USAARL Report No. 2012-09

Noise Attenuation Loss Due to Wearing APEL Eye Protection with Ear-Muff Style Headset Systems

By Efrem Reeves
Elmaree Gordon
Summer Nomura

United States Army Aeromedical Research Laboratory

Sensory Research Division

February 2012

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REPORT DOCUMENTATION PAGE	*Form Approved* *OMB No. 0704-0188*

1. REPORT DATE *(DD-MM-YYYY)*: 14-02-2012

2. REPORT TYPE: Final

3. DATES COVERED *(From - To)*:

4. TITLE AND SUBTITLE

Attenuation Loss Due to Wearing APEL Eye Protection with Ear-Muff Style Headset Systems

5a. CONTRACT NUMBER

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

5d. PROJECT NUMBER

5e. TASK NUMBER

5f. WORK UNIT NUMBER

6. AUTHOR(S)

Efrem Reeves
Elmaree Gordon
Summer Nomura

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

U.S. Army Aeromedical Research Laboratory
P.O. Box 620577
Fort Rucker, AL 36362

8. PERFORMING ORGANIZATION REPORT NUMBER

USAARL 2012-09

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

U.S. Army Research Development and Engineering Command
3071 Aberdeen Blvd
Aberdeen Proving Ground, MD 21005

10. SPONSOR/MONITOR'S ACRONYM(S)

USARDECOM

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT

Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT

This report describes a baseline study to determine the level of acoustic leakage that can be expected when donning APEL eye protection while using earmuff type communication headsets. For the first phase of this study, three headsets, two helmets, nine pair of APEL eyewear, and four pair of non-APEL eyewear were tested using an ATF to determine the amount of attenuation loss due to eyewear. For the second phase of the study three headsets, three helmets, three pair of APEL eyewear, with and without prescription inserts, and two additional pair of eyewear were tested using an ATF to determine the amount of attenuation loss due to eyewear. Both phases measurements were done following the insertion loss measurement procedure outlined in ANSI S12.42-2010. The results show that wearing APEL spectacles with headset style communication systems is detrimental to the amount of noise attenuation provided by the headset. However, some spectacles produce smaller leaks than others, resulting in a smaller amount of attenuation loss. It is very important, however, to strike a balance so one sense organ will not be protected at the expense of another.

15. SUBJECT TERMS

APEL eyewear, communication headset, hearing protection, noise attenuation

16. SECURITY CLASSIFICATION OF: a. REPORT	b. ABSTRACT	c. THIS PAGE	17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON / 19b. TELEPHONE NUMBER *(Include area code)*
UNCLAS	UNCLAS	UNCLAS	SAR	36	Loraine St. Onge, PhD / 334-255-6906

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Introduction

According to U.S. Army: Authorized Protective Eyewear List (APEL) June 2010, 10 to 16 percent of casualties on the battlefield incur eye injuries. Further, hearing and auditory system injuries are also commonly sustained in combat; as a result, hearing and auditory disorders are the most prevalent occupational injuries suffered by military service members in recent years (Veterans Benefits Administration Annual Benefits Report, 2010). To adequately protect the visual and auditory senses, protective eyewear and hearing protective devices are imperative; however, at times, protective eyewear interferes with the proper wearing of hearing protective devices. In order to maximize the protective properties of each system, it is important to understand how eye protection can change the effectiveness of earmuff style hearing protection in an operational environment.

This report describes a baseline study conducted to determine the level of acoustic leakage that can be expected when donning APEL eye protection (figure 1.) while using earmuff type communication headsets. The study determined the effect of acoustic leakage on both active and passive attenuation. Knowledge of this information will allow educated decisions to be made regarding appropriate matching of eyewear to headsets.

Figure 1. APEL spectacles.

Method

Testing was performed using a Knowles Electronics Manikin for Acoustic Research (KEMAR) following the insertion loss measurement procedure outlined in American National Standards Institute (ANSI) S12.42-2010 “Methods for the measurement of insertion loss of hearing protection devices in continuous or impulsive noise using microphone-in-real-ear or acoustic test fixture procedures” (ANSI, 2010). However, the test was not done in strict accordance with ANSI S12.42-2010, because the KEMAR manikin that was used for data collection did not meet the acoustic test fixture (ATF) requirements defined in the document. At the time testing began, there was no available ATF that met the strict requirements of ANSI S12.42-2010. At the time of this writing, however, a newly developed ATF exists that meets all of the specifications outlined by ANSI S12.42-2010, and will be available for use in future work.

Devices tested

In addition to the APEL eyewear that is shown in figure 1, four pair of eyewear that are not on the APEL were tested. These eyewear are the Air Force Frame, HGU-4P, ESS Crossbow Suppressor, and the NEW Revision Sawfly. The Air Force Frame and the HGU-4P are shown below in figure 2.

(a) Air Force Frame.

(b) HGU-4P.

Figure 2. Two of the non-APEL eyewear tested for attenuation loss were the (a) Air Force Frame and the (b) HGU-4P.

Three headsets were used in this evaluation, the MSA Sordin, Racal Acoustics RA5000, and the Bose ITH, and are shown below in figure 3. The Racal Acoustics RA5000 and the Bose ITH have active noise reduction (ANR) circuitry which attenuates low frequency sounds by electronically generating an equal but opposite pressure wave. The waves combine to effectively cancel each other out. The insertion loss provided by the headsets with ANR was measured with the ANR on (active mode) and with the ANR off (passive modes).

(a) MSA Sordin. (b) Racal Acoustics RA5000. (c) Bose ITH.

Figure 3. The headsets used for this study were (a) MSA Sordin, (b) Racal Acoustics, and (c) Bose ITH.

Three helmets were used in this evaluation, namely the CVC helmet, the HGU-56/P helmet, and the Army Combat Helmet (ACH), and are shown below in figure 4. The CVC helmet was tested like a headset by evaluating the insertion loss in the active and passive modes. The HGU-56/P was also evaluated like a headset, but only in the passive mode. The ACH was used in conjunction with the other headsets evaluated in this test.

(a) CVC helmet. (b) HGU-56/P helmet. (c) ACH.

Figure 4. The helmets used in this study were (a) CVC helmet, (b) HGU-56/P helmet, and (c) ACH.

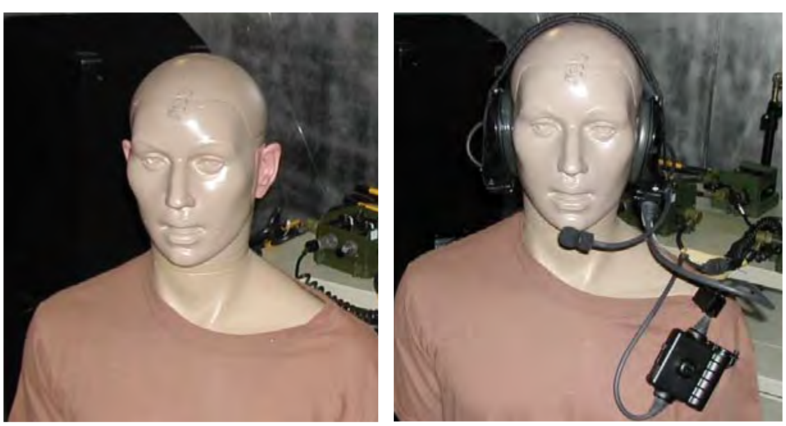
All combinations of helmets, headsets, and eyewear were tested using the Microphone in Real Ear (MIRE) technique in order to determine the noise attenuation (insertion loss) provided by each combination.

Equipment

The test procedure utilized a binaural KEMAR manikin, two QSC Audio PLX 3402 power amplifiers, three Electro-Voice T251 speakers, a National Instruments (NI) PXle-1062Q chassis with digital signal analyzers, data acquisition hardware, and control circuit modules (PXle-8360, PXI-6620, PXI-4461), and a personal computer running Windows XP. The sound field was generated using REATMaster software, and TRIDENT software was used to measure one-third octave band frequency information and to export the results to EXCEL. Both REATMaster and TRIDENT were developed through a partnership between VIAcoustics and Nelson Acoustics. The calibration of the system was checked daily via a sound field measurement using a Bruel & Kjaer (B&K) Type 4145 1-inch microphone, coupled to a B&K Type 2669 preamplifier. Finally, a VIC III intercom system was used to power the ANR headsets.

