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Joint Service Aircrew Mask (JSAM) – Strategic Aircraft (SA): Noise Attenuation Performance

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14. ABSTRACT

The objective of this study was to determine if the Joint Service Aircrew Mask (JSAM) –Strategic Aircraft (SA) performance specification requirements were being met. The requirement stated that the JSAM-SA shall not degrade the noise attenuation performance of the hearing protector by more than 3 dB. Noise attenuation measurements were conducted in accordance with American National Standards Institute (ANSI) S12.6-1997 Methods for Measuring the Real-Ear Attenuation of Hearing Protectors on the following headsets with and without the JSAM-SA: Bose A-20, David Clark H10-76, David Clark P/N 40493G-01, Sonetronics H-173C/AIC, and Telex AIR-3500. A newer version of the ANSI standard exists (2008 version). However, the program office decided to use the 1997 version so that the subjects could be fit by an expert fitter. Active insertion loss performance measurements were also conducted in accordance with 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 (MIRE) or Acoustic Test Fixture Procedures for the Bose A-20 with and without the JSAM-SA. The addition of the JSAM-SA to all headsets measured for this study degraded the noise attenuation performance by more than 3 dB across several frequencies when compared to the headsets alone and therefore did not meet the performance specification requirement.

15. SUBJECT TERMS JSAM, M53, MM53, M50, Bose, David Clark, Sonetronics, Telex, headset, speech intelligibility, communications, chemical, biological, protection, hood, MIRE, REAT, attenuation, active insertion loss

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EXECUTIVE SUMMARY

The noise environment on or around an aircraft can be hazardous to hearing and degrade speech communication performance. Hearing protection and communication headsets have been required to protect the aircraft maintainers and aircrew from potentially hazardous noise exposures and provide effective speech communication. Chemical/biological (CB) protective equipment has also been required to protect aircrew and ground crew in an actual or perceived CB warfare environment. Wearing CB protection under a headset could potentially degrade the noise attenuation performance of the headset and therefore degrade their communication capability as assessed by measuring speech intelligibility performance. Noise attenuation measurements were collected in accordance with the American National Standards Institute (ANSI) S12.6-1997 Methods for Measuring the Real-Ear Attenuation of Hearing Protectors[1] on five different hearing protection and communication headsets with and without the Joint Service Aircrew Mask (JSAM)-Strategic Aircraft (SA), M53 CB hood with M50 head harness. A newer version of the ANSI standard exists (2008 version). However, the program office decided to use the 1997 version so that the subjects could be fit by an expert fitter. The headsets selected for this study were Bose A-20, David Clark H10-76, David Clark P/N 40493G-01, Sonetronics H-173C/AIC, and Telex AIR-3500. Additionally, active insertion loss measurements were conducted in accordance with 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 (MIRE) or Acoustic Test Fixture Procedures[2] for the Bose A-20 with and without the JSAM-SA. Measurements were conducted at the Air Force Research Laboratory (AFRL) bioacoustics facilities at Wright-Patterson Air Force Base (WPAFB) in June-July 2015. The results were compared to the JSAM-SA performance specification requirements for ground and in-flight operations. The requirement stated that the JSAM-SA shall not degrade the noise attenuation performance of the hearing protector by more than 3 dB when compared to the performance of the hearing protector alone. The JSAM-SA, when worn in combination with any of the headsets measured in this study, degraded the attenuation performance by more than 3dB across several frequencies when compared to the headsets alone and therefore did not meet the performance specification requirement.

1.0 INTRODUCTION

The noise environment on or around an aircraft can be hazardous to hearing and degrade speech communication performance. Communication headsets have been required to protect the aircraft maintainers and aircrew from potentially hazardous noise exposure and provide effective speech communication. Chemical/biological (CB) protective equipment has also been required to protect aircrew and ground crew in an actual or perceived CB warfare environment. Wearing CB protection under a communication headset could potentially degrade the noise attenuation performance of the headset and therefore degrade speech communication capability as assessed by measuring speech intelligibility performance.

