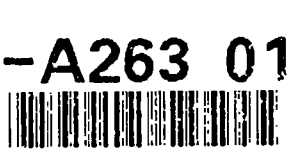

USAARL Report No. 93-10

Sound Attenuation Characteristics of the Standard DH-132A and SPH-4 Helmets Worn in Combination with Standard Issue Earplugs

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Introduction

The Health Hazard Assessment (HHA) of Army systems usually requires a review of noise and hearing protection associated with the systems used. Hearing protection for crews in combat vehicles is specified to be the DH-132A and, in some cases where noise levels are extremely high, earplugs are worn in combination with the helmet in order to provide adequate protection. Hearing protection for Army helicopter crewmembers is the SPH-4 helmet with a few exceptions. The attenuation data used for the HHA are measured at this Laboratory. This report incorporates the results of attenuation measurements of the SPH-4 and DH-132A helmets worn in combination with the standard Army issue earplugs. Earplugs used in the study were the single flange, triple flange, and yellow/white foam plug.

Methods and instrumentation

Real-ear sound attenuation measurements were completed on the standard DH-132A and SPH-4 helmets worn in combination with standard Army issue earplugs (see Appendixes). The measurements utilized the procedures described in ANSI Standard S12.6-1984, "Method for the measurement of the real-ear attenuation of hearing protectors." Figure 1 shows the test system used in determining the attenuation characteristics of the protective devices. Stimuli required by the S12.6 method are 1/3 octave bands of noise with center frequencies at 125, 250, 500, 1000, 2000, 3150, 4000, 6300, and 8000 Hz. The noise bands were presented to the listener in a hard-walled room which provided a nondirectional sound field.

Ten listeners, male and female, with normal hearing were selected, in accordance with ANSI S3.6-1989 (R1969), to evaluate the real-ear attenuation characteristics of the devices. Real-ear attenuation was defined as the difference in auditory threshold of occluded (wearing the helmet) and unoccluded (not wearing the helmet) measurements. The method of adjustments psychophysical procedure was used to measure the hearing threshold of the subjects. Subjects, one at a time, were seated in the sound room with their heads placed at a fixed location in space. A key pad, which is controlled by the subject, was used to increase or decrease the stimulus level during the experiment. The subjects were instructed to adjust the stimulus level to their auditory threshold for four separate trials for each of the test frequencies while wearing and not wearing the hearing protector. The average stimulus level of the four trials at each test frequency was used as