Procedure

Measuring the insertion loss of a headset in accordance with ANSI S12.42-2010 requires measuring one-third octave band levels of noise in the ears of an ATF in two conditions, open and occluded. For each trial an equivalent-continuous sound level (Leq) was measured for 20 seconds. Three trials for each condition were measured and averaged. Insertion loss was calculated by determining the arithmetic difference in decibels between the averaged measured levels with the ears open versus the ears occluded. For this study the insertion loss of the headset alone was measured and then the insertion loss of each headset/eyewear combination was measured. This was followed by measuring the insertion loss of the headset/eyewear/ACH combination. The primary measurement series is shown in figure 5. The CVC helmet and the HGU-56/P helmet were treated as headsets for the test procedure.



(a) Open ears. (b) Occluded (headset only).

(c) Headset and helmet.

(d) Eyewear and headset.

(e) Eyewear, headset, and helmet.

Figure 5. Measurement series (a) open ears, (b) occluded measurement with headset only, (c) occluded measurement with headset and helmet, (d) occluded measurement with eyewear and headset, (e) occluded measurement with eyewear, headset, and helmet.

Testing was conducted in two phases. During the first phase of testing all of the APEL eyewear, as well as the four eyewear listed above in the 'Devices Tested' section, were evaluated for insertion loss. During the second phase of testing the top performers from phase one, meaning the eyewear that was least detrimental to the attenuation provided by the headset, were re-evaluated with and without the use of prescription inserts, if applicable. The eyewear evaluated in phase two with and without prescription inserts were the UVEX Genesis, NEW Revision Sawfly, and ESS Crossbow Suppressor. The Air Force Frame and the HGU-4P were evaluated in phase two without prescription inserts. The HGU-56/P helmet was a late addition to the study so it was used in phase two of testing but not in phase one.

For both phases of the study, the ATF was set up in a reverberant sound chamber to measure a sound field in one-third octave bands and a VIC III intercom system was used to provide power for the headsets with ANR. The intercom can be seen in the background of figure 6. However, during the first phase of the study the ANR did not appear to work on the Bose or the Racal Acoustics RA5000 headset. Since the evaluation of the ANR capabilities was not of primary interest, testing continued. For the second phase of the study, a different VIC III intercom system was used and the ANR system of each headset with active capability was verified operational.

Figure 6. ATF with VIC III intercom and reference microphone shown in background

For phase one, pink noise of at least 80 dB SPL in one-third octave bands centered from 100 to 10,000 Hz was used for the test, with an overall sound level measured with the ATF of approximately 105 dB(A). For phase two, red noise of at least 75 dB SPL in one-third octave bands centered from 100 to 10,000 Hz was used for the test, with an overall sound level measured with the ATF of approximately 103 dB(A). Compared to pink noise, red noise has a larger concentration of low frequency energy, depicted in figure 7. The use of red noise was requested by a headset manufacturer so the effects of ANR could more easily be seen since ANR primarily attenuates low frequency energy. For each phase of the study, a daily check of the system calibration was performed prior to beginning measurements.

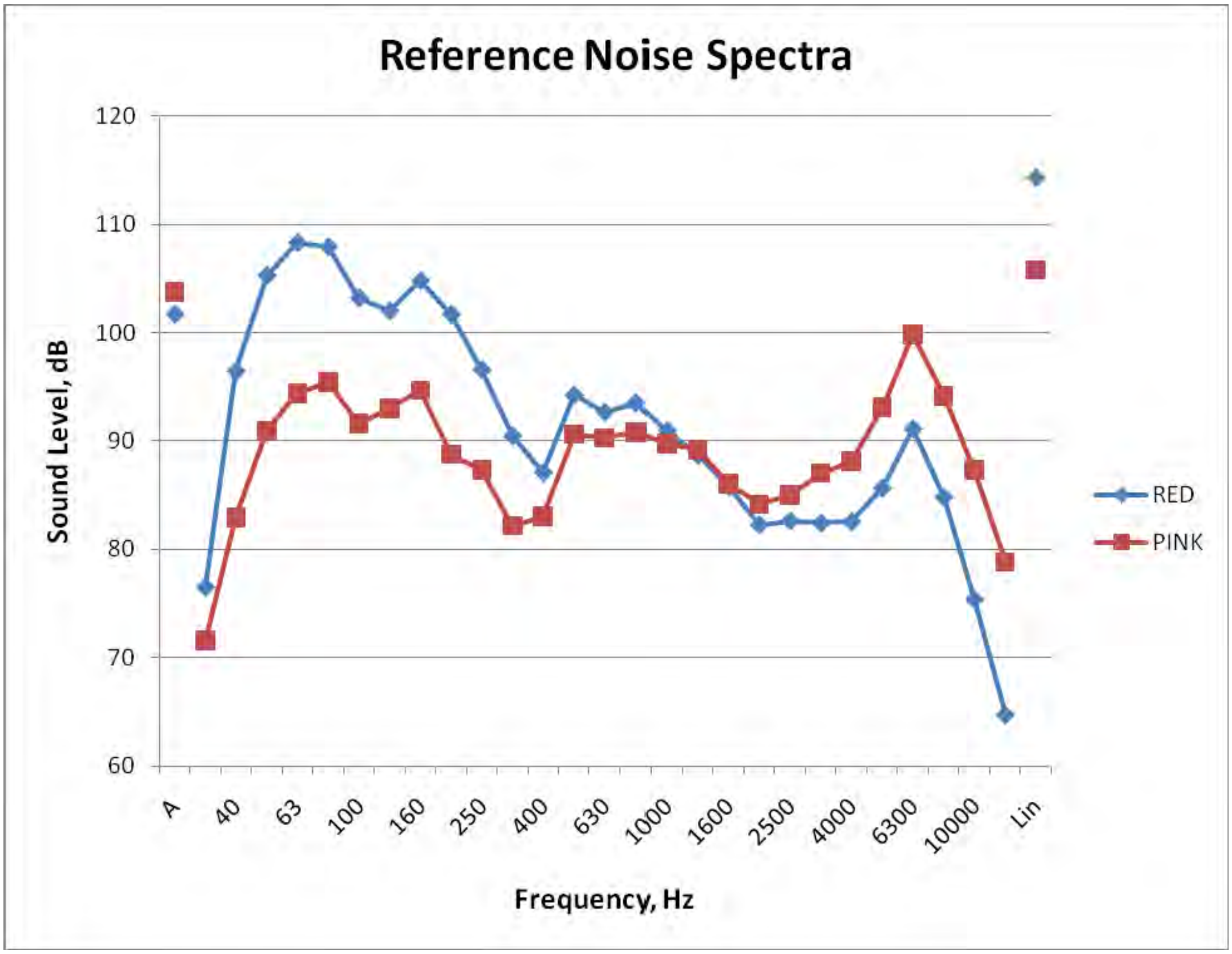


Figure 7. Noise spectra used for testing.

A measurement with ATF ears open was taken prior to beginning the measurement of every headset/eyewear combination. The steps followed to complete a measurement series were as follows:

1. Don chosen circum-aural headset to ATF with ANR turned off.
2. Measure hearing protection across frequency spectrum.
3. Turn ANR on, if applicable, and repeat measurement of hearing protection
4. Don chosen eye protection for measurement.
5. Repeat steps 1 through 3
6. Repeat series three times, removing and replacing headset following each cycle
7. Repeat entire series using ACH in combination with headset

The results from each trial were exported to an EXCEL worksheet contained in a spreadsheet designated for each eyewear/headset combination.

The standard operating procedure (SOP) for the measurement series is shown in the appendix.