Communication headsets have been donned by aircraft maintainers and aircrew to combat noise on flight lines and to provide satisfactory voice communications. Five headsets currently used in military operations were selected for these measurements, Figure 1. The Bose A-20 was a common military aircraft headset that has been in use by the United States Navy (USN) P-8A program. The David Clark H10-76 headset has been in use by the United States Air Force (USAF) E-3C program. The David Clark P/N 40493G-01 headset has been used by the USAF C-17 and C-130 programs. The Sonetronics H-173C/AIC and Telex AIR-3500 headsets have been in use by the USN P-3C program. The Bose A-20 was the only headset in this study with Active Noise Reduction (ANR) capabilities.

Figure 1. Communication headsets (top-left to bottom-right): Bose A-20, David Clark H10-76, David Clark P/N 40493G-01, Sonetronics H-173C/AIC, and Telex AIR-3500.

The JSAM-SA was intended to provide above-the-neck individual respiratory, ocular, and percutaneous protection from chemical and biological warfare agents. This CB hood was fielded for use in the USAF, USN, United States Marine Corps, United States Army, and United States Coast Guard. The JSAM-SA, shown in Figure 2 below, was comprised of the M53 respirator and M50 head harness. The system was designed to be worn with all the current below-the-neck ensembles. Air and ground crewmembers don the JSAM-SA hood based on current threat and operational requirements. Personnel have also performed extended ground duties such as pre-flight, post-flight, rearming, refueling and cargo loading of aircraft while wearing the hood in addition to emergency actions such as ground escape and evasion. The JSAM-SA was available in small, medium, and large. The communication headsets in combination with the JSAM-SA are shown in Figure 3.

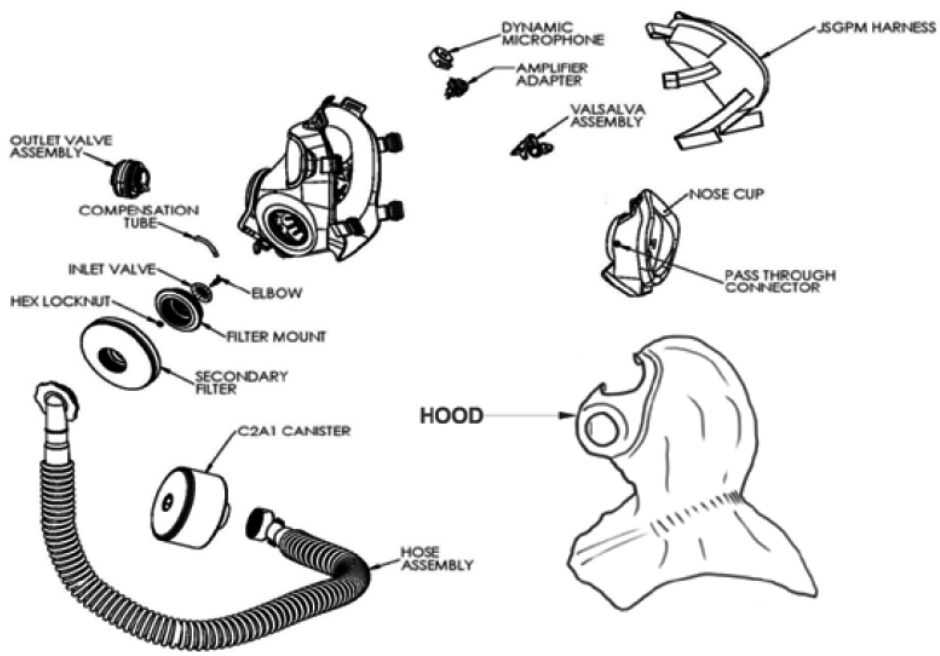

Figure 2. JSAM-SA

Figure 3. Communication headsets with JSAM-SA (top-left to bottom-right): Bose A-20, David Clark H10-76, David Clark P/N 40493G-01, Sonetronics H-173C/AIC, and Telex AIR-3500.

The objective of this study was to measure the noise attenuation performance of the Bose A-20, David Clark H10-76, David Clark P/N 40493G-01, Sonetronics H-173C/AIC, and Telex AIR-3500 with and without the JSAM-SA to determine if the JSAM-SA satisfied Safe-to-Fly (StF) recommendations and airworthiness requirements. The performance specification requirement is shown below.

"Hearing Protection: The mask, when integrated with existing head-mounted personal/life support equipment in Appendix D (referring to performance specification), shall result in no more than a three (3) dBA degradation of the measured one-third octave band hearing protection compared to the original (non-mask) configuration."