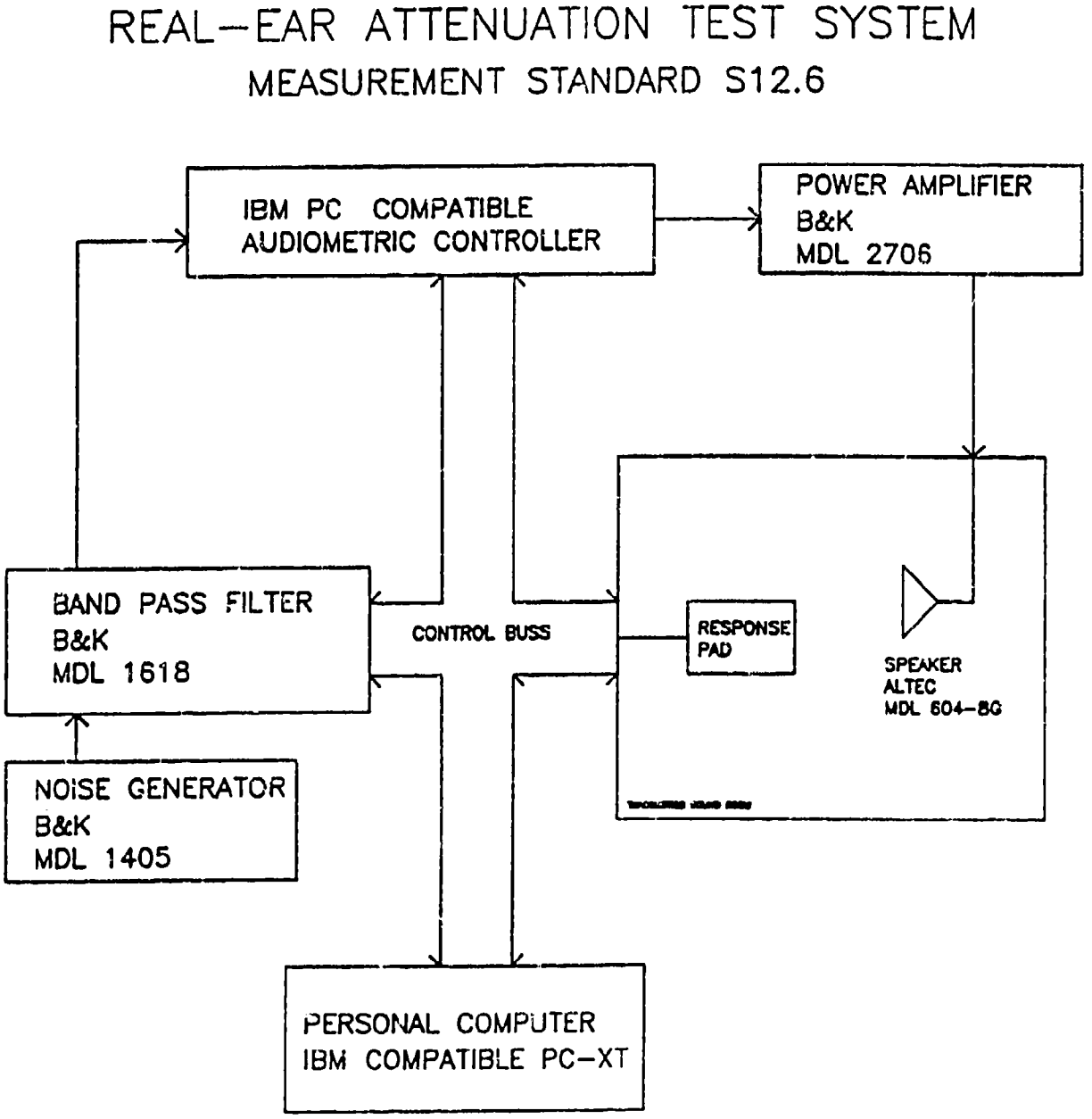

Figure 1. Real-ear attenuation test system measurement standard S12.6.

threshold for that test condition. The attenuation for each of the test frequencies was measured for three fittings of the hearing protector for each of the subjects in the evaluation. The attenuation for each fitting of the 10 subjects was used to calculate mean and standard deviation values for each of the test frequencies.

Real-ear attenuation characteristics were measured on three earplugs, one foam and two premolded, in combination with a DH-132A and an SPH-4 helmet. Subjects were provided training in the proper procedures of fitting the earplugs and the helmet combination. Each device was fitted by the subject under the supervision of the experimenter. Earplug and helmet size were determined by the experimenter.

The test sequence was designed to allow measurement of the helmet/earplug combination and the earplug only. The fit of the earplug was the same for both measurements. A single unoccluded measure was paired with each of the two occluded measures. Each of the three test measurements were repeated three times for each subject.

Results and discussion

The results of the attenuation measurements are shown in Tables 1 and 2. As expected, these data indicate improvements in attenuation for the helmet/earplug combination when compared to attenuation results while wearing earplugs only.

The noise hazard that an individual is exposed to may be estimated by combining noise level and sound attenuation measurements to determine noise at the ear. This estimated effective exposure level (EEL) is an indicator of the hearing protective capability of the helmet and earplugs for the noise environment in which it is to be used. Use of the EEL provides insight into the hearing protector's capability when used in a particular noise environment. DoD Instruction 6055.12, "Hearing Conservation," states that steady noise of 85 dBA or greater is considered hazardous, regardless of duration of exposure.

Table 3 shows the EEL of aviators wearing the SPH-4 helmet in combination with three types of earplugs while flying in various Army aircraft. EELs for each of the hearing protective devices evaluated are well below the 85 dBA criteria for all aircraft indicated. Table 4 shows the EELs of combat vehicle crewmen wearing the DH-132A helmet in combination with three types of earplugs for noise levels produced by the M3, M1 and the M113. EELs for each of the hearing protective devices evaluated exceed the 85 dBA criteria for the M113 and M3 except the DH-132A/foam earplug combination. The EELs for the M1 are below the 85 dBA criteria for all DH-132A/earplug combinations.

Table 1.

Mean real-ear attenuation and standard deviation results in dB of the DH-132A and SPH-4 helmets used in combination with three types of earplugs