Results

Phase one

For phase one of the study, a total of 13 different pair of eyewear were evaluated to determine the effect on insertion loss. The results, shown in the tables below, are the averaged overall A-weighted decibel levels. All of the measurements with eyewear on the ATF are compared to a 'Baseline' measurement which is the insertion loss measurement of the headset without eyewear. 'Active' and 'Act' are the results attained with the radio and headset turned on. 'Helmet' and 'Act Helmet' are the results of the headset and helmet combination with the ANR turned off and on, respectively. 'Difference' is the 'Baseline' measurement subtracted from the eyewear measurement. 'Difference' is a negative number since it represents the amount of attenuation lost, in decibels, due to the eyewear. The smaller the 'Difference' the better, in terms of attenuation loss since this means the eyewear did not have a large effect on the measured insertion loss. 'Avg Diff' is the average of the 'Difference' values for each pair of eyewear. Variations between the 'Right Ear' and 'Left Ear', especially during 'Baseline' measurements, are in part due to an unequal distribution of headset clamping force. This was caused by the different adjustment systems, unique to each headset, used to secure the headsets to the head.

Bose ITH with ACH

Table 1.
Bose ITH with ACH.

		Occluded	Difference	Act Occluded	Difference	Helmet	Difference	Act Helmet	Difference	Avg Diff
Baseline	Right Ear	92.5		92.5		88.0		88.1		
	Left Ear	91.7		91.5		85.4		85.7		
ESS Crossbow	Right Ear	97.0	-4.4	97.0	-4.6	94.5	-6.6	94.5	-6.5	-5.5
	Left Ear	100.3	-8.7	99.8	-8.2	95.0	-9.6	95.0	-9.3	-8.9
ESS Crossbow Suppressor	Right Ear	94.4	-1.8	94.3	-1.8	93.4	-5.4	93.3	-5.3	-3.6
	Left Ear	94.0	-2.4	94.0	-2.4	91.7	-6.3	91.7	-6.0	-4.3
Oakley SI Ballistic M 2.0	Right Ear	94.0	-1.5	93.9	-1.4	93.3	-5.4	93.3	-5.2	-3.4
	Left Ear	97.5	-5.9	97.6	-6.1	92.0	-6.6	92.0	-6.3	-6.2
Revision Sawfly	Right Ear	98.7	-6.2	98.7	-6.3	94.6	-6.6	94.6	-6.5	-6.4
	Left Ear	98.9	-7.2	98.8	-7.3	94.1	-8.7	94.1	-8.4	-7.9
NEW Revision Sawfly	Right Ear	93.6	-1.1	93.6	-1.1	92.9	-4.9	92.9	-4.9	-3.0
	Left Ear	95.7	-4.0	95.6	-4.1	88.2	-2.8	88.3	-2.6	-3.4
Smith Optics Aegis	Right Ear	95.9	-3.4	96.0	-3.5	93.4	-5.4	93.4	-5.3	-4.4
	Left Ear	97.6	-5.9	97.5	-6.0	92.5	-7.1	92.5	-6.8	-6.4
UVEX Genesis	Right Ear	93.6	-1.0	93.5	-1.1	92.9	-4.9	92.9	-4.8	-2.9
	Left Ear	92.6	-1.0	92.6	-1.1	91.2	-5.7	91.1	-5.4	-3.3
UVEX XC	Right Ear	94.2	-1.6	94.2	-1.7	92.8	-4.9	92.8	-4.7	-3.2
	Left Ear	93.2	-1.5	93.2	-1.7	91.6	-6.2	91.6	-5.9	-3.8
Wiley X Talon	Right Ear	95.1	-2.6	95.0	-2.5	92.9	-4.9	92.8	-4.8	-3.7
	Left Ear	96.3	-4.7	96.2	-4.7	92.4	-7.0	92.4	-6.7	-5.8
Wiley X SG-1	Right Ear	95.9	-3.4	95.9	-3.4	93.7	-5.7	93.7	-5.7	-4.5
	Left Ear	98.9	-7.3	98.9	-7.3	94.2	-8.7	94.2	-8.5	-7.9
Wiley X PT-1	Right Ear	94.6	-2.1	94.5	-2.0	93.8	-5.9	93.8	-5.8	-3.9
	Left Ear	95.1	-3.4	94.9	-3.4	92.5	-7.1	92.5	-6.8	-5.2
HGU 4P	Right Ear	94.1	-1.6	94.1	-1.6	93.5	-5.5	93.5	-5.4	-3.5
	Left Ear	91.7	0.0	91.7	-0.2	91.7	-6.3	91.7	-6.0	-3.1
Air Force Frame	Right Ear	93.6	-1.1	93.7	-1.2	93.1	-5.2	93.1	-5.1	-3.1
	Left Ear	92.7	-1.0	92.6	-1.0	90.9	-5.5	90.9	-5.2	-3.2

Note: Table 1 presents overall dB(A) insertion loss and the difference from baseline for eyewear with the Bose ITH headset and the ACH.

Racal Acoustics RA5000 with ACH.

Table 2.
Racal Acoustics RA5000 with ACH.

		Occluded	Difference	Act Occluded	Difference	Helmet	Difference	Act Helmet	Difference	Avg Diff
Baseline	Right Ear	97.2		97.1		79.5		79.5		
	Left Ear	91.4		91.3		78.4		78.4		
ESS Crossbow	Right Ear	103.5	-6.3	103.5	-6.3	96.4	-16.9	96.4	-16.9	-11.6
	Left Ear	101.6	-10.2	101.6	-10.3	95.9	-17.5	96.0	-17.6	-13.9
ESS Crossbow Suppressor	Right Ear	98.7	-1.5	98.7	-1.5	87.4	-7.9	87.4	-7.9	-4.7
	Left Ear	94.5	-3.1	94.5	-3.2	86.5	-8.1	86.5	-8.1	-5.6
Oakley SI Ballistic M 2.0	Right Ear	100.9	-3.8	100.8	-3.7	91.1	-11.6	91.1	-11.5	-7.6
	Left Ear	98.4	-7.0	98.3	-7.0	90.0	-11.6	90.0	-11.6	-9.3
Revision Sawfly	Right Ear	102.2	-5.0	102.2	-5.1	95.5	-16.0	95.5	-16.0	-10.5
	Left Ear	100.5	-9.1	100.4	-9.1	94.0	-15.6	94.0	-15.6	-12.4
NEW Revision Sawfly	Right Ear	100.6	-3.4	100.6	-3.5	89.6	-10.1	89.5	-10.0	-6.7
	Left Ear	95.7	-4.3	95.7	-4.4	87.6	-9.2	87.5	-9.1	-6.8
Smith Optics Aegis	Right Ear	102.3	-5.2	102.3	-5.2	93.2	-13.7	93.2	-13.7	-9.4
	Left Ear	101.0	-9.6	100.9	-9.5	93.1	-14.7	93.1	-14.7	-12.1
UVEX Genesis	Right Ear	102.1	-5.0	102.2	-5.0	95.0	-15.5	95.0	-15.5	-10.2
	Left Ear	97.7	-6.3	97.7	-6.4	91.4	-13.0	91.4	-13.0	-9.7
UVEX XC	Right Ear	102.3	-5.1	102.2	-5.1	94.1	-14.6	94.1	-14.5	-9.8
	Left Ear	99.2	-7.8	99.1	-7.8	92.5	-14.1	92.4	-14.0	-10.9
Wiley X Talon	Right Ear	101.4	-4.3	101.5	-4.3	95.2	-15.7	95.2	-15.6	-10.0
	Left Ear	99.0	-7.6	99.0	-7.6	92.4	-14.0	92.4	-14.0	-10.8
Wiley X SG-1	Right Ear	103.2	-6.1	103.3	-6.2	97.1	-17.6	97.1	-17.5	-11.8
	Left Ear	100.2	-8.8	100.2	-8.9	92.6	-14.2	92.6	-14.2	-11.5
Wiley X PT-1	Right Ear	101.3	-4.1	101.3	-4.2	92.8	-13.3	92.9	-13.4	-8.7
	Left Ear	98.1	-6.7	98.1	-6.7	90.9	-12.5	91.0	-12.6	-9.6
HGU 4P	Right Ear	100.5	-3.3	100.5	-3.4	89.9	-10.4	89.9	-10.4	-6.9
	Left Ear	92.6	-1.2	92.5	-1.2	88.1	-9.7	88.1	-9.7	-5.5
Air Force Frame	Right Ear	99.4	-2.2	99.3	-2.2	91.8	-12.3	91.8	-12.3	-7.2
	Left Ear	95.4	-4.0	95.4	-4.0	92.4	-14.0	92.3	-13.9	-9.0

Note: Table 2 presents the overall dB(A) insertion loss and the difference from baseline for eyewear with the Racal Acoustics RA5000 headset and the ACH.