2.0 METHODS

2.1 Subjects

Ten paid volunteer subjects (5 male, 5 female) participated in the continuous noise attenuation and active insertion loss performance measurements. The subjects ranged in age from 19 to 34 years old. All subjects were required to have a computer administered screening audiogram via Hughson-Westlake method, with behavioral hearing thresholds inside the normal hearing range, 25 dB hearing level (HL) or better from 125 Hz to 8000 Hz. Anthropometric head measurements were also collected for each subject. Subjects were assigned a JSAM-SA size based on these measurements. Hood fittings and sizing adjustments were conducted by a JSAM-SA Subject Matter Expert (SME). Subjects' anthropometric measurements and assigned sizes are listed in Table 1.

Table 1. Subjects' anthropometric head measurements and sizing matrix

Subject ID	Head Circumference (mm)	Width (mm)	Length (mm)	SNR (mm)	Neck Circumference (mm)	JSAM-SA Size
1550	560	140	195	87	360	Medium
1564	540	125	180	95	305	Medium
1584	570	140	190	81	390	Medium
1602	525	125	170	86	305	Small
1616	510	125	175	81	275	Small
1622	525	120	180	70	290	Medium
1625	565	123	185	89	350	Medium
1629	565	145	190	89	380	Large
1630	510	125	170	87	280	Small
1631	560	140	190	92	365	Large

2.2 Continuous Noise Attenuation

The AFRL facility used for this portion of the study was specifically built for the measurement of the sound attenuation properties of passive hearing protection devices. The chamber (Figure 4), its instrumentation, and measurement procedures were in accordance with ANSI S12.6-1997[1]. A newer version of the ANSI standard exists (2008 version). However, the program office decided to use the 1997 version so that the subjects could be fit by an expert fitter. The subjects were seated in the center of the room and tasked to respond to a series of tones using a hand-held response wand (Figure 5). ANSI S12.6 required measuring the occluded (with hearing protector in place) and unoccluded hearing threshold of human subjects using a von Békésy tracking procedure. The thresholds were measured two times for the unoccluded ear condition and two times for the occluded ear condition. The real-ear attenuation at threshold for each subject was computed at each octave band frequency, 125 to 8000 Hz, by averaging the two trials (the difference between unoccluded and occluded ear hearing thresholds).

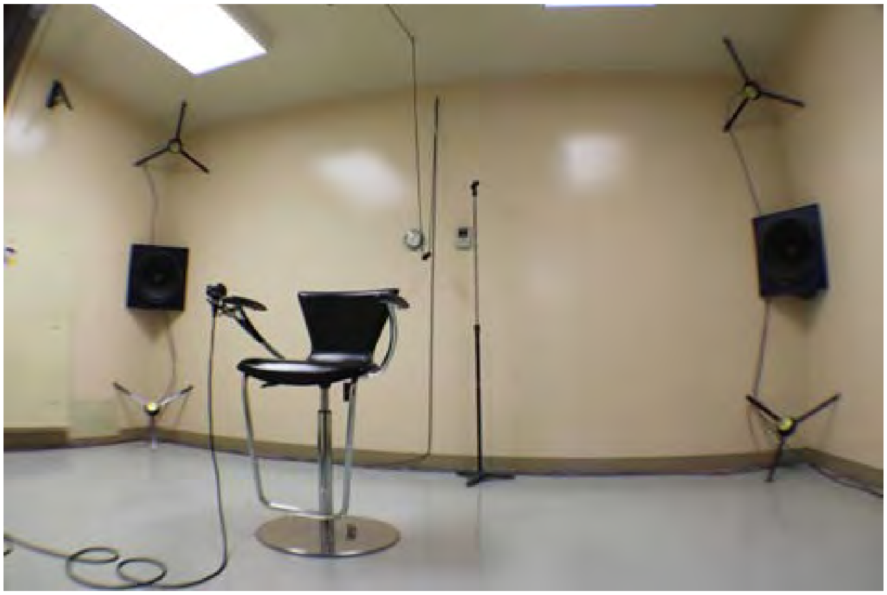

Figure 4. Facility used for measurement of passive continuous noise attenuation

Figure 5. Subject completing the threshold measurement with the JSAM-SA and a communication headset

