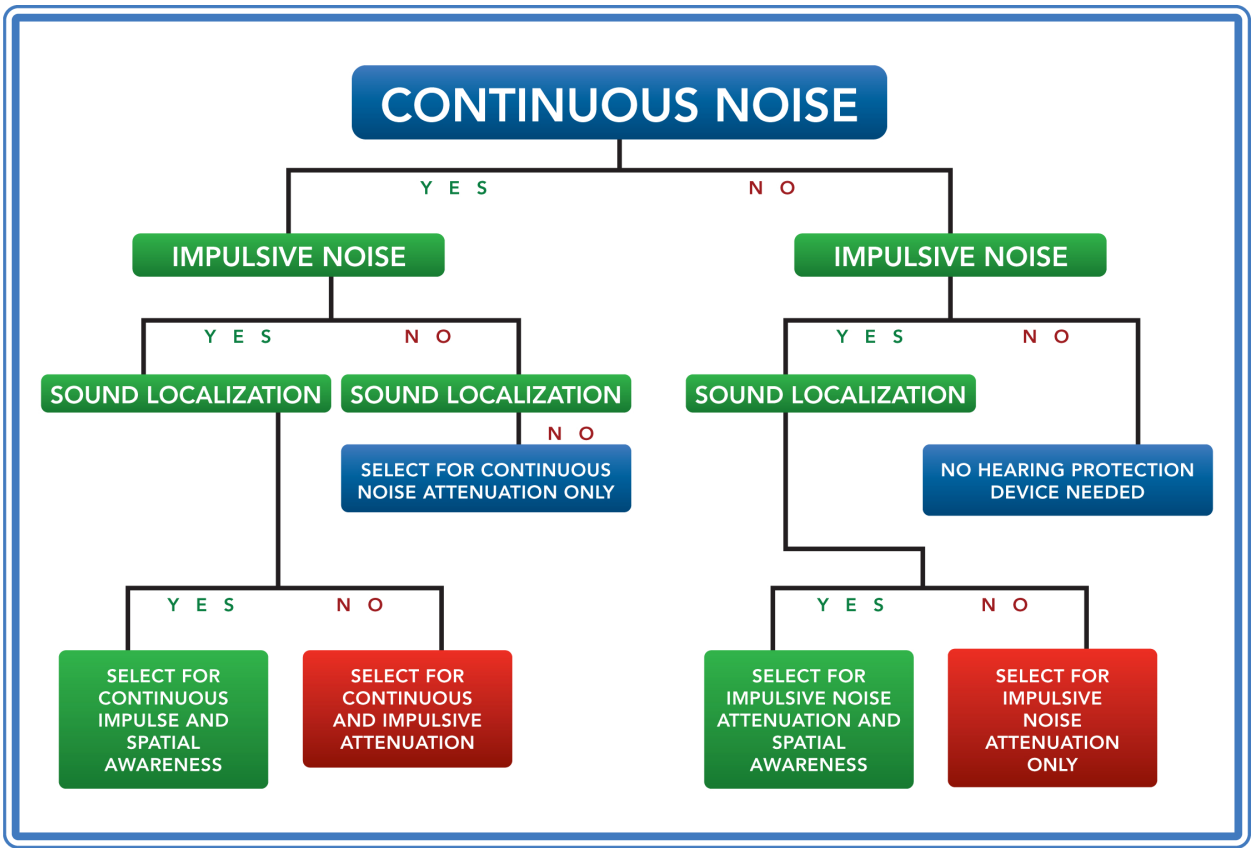
C. Spatial awareness (localization)