MSA Sordin with ACH.

Table 3.
MSA Sordin with ACH.

		Occluded	Difference	Act Occluded	Difference	Helmet	Difference	Act Helmet	Difference	Avg Diff
Baseline	Right Ear	92.1		92.0		87.5		87.3		
	Left Ear	90.4		90.3		83.6		83.4		
ESS Crossbow	Right Ear	94.3	-2.3	94.3	-2.3	93.4	-5.9	93.4	-6.1	-4.2
	Left Ear	94.6	-4.2	94.6	-4.3	92.7	-9.1	92.8	-9.3	-6.7
ESS Crossbow Suppressor	Right Ear	92.8	-0.7	92.8	-0.8	92.5	-5.1	92.6	-5.3	-2.9
	Left Ear	91.6	-1.1	91.6	-1.3	88.2	-4.6	88.2	-4.7	-3.0
Oakley SI Ballistic M 2.0	Right Ear	94.0	-1.9	93.8	-1.8	93.4	-5.9	93.4	-6.1	-3.9
	Left Ear	93.3	-2.8	93.2	-2.9	92.1	-8.5	92.1	-8.7	-5.7
Revision Sawfly	Right Ear	94.7	-2.6	94.6	-2.6	93.5	-6.1	93.6	-6.3	-4.4
	Left Ear	94.5	-4.1	94.5	-4.2	92.3	-8.7	92.4	-9.0	-6.5
NEW Revision Sawfly	Right Ear	93.4	-1.4	93.4	-1.4	92.5	-5.0	92.5	-5.2	-3.2
	Left Ear	92.8	-2.4	92.8	-2.5	92.0	-8.4	91.9	-8.5	-5.4
Smith Optics Aegis	Right Ear	94.8	-2.7	94.7	-2.7	93.4	-5.9	93.4	-6.1	-4.4
	Left Ear	94.5	-4.1	94.5	-4.2	92.5	-8.9	92.3	-8.9	-6.5
UVEX Genesis	Right Ear	93.1	-1.0	93.0	-1.0	93.0	-5.6	93.1	-5.8	-3.4
	Left Ear	92.4	-1.9	92.3	-2.0	91.0	-7.4	91.0	-7.6	-4.7
UVEX XC	Right Ear	93.1	-1.1	93.1	-1.1	93.0	-5.5	93.0	-5.7	-3.3
	Left Ear	92.3	-1.9	92.3	-2.0	91.9	-8.3	91.9	-8.4	-5.2
Wiley X Talon	Right Ear	94.5	-2.4	94.4	-2.4	93.4	-5.9	93.5	-6.2	-4.2
	Left Ear	93.7	-3.2	93.6	-3.3	92.4	-8.8	92.4	-8.9	-6.1
Wiley X SG-1	Right Ear	94.9	-2.8	94.7	-2.7	93.6	-6.1	93.6	-6.3	-4.5
	Left Ear	95.2	-4.8	95.2	-4.9	92.8	-9.2	92.8	-9.3	-7.1
Wiley X PT-1	Right Ear	93.5	-1.4	93.5	-1.5	92.9	-5.5	92.9	-5.6	-3.5
	Left Ear	93.3	-2.9	93.3	-3.0	92.4	-8.8	92.4	-9.0	-5.9
HGU 4P	Right Ear	94.2	-2.1	94.1	-2.1	92.6	-5.1	92.5	-5.2	-3.6
	Left Ear	91.7	-1.3	91.6	-1.3	91.1	-7.5	91.0	-7.6	-4.4
Air Force Frame	Right Ear	93.0	-1.0	92.9	-0.9	92.4	-5.0	92.6	-5.3	-3.0
	Left Ear	92.1	-1.7	92.1	-1.8	92.0	-8.4	92.2	-8.7	-5.2

Note: Table 3 presents the overall dB(A) insertion loss and the difference from baseline for eyewear with the MSA Sordin headset and the ACH.

CVC helmet.

Table 4.
CVC helmet.

		Helmet	Difference	Act Helmet	Difference	Avg Diff
Baseline	Right Ear	74.4		84.2		
	Left Ear	72.5		82.2		
ESS Crossbow	Right Ear	92.4	-18.0	93.0	-8.8	-13.4
	Left Ear	93.2	-20.7	93.4	-11.2	-16.0
ESS Crossbow Suppressor	Right Ear	85.4	-11.1	87.7	-3.5	-7.3
	Left Ear	83.2	-10.7	85.5	-3.3	-7.0
Oakley SI Ballistic M 2.0	Right Ear	88.7	-14.4	90.0	-5.8	-10.1
	Left Ear	91.6	-19.1	91.9	-9.7	-14.4
Revision Sawfly	Right Ear	91.1	-16.7	91.8	-7.6	-12.2
	Left Ear	91.4	-18.9	91.9	-9.7	-14.3
NEW Revision Sawfly	Right Ear	88.5	-14.1	89.2	-5.0	-9.6
	Left Ear	91.9	-19.4	92.1	-9.9	-14.7
Smith Optics Aegis	Right Ear	87.7	-13.3	88.7	-4.5	-8.9
	Left Ear	92.4	-19.9	92.8	-10.6	-15.3
UVEX Genesis	Right Ear	86.4	-12.1	88.4	-4.2	-8.1
	Left Ear	88.4	-15.9	89.2	-7.0	-11.4
UVEX XC	Right Ear	86.5	-12.2	88.5	-4.3	-8.2
	Left Ear	90.0	-17.5	90.3	-8.1	-12.8
Wiley X Talon	Right Ear	89.0	-14.6	90.1	-5.9	-10.3
	Left Ear	90.8	-18.3	91.2	-9.0	-13.7
Wiley X SG-1	Right Ear	89.7	-15.3	90.9	-6.7	-11.0
	Left Ear	91.9	-19.4	92.4	-10.2	-14.8
Wiley X PT-1	Right Ear	83.5	-9.1	86.8	-2.6	-5.9
	Left Ear	86.4	-13.9	87.7	-5.5	-9.7
HGU 4P	Right Ear	83.0	-8.6	86.4	-2.2	-5.4
	Left Ear	81.4	-8.9	85.2	-3.0	-6.0
Air Force Frame	Right Ear	79.8	-5.4	85.2	-1.0	-3.2
	Left Ear	79.3	-6.8	83.9	-1.7	-4.2

Note: Table 4 presents the overall dB(A) insertion loss and the difference from baseline for eyewear with the CVC helmet.

Phase two

For phase two of the study, the top performing eyewear from the first phase of the study was re-evaluated with and without prescription inserts. The HGU-4P and the Air Force Frame were re-evaluated and the HGU-56/P was added to the test.

Bose ITH with ACH.

Table 5.
Bose ITH with ACH.