2.3 Active Insertion Loss

The AFRL facility used for this portion of the study was specifically built to measure the insertion loss of hearing protectors (Figure 6). Insertion loss was defined as the algebraic difference in dB between the sound pressure levels (SPL) measured at a reference point with and without the hearing protection device in place. The facility and measurements were operated in accordance with ANSI S12.42-2010[2]. Miniature microphones (Knowles model BT-1759) were used to simultaneously measure the SPL at the entrance of both ear canals. Subjects were required to wear foam earplugs during all measurements to reduce the noise exposure. The miniature microphones rested on top of the foam earplug at the entrance to the ear canal. 115 dB overall SPL was generated and three objective measurements were collected to complete one trial: open ear, occluded ear with ANR off, and occluded ear with ANR on. Three trials were collected per subject, per configuration. For each subject, the mean active insertion loss of the three trials was computed. Average active insertion loss for the ten subjects was then calculated for each configuration.

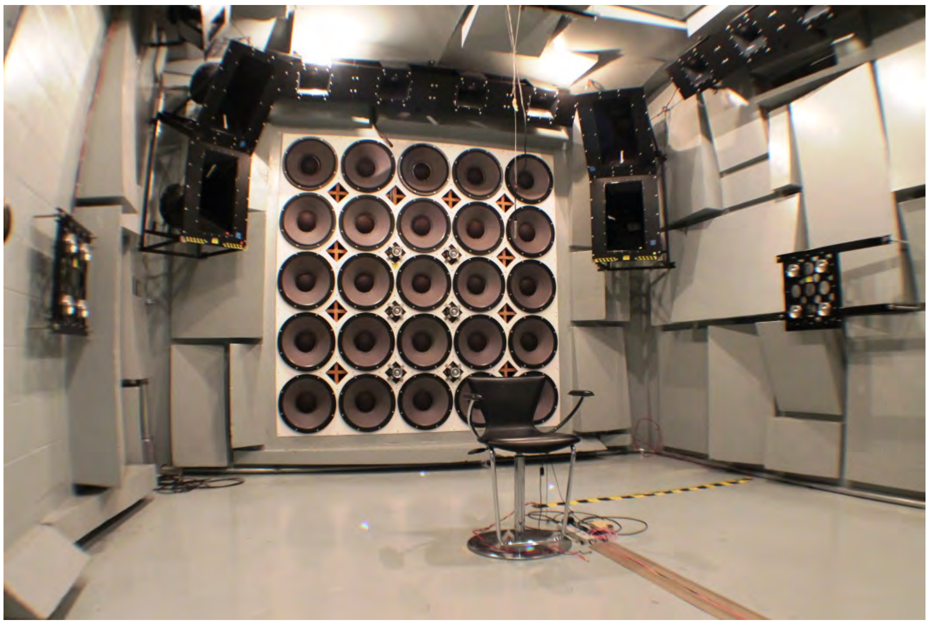

Figure 6. Facility used to measure active insertion loss

3.0 RESULTS

ANSI S12.6 measurements of the Bose A-20, David Clark H10-76, David Clark P/N 40493G-01, Sonetronics H-173C/AIC, and Telex AIR-3500 headsets were collected with and without the JSAM-SA. Additionally, ANSI S12.42 measurements of the Bose A-20 were collected with and without the JSAM-SA to assess ANR performance. The results were analyzed to compare the noise attenuation performance of the headsets with and without the JSAM-SA in order to understand the effect the hood has on the noise attenuation performance of each headset. The requirement stated that the addition of the JSAM-SA shall not degrade the noise attenuation of the headset by more than 3dB.

3.1 Continuous Noise Attenuation Results

Passive noise attenuation data were analyzed in accordance with ANSI S12.6-1997 to obtain mean attenuation values and standard deviations at all the measurement frequencies. Mean and standard deviation (SD) noise attenuation data were calculated across subjects at each octave band frequency. The headset with JSAM-SA attenuation per octave band was subtracted from the headset only attenuation per octave band to determine if there was degradation in attenuation. A single Noise Reduction Rating (NRR) was also calculated for mean minus 1 and mean minus 2 standard deviations (Table 2). Figures 7-11 display a graphical representation of the attenuation results at each measured frequency for each headset with and without the JSAM-SA. The attenuation levels of the headsets were minimal at the low frequencies (ranging from 6-15 dB at 125 Hz) and increased as the frequencies increased (ranging from 35-41 dB at 8000 Hz). The use of the JSAM-SA degraded the passive noise attenuation performance of the headsets when compared to the headsets alone.