		Test frequencies in hertz								
		125	250	500	1000	2000	3150	4000	6300	8000
DH-132A w/triple flange plug	Mean	32.0	37.1	40.2	34.9	34.0	43.1	45.1	47.4	50.2
	S.D.	5.3	6.0	5.4	5.2	4.8	4.5	4.8	6.0	3.6
SPH-4 w/triple flange plug	Mean	30.6	33.3	36.2	32.0	38.6	49.0	52.2	53.6	53.7
	S.D.	6.6	5.9	6.8	4.0	4.3	4.0	3.8	4.5	3.6
DH-132A w/single flange plug	Mean	27.6	34.2	34.0	32.0	39.0	47.9	50.7	52.2	50.8
	S.D.	5.9	6.3	6.4	3.5	4.3	5.3	4.8	5.8	5.8
SPH-4 w/single flange plug	Mean	27.5	29.5	34.4	32.1	38.3	49.6	53.6	55.3	54.7
	S.D.	4.9	5.5	6.0	5.5	4.4	5.0	5.6	5.5	4.0
DH-132A w/foam plug	Mean	33.9	40.7	47.0	38.7	38.1	48.7	52.7	53.9	55.4
	S.D.	6.0	6.9	7.8	5.1	4.2	5.3	5.4	4.9	4.7
SPH-4 w/foam plug	Mean	32.7	36.9	42.4	37.2	37.5	50.7	52.7	55.5	54.8
	S.D.	7.2	7.2	7.9	7.6	4.1	5.9	6.1	5.2	4.5

Table 2.

Mean real-ear attenuation and standard deviation results in dB of three earplugs used in the evaluation of the DH-132A and SPH-4 helmets

		Test frequencies in hertz								
		125	250	500	1000	2000	3150	4000	6300	8000
*Triple flange plug	Mean	21.5	20.3	21.5	23.0	27.8	32.0	31.3	36.2	38.0
	S.D.	6.5	6.2	7.0	4.7	5.0	9.2	10.5	9.3	7.3
**Triple flange plug	Mean	21.2	21.0	20.8	21.0	27.6	30.0	27.9	35.0	36.2
	S.D.	7.4	7.4	7.7	4.7	6.3	9.3	10.3	9.4	9.6
*Single flange plug	Mean	19.2	19.3	19.4	19.9	26.5	28.9	26.1	28.9	27.0
	S.D.	6.6	6.1	7.0	4.7	5.0	5.2	5.3	7.0	6.1
**Single flange plug	Mean	20.7	19.2	20.5	21.4	26.7	28.8	26.0	29.9	27.9
	S.D.	4.6	4.9	5.1	4.5	3.5	5.0	4.2	7.3	7.3
*Foam plug	Mean	28.1	28.1	31.0	29.4	31.1	39.9	40.2	41.3	42.8
	S.D.	8.8	8.0	7.8	6.0	5.0	4.1	3.2	3.7	3.6
**Foam plug	Mean	27.8	26.6	29.2	27.8	30.4	39.0	39.3	41.0	41.2
	S.D.	7.3	6.1	7.8	6.4	4.9	3.9	4.6	3.5	3.3

*DH-132A helmet
**SPH-4 helmet

Table 3.

Estimated effective exposure level (EEL) in dBA of aviators wearing the SPH-4 helmet in combination with three types of earplugs at the pilot's position while in noise levels produced by various Army aircraft

Protector	UH-60A 120 kn	CH-47C 100 kn	AH-1S 100 kn	OH-58 cruise	UH-1H 100 kn
SPH-4 with triple flange plug	72.6	77.5	70.2	65.7	70.7
SPH-4 with single flange plug	75.3	78.4	71.5	67.4	71.9
SPH-4 with foam plug	70.4	77.3	68.8	63.5	68.8

Table 4.

Estimated effective exposure level (EEL) in dBA of combat vehicle crewmen wearing the DH-132A helmet in combination with three types of earplugs while in noise levels produced by various ground combat vehicles

Protector	M3 30 mph	M1E1 32 mph	M113 30 mph
Triple flange plug	85.5	78.5	91.3
Single flange plug	89.8	82.4	94.7
Foam plug	83.2	76.6	89.4

Conclusions

The foam earplug combined with helmet provides highest sound attenuation while the single flange combined with helmet provides lowest sound attenuation of the hearing protectors evaluated. Sound attenuation characteristics of the SPH-4/earplug combination provides adequate hearing protection for Army aviation noise environments. DH-132A/foam earplug combination provides adequate hearing protection for M1E1 and M3 noise environments. Noise levels produced by the M113 at 30 mph exceed protective capabilities of any of the hearing protector conditions evaluated.

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American National Standards Institute. 1989. Specification for audiometers. S3.6-1989 (R1969).

American National Standards Institute. 1984. Method for the measurement of the real-ear attenuation of hearing protectors. S12.6-1984.

Department of Defense. 1991. Hearing conservation. Washington, DC: Department of the Army. Department of Defense Instruction 6055.12.

Appendix A

Photographic display of SPH-4 helmet with standard Army issue earplugs

Appendix B

Photographic display of DH-132A helmet with standard Army issue earplugs

Appendix C

Manufacturers' list

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1515 South Manchester Avenue
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