		Occluded	Difference	Act Occluded	Difference	Helmet	Difference	Act Helmet	Difference	Avg Diff
Baseline	Right Ear	98.8		86.8		96.7		85.2		
	Left Ear	96.9		86.4		92.8		84.7		
ESS Crossbow Suppressor	Right Ear	99.8	-1.0	94.4	-7.6	99.8	-3.2	88.2	-3.0	-3.7
	Left Ear	99.0	-2.0	93.2	-6.8	97.0	-4.2	86.4	-1.7	-3.7
ESS Crossbow Suppressor ins	Right Ear	100.2	-1.4	95.7	-8.9	100.0	-3.3	89.4	-4.2	-4.4
	Left Ear	98.9	-2.0	94.7	-8.3	97.7	-4.9	87.2	-2.5	-4.4
NEW Revision Sawfly	Right Ear	99.8	-1.0	97.3	-10.5	100.6	-4.0	94.9	-9.7	-6.3
	Left Ear	99.1	-2.2	98.1	-11.7	99.1	-6.3	92.7	-8.0	-7.0
NEW Revision Sawfly ins	Right Ear	100.0	-1.2	98.2	-11.4	100.4	-3.8	95.3	-10.1	-6.6
	Left Ear	99.0	-2.1	97.6	-11.2	99.2	-6.4	91.6	-6.9	-6.6
UVEX Genesis	Right Ear	99.9	-1.1	98.4	-11.5	100.7	-4.1	95.1	-9.9	-6.7
	Left Ear	99.1	-2.1	98.1	-11.7	99.2	-6.4	95.3	-10.6	-7.7
UVEX Genesis ins	Right Ear	99.9	-1.1	97.5	-10.7	100.4	-3.7	94.8	-9.6	-6.3
	Left Ear	98.7	-1.8	95.4	-9.0	99.0	-6.2	91.5	-6.8	-6.0
HGU 4P	Right Ear	100.2	-1.4	98.9	-12.1	100.4	-3.8	96.2	-11.0	-7.1
	Left Ear	99.6	-2.7	98.6	-12.2	98.6	-5.8	92.1	-7.4	-7.0
Air Force Frames	Right Ear	99.9	-1.1	94.8	-8.0	99.6	-2.9	89.2	-4.0	-4.0
	Left Ear	98.7	-1.8	94.6	-8.2	97.6	-4.8	87.9	-3.2	-4.5

Note: Table 5 Presents the overall dB(A) insertion loss and the difference from baseline for eyewear with and without prescription inserts with the Bose ITH headset and ACH.

Racal Acoustics RA5000 with ACH.

Table 6.
Racal Acoustics RA5000 with ACH.

		Occluded	Difference	Act Occluded	Difference	Helmet	Difference	Act Helmet	Difference	Avg Diff
Baseline	Right Ear	102.6		99.9		99.6		99.0		
	Left Ear	99.9		99.7		98.8		98.6		
ESS Crossbow Suppressor	Right Ear	103.0	-0.4	102.4	-2.4	101.9	-2.2	101.5	-2.5	-1.9
	Left Ear	100.7	-0.8	100.3	-0.6	99.8	-1.0	99.6	-1.0	-0.9
ESS Crossbow Suppressor ins	Right Ear	103.2	-0.5	102.5	-2.6	98.7	1.0	98.1	0.9	-0.3
	Left Ear	99.8	0.2	99.5	0.2	98.0	0.8	97.8	0.8	0.5
NEW Revision Sawfly	Right Ear	105.4	-2.7	104.7	-4.7	104.9	-5.3	104.2	-5.2	-4.5
	Left Ear	103.9	-3.9	103.3	-3.6	100.8	-2.0	100.7	-2.2	-2.9
NEW Revision Sawfly ins	Right Ear	104.5	-1.9	103.7	-3.8	101.6	-1.9	101.3	-2.3	-2.5
	Left Ear	102.7	-2.8	102.0	-2.3	100.8	-2.0	100.7	-2.1	-2.3
UVEX Genesis	Right Ear	104.4	-1.7	103.7	-3.7	102.3	-2.7	102.1	-3.1	-2.8
	Left Ear	102.6	-2.6	102.0	-2.4	101.3	-2.5	101.0	-2.4	-2.5
UVEX Genesis ins	Right Ear	104.9	-2.3	104.3	-4.3	103.8	-4.1	103.4	-4.4	-3.8
	Left Ear	102.2	-2.2	101.6	-1.9	101.0	-2.2	100.8	-2.2	-2.1
HGU 4P	Right Ear	103.7	-1.0	103.1	-3.2	100.9	-1.2	100.7	-1.7	-1.8
	Left Ear	100.1	-0.2	99.9	-0.2	98.4	0.4	98.3	0.3	0.1
Air Force Frames	Right Ear	104.1	-1.5	103.6	-3.7	101.3	-1.6	100.7	-1.8	-2.1
	Left Ear	101.9	-1.9	101.4	-1.8	100.6	-1.8	100.3	-1.8	-1.8

Note: Table 6 shows the overall dB(A) insertion loss and the difference from baseline for eyewear with and without prescription inserts with the Racal Acoustics RA5000 headset and ACH.

Due to the large amount of low frequency energy in the noise spectrum used for this phase of testing, the results were inconclusive for the HGU-56/P helmet and for the MSA Sordin headset, with most of the ‘Difference’ in levels being less than 1 dB(A). Therefore, results for these cases are reported with the overall level across the entire measured frequency spectrum as well as the level from 500 to 8000 Hz which eliminates much of the low frequency energy, which is the range of the spectrum that would be attenuated with ANR circuitry.

<u>MSA Sordin with ACH.</u>

<u>Table 7.</u>
MSA Sordin with ACH.

		Overall dB(A)					500 Hz to 8k Hz				
		Occluded	Difference	Helmet	Difference	Avg Diff	Occluded	Difference	Helmet	Difference	Avg Diff
Baseline	Right Ear	99.7		99.2			88.3		86.6		
	Left Ear	99.2		98.0			87.0		85.0		
ESS Crossbow Suppressor	Right Ear	100.0	-0.3	100.2	-1.0	-0.6	90.4	-2.1	89.2	-2.7	-2.4
	Left Ear	99.1	0.1	99.6	-1.6	-0.8	89.0	-2.1	88.1	-3.1	-2.6
ESS Crossbow Suppressor ins	Right Ear	99.5	0.2	99.8	-0.6	-0.2	90.1	-1.8	88.1	-1.5	-1.7
	Left Ear	99.0	0.1	99.2	-1.2	-0.5	88.3	-1.4	86.7	-1.7	-1.5
NEW Revision Sawfly	Right Ear	99.2	0.5	99.0	0.2	0.3	90.3	-2.0	88.5	-2.0	-2.0
	Left Ear	98.6	0.6	98.9	-0.9	-0.2	88.4	-1.4	87.1	-2.1	-1.7
NEW Revision Sawfly ins	Right Ear	99.4	0.3	99.8	-0.6	-0.1	91.4	-3.1	90.5	-3.9	-3.5
	Left Ear	98.4	0.8	99.1	-1.1	-0.2	89.7	-2.8	88.0	-3.0	-2.9
UVEX Genesis	Right Ear	99.9	-0.2	100.9	-1.7	-0.9	91.0	-2.8	88.9	-2.3	-2.5
	Left Ear	99.0	0.2	99.5	-1.5	-0.7	89.1	-2.2	88.0	-3.0	-2.6
UVEX Genesis ins	Right Ear	99.5	0.2	99.8	-0.6	-0.2	90.6	-2.3	87.0	-0.5	-1.4
	Left Ear	98.8	0.3	99.7	-1.7	-0.7	88.4	-1.5	85.4	-0.4	-0.9
HGU 4P	Right Ear	99.4	0.3	100.4	-1.2	-0.4	92.8	-4.5	88.7	-2.1	-3.3
	Left Ear	98.7	0.5	97.8	0.2	0.4	89.3	-2.3	86.3	-1.3	-1.8
Air Force Frames	Right Ear	99.8	-0.1	100.0	-0.8	-0.5	91.3	-3.0	88.6	-2.0	-2.5
	Left Ear	99.1	0.0	99.2	-1.2	-0.6	88.4	-1.4	86.4	-1.4	-1.4

Note: Table 7 shows the overall dB(A) insertion loss, insertion loss in the 500 to 8000 Hz region, and the difference from baseline for eyewear with and without prescription inserts with the MSA Sordin headset and the ACH.

CVC helmet.

Table 8.
CVC helmet.