Table 2. Passive noise attenuation data for communication headsets with and without JSAM-SA

		Frequency (Hz)							NRR	
Headset / Combination		125	250	500	1000	2000	4000	8000	Mean -1SD	Mean -2SD
Bose A-20	Mean	6	9	13	20	27	37	38		
	SD	2	3	3	3	3	4	5	14	12
Bose A-20 with JSAM-SA	Mean	6	4	6	10	16	28	33		
	SD	5	4	4	4	6	3	3	6	2
	Attenuation Loss	0	(5)	(7)	(10)	(11)	(9)	(5)		
David Clark H10-76	Mean	14	15	18	27	28	38	41		
	SD	3	2	2	5	6	4	2	20	16
David Clark H10-76 with JSAM-SA	Mean	9	6	5	10	16	30	33		
	SD	6	4	3	3	6	5	2	7	3
	Attenuation Loss	(5)	(9)	(13)	(17)	(12)	(8)	(8)		
David Clark P/N 40493G-01	Mean	11	16	25	30	29	33	36		
	SD	3	2	4	3	4	3	1	21	18
David Clark P/N 40493G-01 with JSAM-SA	Mean	6	5	11	11	17	30	34		
	SD	4	4	3	5	4	4	4	7	3
	Attenuation Loss	(5)	(11)	(14)	(20)	(11)	(3)	(1)		
Sonetronics H-173C/AIC	Mean	12	16	16	15	26	37	41		
	SD	5	3	4	3	5	4	4	14	11
Sonetronics H-173C/AIC with JSAM-SA	Mean	7	6	6	9	17	32	38		
	SD	3	4	4	4	3	4	3	6	1
	Attenuation Loss	(6)	(10)	(10)	(6)	(8)	(5)	(4)		
Telex AIR-3500	Mean	15	19	22	25	28	32	35		
	SD	7	5	3	3	4	5	3	20	16
Telex AIR-3500 with JSAM-SA	Mean	4	6	13	13	17	28	32		
	SD	4	4	3	4	4	4	3	9	5
	Attenuation Loss	(10)	(12)	(9)	(12)	(11)	(4)	(3)		