1. Spatial awareness was assessed using an aurally guided visual search. This task demonstrates the impact HPDs have on the time required to accurately locate the origin of a sound. In the test, subjects are tested in three conditions, (1) visual target without aural guide, (2) visual target with aural guide, no hearing protector, and (3) visual target with aural guide and hearing protector. Without an aural guide, subjects average 12.2 seconds to find the target. With hearing protection, subjects take longer to find a target until the aural guide presentation levels are around 80 dB.
    a. Poster displays the search time when the presentation level was at 40 dB via a color code.
        i. Blue – 4 seconds or less
        ii. Green – 4 - 7 seconds
        iii. Yellow – 7 – 10 seconds
        iv. Red – 10 seconds or greater

Hearing Protector	Target Level (dB SPL)					Total (30, 40, 60)	Poster Rating
	15	30	40	60	80		
3M EAR UltraFit		12	11	5	4	28	Red
Allen Sound Sensor		10	8	5	5	22	Yellow
EarPlugz PC with cord		13	11	5	5	29	Red
EarPlugz PC without cord		11	9	5	4	25	Yellow
Etymotic ER20 ETY	12	9	6	3		18	Green
Hear Defenders DF		12	11	5	4	28	Red
Hearing Armor		10	9	5	3	24	Yellow
Howard Leight Max		12	12	8	6	33	Red
Moldex BattlePlugs Closed		--	--	--	--	--	--
Moldex BattlePlugs Open		--	--	--	--	--	--
Moldex PuraFit		12	13	12	6	37	Red
SensGard SG26		10	7	4	5	21	Green
SensGard SG31		9	7	5	4	21	Yellow
Sonic Defenders EP3 Closed		12	8	4	4	24	Yellow
Sonic Defenders EP3 Open	12	11	6	4		21	Green
Sonic Defenders EP4 Closed		--	--	--	--	--	--
Sonic Defenders EP4 Open		--	--	--	--	--	--
Sonic Defenders EP7 Closed		13	12	5	4	30	Red
Sonic Defenders EP7 Open	12	12	10	4		26	Red

4.0 Selecting Hearing Protection

The chart below is a decision tree that will assist in selecting the best hearing protection for the expected noise exposure and the job task. The HPDs depicted in the poster and in this guidebook are passive earplugs only. If communication in a noise hazardous environment is essential, devices with additional capabilities should be used as opposed to the HPDs in this document.



A. Considerations in selecting appropriate hearing protection

1. Noise environment

a. A hazardous continuous noise environment is where the ambient noise level lasts for 1 second or more (usually much longer), but which can be variable, steady or intermittent over time. DoDI 6055.12 defines hazardous steady state noise levels at 85 dBA time weighted average (TWA) or greater over an 8-hour timeframe. Shipboard engineering spaces, generator noise and helicopter noise are examples of continuous noise.

i. Single hearing protection shall be worn when noise levels meet or exceed 85 dBA, regardless of duration.

ii. The DoD noise exposure criterion to reduce the risk of hearing loss or hearing related disabilities is 85 dBA for a duration of 8 hours with a 3 dB per doubling exchange rate. Therefore, if the noise level increases to 88 dBA the allowable duration of time in noise, if unprotected, is reduced to 4 hours.

iii. Guidance on the use of earplug and earmuff combinations, commonly referred to as double hearing protection, differs among the Services. The term “double” hearing protection is misleading as the attenuation from earplug and earmuff is less than

the arithmetic sum of their individual attenuation values. When guidance indicates double hearing protection is needed, the Occupational Safety and Health Administration recommends adding 5 dB to the derated NRR of the hearing protector with the highest NRR to determine total attenuation provided by the earplug and earmuff combination. Regardless of whether using single or double protection, the service members or employee's total exposure shall be reduced to below 85 dBA TWA for an 8-hour work day.