		Helmet	Difference	Act Helmet	Difference	Avg Diff
Baseline	Right Ear	80.3		83.6		
	Left Ear	80.3		80.6		
ESS Crossbow Suppressor	Right Ear	91.3	-11.0	85.3	-1.7	-6.4
	Left Ear	93.3	-13.0	86.5	-5.9	-9.4
ESS Crossbow Suppressor ins	Right Ear	88.4	-8.1	85.0	-1.4	-4.8
	Left Ear	87.9	-7.6	81.7	-1.1	-4.4
NEW Revision Sawfly	Right Ear	94.2	-13.9	86.9	-3.3	-8.6
	Left Ear	95.0	-14.7	87.2	-6.6	-10.6
NEW Revision Sawfly ins	Right Ear	96.3	-16.0	88.8	-5.2	-10.6
	Left Ear	97.4	-17.1	89.4	-8.8	-12.9
UVEX Genesis	Right Ear	95.0	-14.7	87.7	-4.1	-9.4
	Left Ear	94.8	-14.5	86.8	-6.2	-10.3
UVEX Genesis ins	Right Ear	95.8	-15.5	88.5	-4.9	-10.2
	Left Ear	95.5	-15.3	87.5	-6.9	-11.1
HGU 4P	Right Ear	96.8	-16.5	87.5	-3.9	-10.2
	Left Ear	96.6	-16.4	88.3	-7.7	-12.0
Air Force Frames	Right Ear	91.2	-10.9	80.3	3.3	-3.8
	Left Ear	91.6	-11.3	81.9	-1.3	-6.3

Note: Table 8 shows the overall dB(A) insertion loss and the difference from baseline for eyewear with and without prescription inserts with the CVC helmet.

HGU-56/P helmet.

Table 9.
HGU-56/P helmet.

		Overall dB(A)		500 Hz to 8k Hz	
		Helmet	Difference	Helmet	Difference
Baseline	Right Ear	102.3		90.1	
	Left Ear	100.9		89.9	
ESS Crossbow Suppressor	Right Ear	102.2	0.1	89.4	0.6
	Left Ear	100.9	0.0	89.5	0.4
ESS Crossbow Suppressor ins	Right Ear	102.4	-0.1	90.6	-0.6
	Left Ear	101.0	-0.1	89.8	0.1
NEW Revision Sawfly	Right Ear	102.0	0.3	91.9	-1.8
	Left Ear	100.8	0.1	90.7	-0.8
NEW Revision Sawfly ins	Right Ear	102.2	0.1	89.8	0.2
	Left Ear	101.0	-0.1	89.4	0.4
UVEX Genesis	Right Ear	101.9	0.4	92.3	-2.2
	Left Ear	101.0	-0.2	89.7	0.1
UVEX Genesis ins	Right Ear	101.2	1.1	93.5	-3.5
	Left Ear	100.3	0.5	92.6	-2.7
HGU 4P	Right Ear	101.8	0.5	93.3	-3.3
	Left Ear	100.7	0.2	90.6	-0.7
Air Force Frames	Right Ear	102.1	0.2	92.3	-2.3
	Left Ear	101.0	-0.2	89.1	0.8

Note: Table 9 shows the overall dB(A) insertion loss, insertion loss in the 500 to 8000 Hz region, and the difference from baseline for eyewear with and without prescription inserts with the HGU-56/P helmet.

Attenuation

In order to better see the effects of eyewear the octave band insertion loss levels were calculated for the top performing eyewear with each headset used in the second phase of the study to give an estimation of attenuation. Insertion loss, when measured using microphone-based techniques, is an objective estimate of the attenuation of noise by a hearing protection device (ANSI S12.42-2010). The effect of the eyewear is found by comparing the results for the listed eyewear with the 'Baseline' results.

Bose ITH with ACH and listed eyewear.

Table 10.
Bose ITH attenuation with ACH and listed eyewear.

Bose ITH (dB)

			125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	8000 Hz
Baseline	Active	Right	19.13	16.69	17.35	17.03	29.07	34.92	39.12
		Left	20.94	19.88	17.16	14.72	29.56	34.49	36.38
	Passive	Right	-1.00	1.23	14.45	20.56	29.63	35.33	39.50
		Left	1.20	4.72	14.65	19.19	29.94	35.00	36.59
ESS Crossbow Suppressor	Active	Right	14.07	13.61	13.65	14.16	26.52	32.96	34.93
		Left	15.97	16.82	14.94	13.15	28.16	31.86	32.44
	Passive	Right	-3.03	-3.62	10.28	17.95	27.26	33.45	35.47
		Left	-2.16	-0.10	11.87	17.72	28.70	32.62	32.86
ESS Crossbow Suppressor w/insert	Active	Right	10.06	10.87	11.33	14.88	26.97	30.95	33.84
		Left	14.14	15.96	13.64	12.74	28.27	31.02	30.74
	Passive	Right	-3.16	-3.45	10.24	17.93	27.55	31.35	34.16
		Left	-2.54	-0.92	11.01	17.22	28.81	31.77	31.04
Air Force Frames	Active	Right	12.62	12.58	12.49	12.82	27.57	33.21	35.93
		Left	12.31	14.76	12.63	12.75	28.99	32.11	31.43
	Passive	Right	-2.94	-3.56	10.03	16.99	28.32	33.74	36.36
		Left	-2.68	-0.64	10.76	16.83	29.29	32.61	31.60

Racal Acoustics RA5000 with ACH and listed eyewear.

Table 11.
Racal Acoustics RA 5000 attenuation with ACH and listed eyewear.

Racal Acoustics (dB)

			125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	8000 Hz
Baseline	Active	Right	-1.43	2.17	-0.31	6.92	15.96	32.61	38.31
		Left	-2.98	0.77	0.20	9.16	17.78	31.59	35.41
	Passive	Right	-1.71	-0.24	-1.44	7.58	16.17	32.70	38.35
		Left	-2.47	-1.10	-0.67	9.81	17.91	31.73	35.34
ESS Crossbow Suppressor	Active	Right	-2.17	0.45	-2.61	3.50	11.97	28.48	35.74
		Left	-2.48	0.09	-1.64	7.12	17.26	28.52	28.96
	Passive	Right	-2.08	-0.68	-4.54	4.09	12.31	28.52	35.78
		Left	-2.13	-1.27	-3.10	7.75	17.36	28.47	28.95
ESS Crossbow Suppressor w/insert	Active	Right	-1.64	2.20	1.00	8.96	17.41	31.56	34.59
		Left	-2.43	1.58	1.34	11.26	22.69	31.54	29.52
	Passive	Right	-1.72	-0.10	-0.35	9.69	17.58	31.54	34.63
		Left	-1.94	-0.22	0.36	12.08	22.96	31.58	29.40
HGU 4P	Active	Right	-2.16	1.88	-1.55	3.36	14.03	31.67	39.44
		Left	-2.49	1.63	0.31	8.78	19.96	32.50	33.29
	Passive	Right	-2.00	-0.11	-3.22	4.24	14.33	31.74	39.49
		Left	-2.18	-0.28	-0.70	9.74	20.16	32.59	33.26

MSA Sordin with ACH and listed eyewear.

Table 12.
MSA Sordin attenuation with ACH and listed eyewear.

MSA Sordin (dB)		125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	8000 Hz
Baseline	Right	-2.92	-0.61	9.64	16.36	22.95	26.28	34.06
	Left	-2.97	0.31	11.14	15.81	22.08	28.16	34.49
ESS Crossbow Suppressor w/insert	Right	-2.79	-3.39	7.32	15.55	25.30	27.35	34.24
	Left	-3.12	-3.77	8.53	14.72	20.51	29.95	32.44
NEW Revision Sawfly	Right	-2.48	-2.50	7.14	14.71	23.06	31.74	38.03
	Left	-2.99	-3.06	8.46	14.30	18.83	27.78	33.49
UVEX Genesis w/insert	Right	-3.24	-2.46	8.60	15.95	24.26	29.31	35.94
	Left	-3.32	-4.20	9.54	15.76	22.18	28.26	30.03
Baseline-Pink	Right	-0.80	4.55	16.92	22.70	30.03	35.64	43.19
	Left	1.34	10.47	21.97	24.99	29.69	38.17	43.97

Note: Baseline-pink shows the attenuation measured in the first phase of the experiment for the MSA Sordin headset in pink noise, shown for reference.