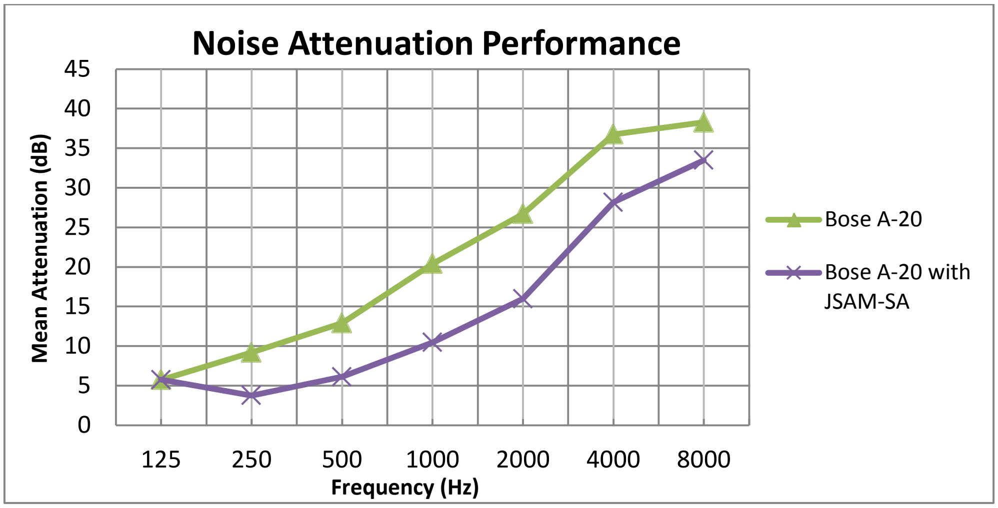

Figure 7. Passive mean noise attenuation for Bose A-20 with and without JSAM-SA

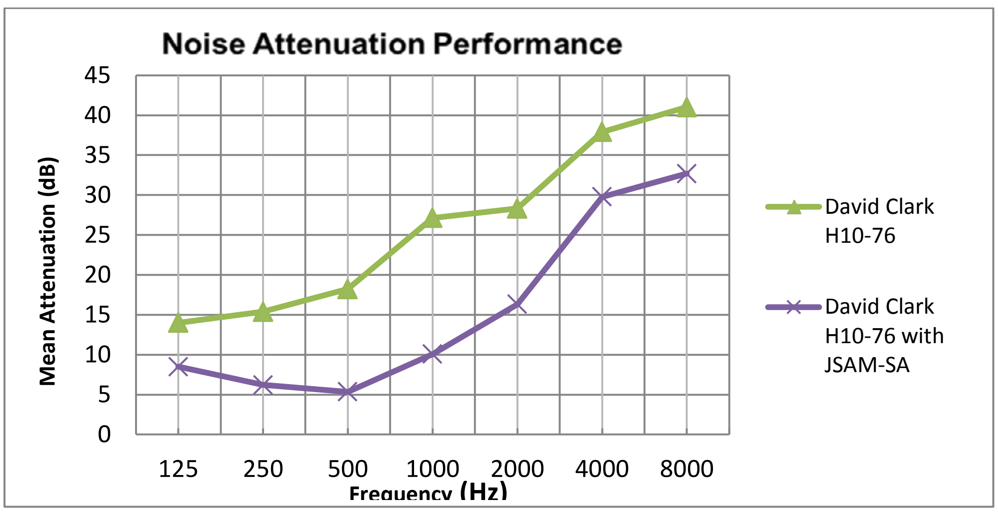

Figure 8. Passive mean noise attenuation for David Clark H10-76 with and without JSAM-SA

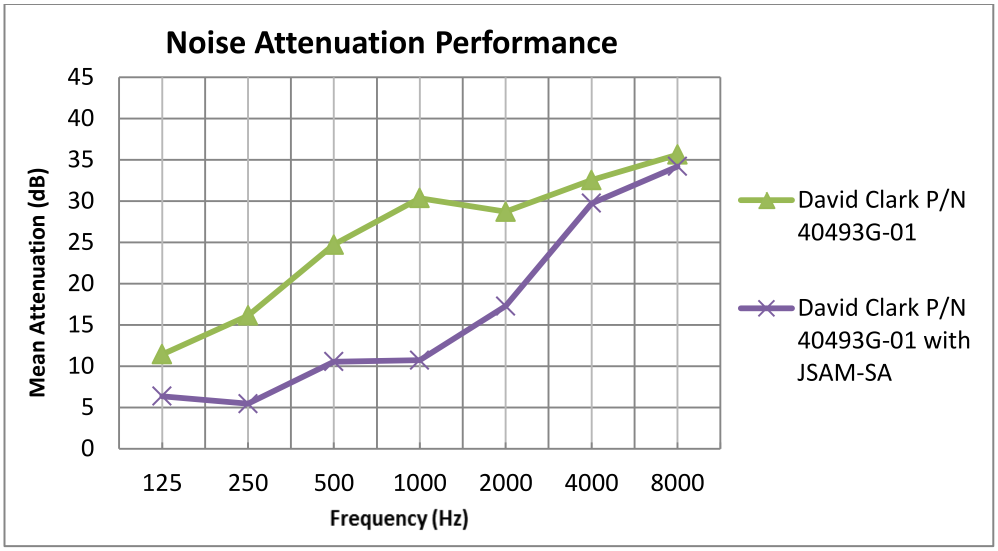

Figure 9. Passive mean noise attenuation for David Clark P/N 40493G-01 with and without JSAM-SA