1. The Army Hearing Program requires use of earplugs and helmet or earplugs and earmuffs when steady state noise levels are 103 dBA TWA and up to 108 dBA TWA.
2. The Revised Interim Navy Medicine Hearing Conservation Program Guidance states areas or equipment where sound pressure levels are 96 dBA or greater shall require the use of double hearing protection that attenuates worker noise exposure below an 8-hour TWA or 85 dBA. The Navy bases double hearing protection upon the effective field derated upper limit of most earplugs and earmuffs.
3. For the Air Force, the hearing protectors provided must be capable of attenuating worker noise exposure below a TWA of 85 dBA. The threshold for using dual hearing protection depends on the protectors selected. Per Air Force Instruction 48-127, 3 dB should be added to the highest NRR of the plug or muff to estimate combined protective rating. Consult the local bioenvironmental unit or the Air Force Environment, Safety and Occupational Health Service (ESOH) Center for assistance in determining the appropriate hearing protection.

3. Impulsive noise is a short duration sound lasting less than 0.5 seconds, containing one or more pulses. Impulsive noise is considered hazardous if one or more of the pulses exceeds 140 decibels peak (dBP) or greater. Gun shots and manual hammering are examples of impulsive noise.
    a. Impulsive noise greater than 140 dBP requires hearing protection.
    b. Per the Army Hearing Program and the Navy Hearing Conservation Program Guidance exposure to levels above 165 dBP requires double hearing protection unless the single protection can be demonstrated to reduce at-ear levels to below 140 dBP.
    c. For the Air Force, contact the local bioenvironmental unit or ESOH Center for assistance in selecting HPDs for impulsive noise.

4. Hearing Critical Tasks

a. Sound localization, which is defined as the ability to determine the apparent direction and/or distance of a sound source, as measured by the time it takes to fixate on the source. **NOTE:** At this time, we have not established the point at which it takes too much time to perform a military task.
    i. The poster depicts sound localization as spatial awareness.
b. Speech Intelligibility reflects the ability to understand transmitted words. When this task is important, it may require the speech be electronically transmitted to bypass the

attenuation of the hearing protector or use of level-dependent hearing protectors that selectively suppress unwanted sounds.

5. *Wearability*
    a. Includes whether a device can be worn without interfering with other required equipment such as battle helmet and/or eye protection.
    b. Wearer finds it comfortable when worn. Comfort may depend on how long the product has to be worn and the environment in which the product is used (such as ambient temperature).

B. Determining Hazardous Noise Requirements

The Services use noise surveys conducted by occupational safety and health professionals, occupational audiologists, industrial hygienists, and bioenvironmental engineers to determine locations and equipment that are noise hazardous. Noise surveys report sound pressure levels (SPLs) and characterize the sound source as either continuous or impulsive noise. HPDs should be selected to provide the adequate protection against the identified noise hazard.

C. Determining Spatial Awareness Needs

Spatial awareness is the ability to accurately locate the origin of a detected sound in any direction. The concept is illustrated by the questions 'Can I hear the sound?' and 'Can I determine the direction of the sound?' In the military, the ability to answer these questions is important to many jobs and missions and certain hearing protection can interfere with these capabilities. Jobs that require localization include dismounted operations, special operations, and force protection. By understanding the performance of devices and the impact on the user's ability to locate sounds, warfighters can select a device that will have minimal impact on spatial awareness while protecting from hazardous noise.

5.0 Conclusion

The information provided in this guide is to assist audiologists, industrial hygienists/bioenvironmental engineers, and safety professionals in selecting passive hearing protection devices. Questions on the information in this guide or how to use it should be addressed to the Service Public Health Commands/Centers, the ESOH Service Center or to the DoD Hearing Center of Excellence (https://hearing.health.mil/).

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Annex A. Acronyms

ANSI – American National Standards Institute

ASA – Acoustical Society of America

AFRL – Air Force Research Laboratory

dB – decibel

dBA – decibel A-weighted

dBP – decibel Peak (measured unweighted or using the C-weighted scale)

DoDI – Department of Defense instruction

EPA – Environmental Protection Agency

ESOH – Air Force Environment, Safety and Occupational Health Office

HPD – hearing protective device

NRR – noise reduction rating

NRS_A – noise reduction statistic A-weighting

SPL – sound pressure level

TWA – time weighted average

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