CVC helmet with listed eyewear.

Table 13.
CVC helmet attenuation with listed eyewear.

CVC Helmet (dB)			125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	8000 Hz
Baseline	Active	Right	26.5	33.0	29.7	26.3	20.0	24.1	47.0
		Left	24.0	34.1	28.7	25.9	22.6	25.8	50.1
	Passive	Right	13.1	21.9	22.8	29.8	37.7	45.9	48.4
		Left	11.3	23.7	24.9	29.4	38.2	43.8	51.4
ESS Crossbow Suppressor w/Insert	Active	Right	18.3	25.9	27.1	25.1	19.2	23.4	44.8
		Left	17.4	27.7	27.8	24.9	22.6	25.8	42.5
	Passive	Right	4.2	15.5	19.9	28.1	34.3	43.2	45.8
		Left	4.0	17.3	23.1	28.6	35.8	40.1	42.8
Air Force Frames	Active	Right	15.8	23.5	25.7	24.5	34.4	39.7	44.2
		Left	12.8	21.7	25.4	22.8	33.4	38.1	48.5
	Passive	Right	1.6	13.2	18.8	26.1	35.4	42.5	44.8
		Left	0.5	13.7	20.8	26.1	34.5	40.6	49.5

HGU-56/P with listed eyewear.

Table 14.
HGU-56/P attenuation with listed eyewear.

HGU-56/P Helmet (dB)		125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	8000 Hz
Baseline	Right	-3.4	-8.5	4.3	15.7	27.2	27.9	24.1
	Left	-3.0	-7.7	3.1	16.4	29.7	27.8	31.9
ESS Crossbow Suppressor	Right	-3.4	-8.4	4.9	15.8	24.1	27.6	22.8
	Left	-2.9	-7.8	3.3	16.8	30.1	26.5	30.2
NEW Revisison Sawfly w/Insert	Right	-2.8	-8.7	2.0	13.6	23.3	25.8	18.8
	Left	-2.7	-7.9	1.7	16.7	30.4	24.9	25.7
ESS Crossbow Suppressor w/Insert	Right	-3.2	-9.0	3.5	14.5	24.0	27.1	21.9
	Left	-2.8	-8.1	2.9	16.6	29.4	27.2	33.7

Discussion

Phase one

For the first phase of this study, three headsets, two helmets, nine pair of APEL eyewear, and four pair of non-APEL eyewear were tested using an ATF to determine the amount of attenuation loss due to eyewear.

Bose ITH with ACH

The UVEX Genesis and ESS Crossbow Suppressor yielded the best results without the helmet.

The NEW Revision Sawfly and UVEX Genesis yielded the best results with the helmet. Averaging the results with and without the helmet showed that UVEX Genesis and NEW Revision Sawfly yielded the best results, meaning they had the smallest effect on attenuation.

Racal Acoustics RA5000 with ACH

The ESS Crossbow Suppressor and NEW Revision Sawfly yielded the best results with and without the helmet and therefore produced the best average results.

MSA Sordin with ACH

The ESS Crossbow Suppressor, UVEX XC and UVEX Genesis yielded the best results without the helmet. The ESS Crossbow Suppressor and UVEX Genesis yielded the best results with the helmet and the best average results.

CVC helmet

The ESS Crossbow Suppressor and Wiley X PT-1 yielded the best results with and without the helmet and therefore produced the best average results.

Overall the results showed that the ESS Crossbow Suppressor, the NEW Revision Sawfly, and the UVEX Genesis had the smallest impact on attenuation. The ESS Crossbow and the Revision Sawfly had the greatest impact on attenuation. The width of the temples of the ESS Crossbow Suppressor, the NEW Revision Sawfly, and the UVEX Genesis are 1.8 mm, 2.8 mm, and 2.5 mm respectively. The width of the temples of the ESS Crossbow and the Revision Sawfly are 4.5 mm and 5.2 mm respectively. The ESS Crossbow Suppressor is designed to be worn with earmuff-style headsets and hearing protection. This explains the narrow temple width and good performance relative to the other eyewear tested. Table 15 shows the temple thickness of each frame and the performance rank based on overall average attenuation loss, with the rank of “1” indicating the best performer. Figure 8 shows a graphical representation of the temple thickness versus overall performance rank.

Table 15.
Temple thickness of each frame and overall performance rank

	Temple Thickness (mm)	Avg Rank
ESS Crossbow Suppressor	1.8	1
NEW Revision Sawfly	2.8	2
UVEX Genesis	2.5	3
Oakley SI Ballistic M 2.0	4.6	4
UVEX XC	3	5
Wiley X PT-1	4	6
Wiley X Talon	3.9	7
Smith Optics Aegis	5	8
Wiley X SG-1	4	9
Revision Sawfly	5.2	10
ESS Crossbow	4.5	11

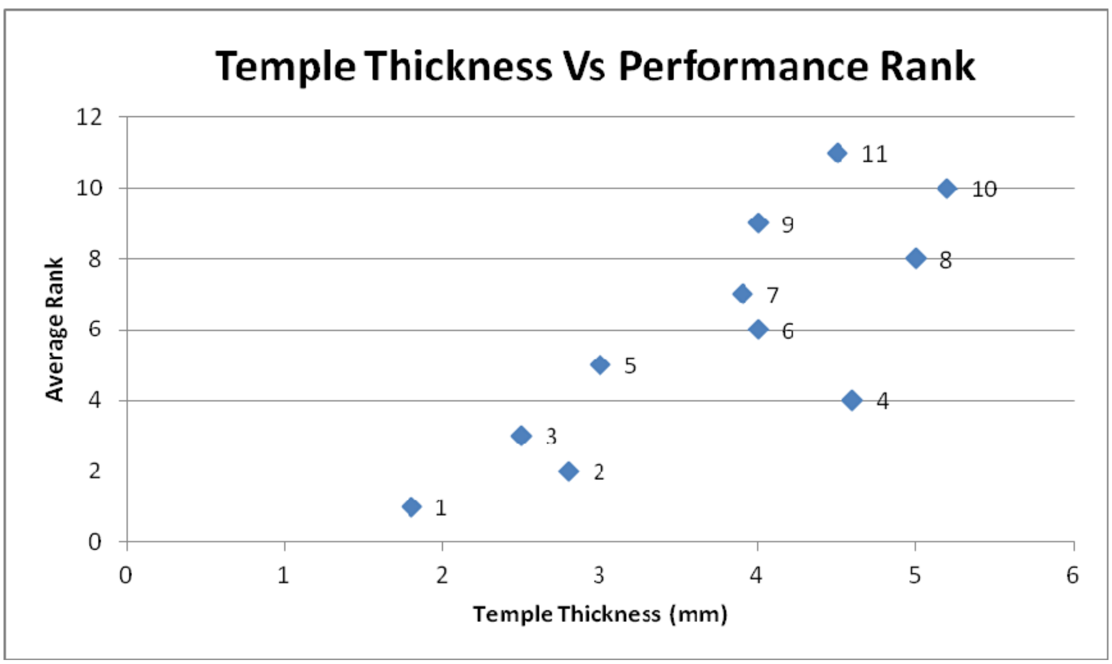


Figure 8. Temple thickness of each frame versus performance rank based on overall average attenuation loss

Phase two

For the second phase of this study three headsets, three helmets, three pair of APEL eyewear, with and without prescription inserts, and two additional pair of eyewear were tested using an ATF to determine the amount of attenuation loss due to eyewear. Red noise, a noise with a large concentration of low frequency energy, was used for these tests which resulted in an indistinguishable difference between eyewear with the HGU-56/P helmet and the MSA Sordin headset. Therefore, in order to rank order the eyewear with the HGU-56/P helmet and MSA Sordin headset results were calculated using frequencies from 500 to 8000 Hz. The attenuation, or insertion loss, for each octave band from 125 to 8000 Hz was also calculated.

Bose ITH with ACH

The ESS Crossbow Suppressor and Air Force Frames yielded the best results without the helmet.