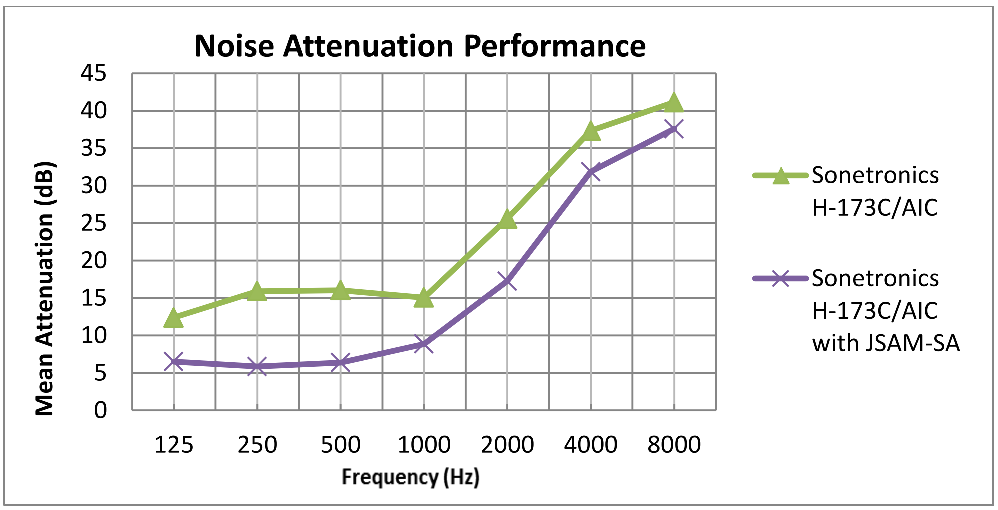

Figure 10. Passive mean noise attenuation for Sonetronics H-173C/AIC with and without JSAM-SA

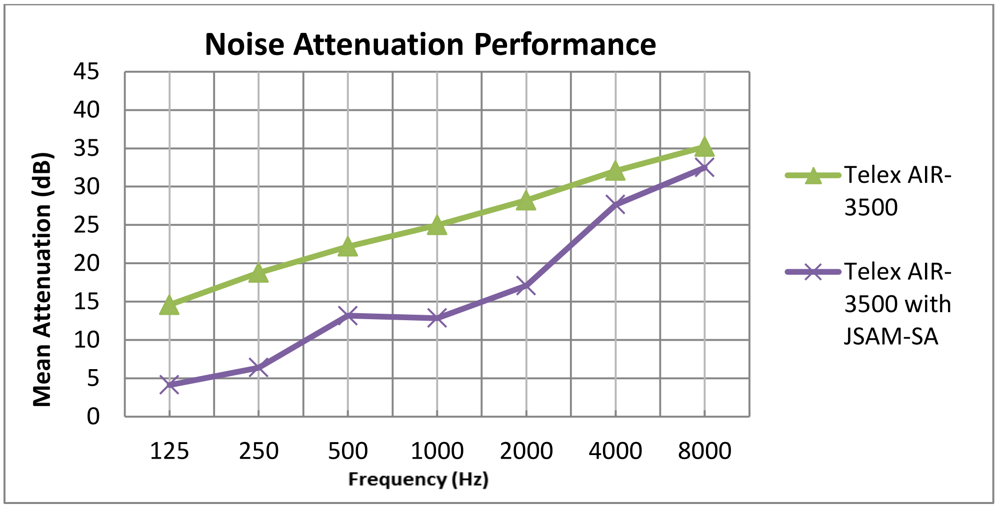

Figure 11. Passive mean noise attenuation for Telex AIR-3500 with and without JSAM-SA

3.2 Active Insertion Loss Results

Active insertion loss (AIL) data were collected to assess the ANR capability of the Bose A-20 headset with and without JSAM-SA. The active insertion loss data and the passive continuous noise attenuation data have been combined to understand the total attenuation of a hearing protection device (HPD) with ANR capabilities. The total attenuation calculation has been described in ANSI S12.42-2010, section 9.6.3[2]. This calculation was completed by computing the average REAT attenuation value for repeated fits per subject and adding it to the same subjects' average AIL for the repeated fits. The total noise attenuation per octave band for the headset with JSAM-SA was subtracted from the headset alone attenuation per octave band to determine if there was a reduction in total noise attenuation. AIL and total attenuation data from 125-8000 Hz are shown numerically in Table 3 and graphically in Figure 12. The addition of the JSAM-SA degraded the noise attenuation greater than 3 dB across several frequencies. The active insertion loss of the Bose A-20 at 125 Hz went from 36 dB to 0 dB when the JSAM-SA was donned under the headset. There was almost no benefit from the ANR technology when the JSAM-SA was worn.