The ESS Crossbow Suppressor, Air Force Frames, and ESS Crossbow Suppressor with prescription insert yielded the best results with the helmet. Averaging the results with and without the helmet showed that the Crossbow Suppressor and Air Force Frames yielded the best results in terms of having the smallest affect on attenuation. The prescription inserts had essentially no effect on attenuation.

Racal Acoustics RA5000 with ACH

The ESS Crossbow Suppressor without and with prescription inserts yielded the best results with the helmet. The ESS Crossbow Suppressor with prescription inserts and the HGU 4P yielded the best results without the helmet. The ESS Crossbow Suppressor with prescription inserts and the HGU 4P produced the best average results. The prescription inserts produced a small difference in attenuation for the ESS Crossbow Suppressor and for the NEW Revision Sawfly when the headset was used in combination with the helmet.

MSA Sordin with ACH

The overall results showed very little difference between Baseline and any of the eyewear especially without the helmet. Looking at the spectrum from 500 to 8000 Hz shows that the ESS Crossbow Suppressor with prescription insert and the NEW Revision Sawfly yielded the best results without helmet; the UVEX Genesis with prescription insert and ESS Crossbow Suppressor with prescription insert yielded the best results with helmet; and the UVEX Genesis with prescription insert and ESS Crossbow Suppressor with prescription insert yield the best average results followed closely by the NEW Revision Sawfly. The prescription inserts had essentially no effect on attenuation.

CVC helmet

The ESS Crossbow Suppressor with prescription insert and the Air Force Frames yielded the best results in both the passive and active mode

The ESS Crossbow Suppressor with prescription insert and the Air Force Frames yielded the best average results.

When the helmet was in the passive mode the prescription inserts of the ESS Crossbow Suppressor had an effect on attenuation. The prescription inserts on the NEW Revision Sawfly had an effect on attenuation in both the passive and active modes of the helmet.

HGU-56/P

The overall results showed very little difference between Baseline and any of the eyewear, and there was no effect due to the prescription inserts.

Looking at the spectrum from 500 to 8000 Hz shows that the ESS Crossbow Suppressor and the NEW Revision Sawfly with prescription insert yield the best results followed closely by the ESS Crossbow Suppressor with prescription insert.

Attenuation

A draft document entitled “Performance requirements for Tactical Communications and Protective System (TCAPS) electronic headsets” (Department of the Army, 2008) states that the noise attenuation of TCAPS should meet the criteria in table 14 while wearing the ACH and ballistic spectacles. The document states that the attenuation should be measured using ANSI S12.6-2008 “Methods for measuring the real-ear attenuation of hearing protectors” (ANSI, 2008). Commonly known as a REAT test, it requires the use of human test subjects to obtain results. The attenuation in dB(A) includes laboratory measured mean attenuation, plus any calculated effects of active noise reduction (ANR) for headsets that incorporate this feature. The ‘Types’ listed in the table correspond to:

Type A: Over the ear form factor, moderate noise environment
Type B: Over the ear form factor, high noise environment
Type C: In-ear form factor, moderate noise environment
Type D: In-ear form factor, high noise environment

Types A and C are intended for dismounted infantry Soldier use and mounted infantry use in wheeled vehicles. Types B and D are intended for all these same conditions, plus for use for infantry soldiers while mounted in tracked vehicles.

Table 16.
Attenuation criteria of TCAPS with eyewear and helmet at specific frequencies.

Octave Band Attenuation Requirements (frequency in Hz)	125	250	500	1000	2000	4000	*8000*
Types A and C (attenuation in dBA)	**9**	**13**	**18**	**23**	**25**	**32**	***35***
Types B and D *(attenuation in dBA)*	***28***	***30***	***33***	***33***	***33***	***33***	***42***

Comparing the baseline attenuation values shown in tables 10 through 14 to the values shown in table 16, yields that even without eyewear the levels in the guidelines are not quite achieved. However, the testing methods are not identical (REAT vs. MIRE).

Conclusion

Wearing APEL spectacles with headset style communication systems is detrimental to the amount of noise attenuation provided by the headset. However, some spectacles produce smaller leaks than others, resulting in a smaller amount of attenuation loss. The difference between the best performing spectacles and the worst performing spectacles was about 4.5 dB averaged over all headsets.

The loss of attenuation due to eyewear breaking the seal of earmuff style headsets or hearing protection will decrease the allowable time that one can be noise-exposed in a given environment when compared to the allowable exposure time for the same situation without eyewear. For example, the ‘Baseline’ measurement of the Bose ITH with ACH in the active mode, presented in table 5, shows a sound level reaching the ear of 85 dB(A) (averaging the left and right ears). Assuming a consistent sound level, an 85 dB TWA criterion level, and a 3 dB exchange rate, 8 hours of exposure would be allowed. Wearing the ESS Crossbow Suppressor, with an average level of 87.3 dB(A) would allow for 4.7 hours of exposure. The UVEX Genesis however, with an average level of 95.2 dB(A) would allow for only about 46 minutes of exposure.

The prescription inserts in the ESS Crossbow Suppressor had a small effect on attenuation when worn with the combination of the Racal Acoustics RA5000 headset and ACH. An effect was also measured with the CVC helmet in the passive mode. The prescription inserts in the NEW Revision Sawfly had a small effect on attenuation with the CVC helmet in both the active and passive modes, and with the combination of the Racal Acoustics RA5000 headset and ACH. The change in attenuation due to the prescription insert could be caused by the fact that the insert pulls the frame farther out away from the face causing the temples of the frame to meet the headset in a different manner than the frames without the insert.

Even though the wearing of eyewear degrades the effectiveness of hearing protection, it is very important not to forego wearing protective eyewear in loud environments, but to strike a balance so one sense organ will not be protected at the expense of another. When selecting eyewear it is recommended that the eyewear with the thinnest temples that fulfils the eye protection requirement be chosen. Eyewear with a temple thickness of 3mm or less will minimize the loss of noise attenuation due to eyewear caused breaks in the seal of an earcup.

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Appendix.

KEMAR eyewear measurements SOP.

1. Turn on rack power (make sure amplifiers are set to 0)
2. Turn on NI chassis
3. Restart computer
4. Turn on microphone power supplies
5. Start Trident by double clicking shortcut icon on desktop, then select ‘Run’
6. Select configuration with “KEMAR” in the title
7. Start REATMaster by double clicking shortcut icon on desktop, then select ‘Run’
8. Select configuration with “USAARL” in the title
9. Set Amplifiers to 28
10. Click ‘Manual’ tab in ReatMaster and set level to **50** dB
11. In Trident, click ‘Range’ tab and change MaxSPL to 120 dB, click ‘apply all’
12. In ReatMaster click on 1000 Hz, check levels in left and right ear in trident
13. Make sure ‘Attenuator IN’ tab is GREEN
14. If levels are **70** dB +/- 1 continue without calibration, otherwise adjust level as needed
15. When using RADIO
    a. turn main power to INT LIVE
    b. make sure volume is at lower end of yellow band – just above red
    c. ‘work’ is set to B
16. To begin measurement set level in ReatMaster to 85 dB and select ‘Pink’
17. Take a measurement by pressing start in Trident
18. When measurement is complete select Export and save to spreadsheet
    a. You will have to create a new spreadsheet if starting a new measurement
    b. Create multiple tabs after you have created a new spreadsheet
19. Place headset on KEMAR, **wait 2 minutes** and repeat steps 17 and 18
20. Turn on radio and active portion of headset and repeat steps 17 and 18
21. Turn off radio and headset
22. Remove headset
23. Place eyewear on KEMAR and replace headset, **wait 2 minutes**
24. Repeat steps 17 and 18
25. Turn on active portion of headset and repeat steps 17 and 18
26. Turn off headset
27. Remove headset and repeat entire sequence 3 times
28. Repeat test sequence again but using the helmet in addition to the headset.
29. When finished for the day close Trident and ReatMaster
30. Turn amplifiers to 0 and turn off rack power
31. Turn off microphone power supplies
32. Restart computer

Department of the Army
U.S. Army Aeromedical Research Laboratory
Fort Rucker, Alabama, 36362-0577
www.usaarl.army.mil

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