Table 3. Total noise attenuation data for Bose A-20 with and without JSAM-SA

Headset / Combination		Frequency (Hz) 125	250	500	1000	2000	4000	8000
Bose A-20	Active Insertion Loss	36	28	14	1	(3)	(1)	(0)
	Total Noise Attenuation	42	37	27	22	24	36	38
Bose A-20 with JSAM-SA	Active Insertion Loss	0	6	5	(2)	0	0	0
	Total Noise Attenuation	6	9	11	8	16	28	34
Difference between Total Noise Attenuation (dB)		(36)	(28)	(16)	(14)	(8)	(8)	(4)

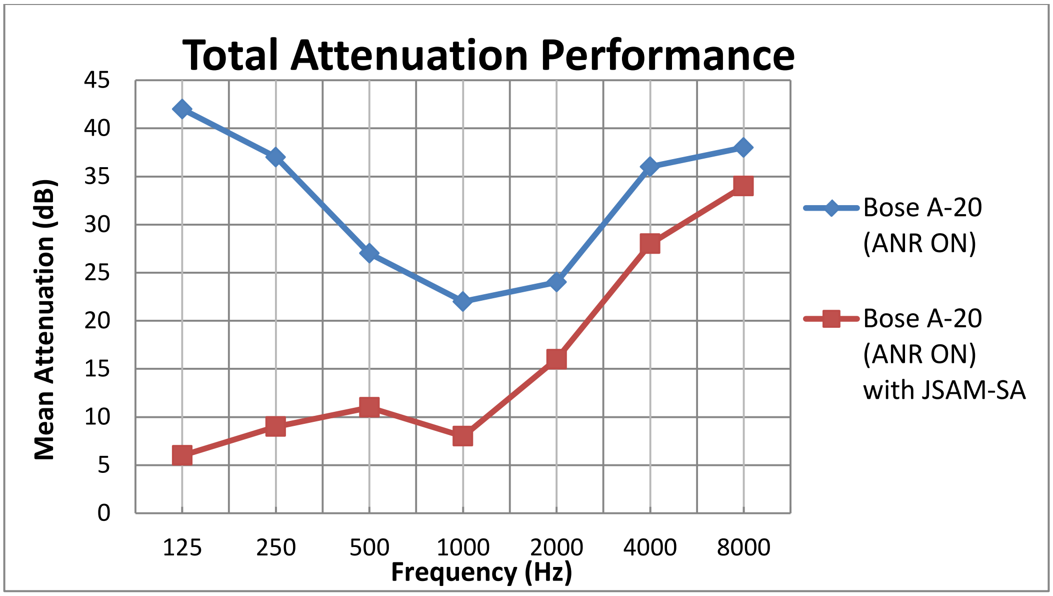

Figure 12. Mean total noise attenuation for Bose A-20 with and without JSAM-SA

4.0 DISCUSSION

Any material or cable that breaks the seal of an earcup in a headset or helmet has the potential to create an acoustic leak. Therefore the performance specification requirement was developed knowing that some degradation was unavoidable and also acceptable. The requirement stated that the JSAM-SA, worn in combination with a headset, would degrade the noise attenuation performance of the headset by no more than 3 dB across all frequencies when compared to the attenuation performance of the headset alone.

One recommended solution to meet the noise attenuation requirement would be to add communication earplugs under the headset and JSAM-SA. Another recommended solution would be to incorporate the earcup into the design of the JSAM-SA. These potential hearing protection configurations could provide the necessary noise attenuation and communication needs when the JSAM-SA would be required. Noise attenuation and speech intelligibility measurements must be conducted to understand the performance capabilities of these potential solutions.

5.0 CONCLUSIONS

Noise attenuation data were collected on the Bose A-20, David Clark H10-76, David Clark P/N 40493G-01, Sonetronics H-173C/AIC, and Telex AIR-3500 headsets with and without the JSAM-SA. The JSAM-SA degraded the noise attenuation performance of each headset by more than three (3) dB across several frequencies in comparison to the headset performances alone. Therefore the JSAM-SA did not meet the performance specification requirement.

6.0 REFERENCES

1. ANSI S12.6-1997 Methods for Measuring the Real-Ear Attenuation of Hearing Protectors Systems.
2. 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 (MIRE) or Acoustic Test Fixture Procedures