Wireless Audiometric Hearing Test System (WAHTS): Attenuation, MPANLs, RETSPLs, and clinical validation

Shoshannah Russell, AuD & Jesse Norris, PhD

Objective: *Summarize WAHTS attenuation, calculation of MPANLs, establishment of RETSPLs, and clinical validation.*

Introduction

The Wireless Audiometric Hearing Test System (WAHTS) increases access for hearing testing in non-traditional environments, while meeting the American National Standards Institute (ANSI) and International Electrotechnical Commission (IEC) specifications for audiometers (ANSI S3.6-2018 and IEC 60645-1:2017). In addition, the WAHTS conforms to the description of audiometric measuring instruments described in Occupational Safety and Health Administration's (OSHA's) occupational noise exposure standard, 29 CFR 1910.95, Appendix C.

The system includes an audiometer integrated into a wireless headset—the *WAHTS headset*—and a software app. The app provides an interface for controlling the audiometer in the WAHTS headset, for patients to respond during a hearing test, and for viewing and managing the results (Figure 1).

Figure 1. WAHTS Testing. The patient wears the headset and responds to stimuli using the app. The WAHTS supports both automated and manual forms of testing.

The WAHTS are manufactured by Edare LLC in New Hampshire. Edare registered the WAHTS with the Food and Drug Administration (FDA) in 2020. The WAHTS air-conduction (AC) is listed on FDA's Global Unique Device Identification Database (GUDID): 00860005068302.

WAHTS headset

The WAHTS headset has large circumaural earcups that provide significant attenuation and protect the built-in wireless audiometer (Figure 2). A speaker and small microphone are mounted in a plastic faceplate, covered with protective fabric, and secured in the earcups. To complete the earphones, an ear seal from X-series hearing protectors (3M, St. Paul, MN) snaps into the earcup.

Figure 2. Components of the WAHTS.

In addition to rethinking the earphones, the WAHTS uses a novel "frictionless fit" headband design. The headband has two separate springs: one provides tension required to ensure a good seal around the ears, and the second bears the weight of the earcups. This design makes it easy to position the headphones quickly and accurately.

Attenuation

As measured by an independent laboratory, the WAHTS headphones provide 30-40 dB of attenuation for octave bands from 250-8000 Hz. This level of attenuation is on-par with single-walled sound booths[1,2]. Figure 3 shows the attenuation of the WAHTS headset, a single-walled sound booth, and the RadioEar DD450 headset. The WAHTS attenuation is on par with the single-walled booth and provides more attenuation than the DD450 in the lower frequencies. Blocking low frequency sounds—whether in a sound booth or under the earcups—is essential because most background noises have low frequency energy that can interfere with measuring hearing thresholds at frequencies important for speech and communication.

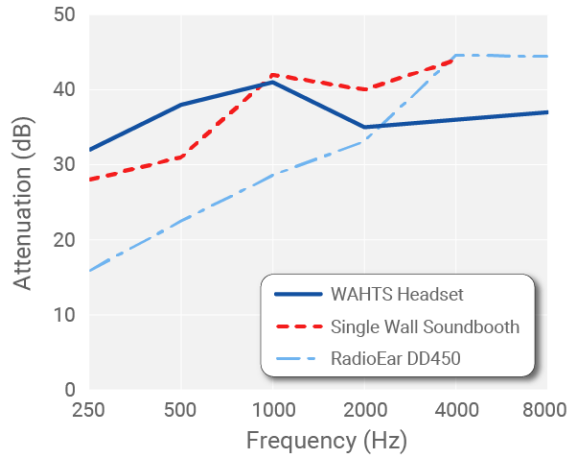

Figure 3. Attenuation of the WAHTS headset is on par with a single wall sound booth and provides more attenuation than the DD450 at 1000 Hz and below. WAHTS headset attenuation measured according to ANSI S12.6-2008 Method A by Michael & Associates, Inc. (NIST NVLAP: 100427-9).

Maximum Permissible Ambient Noise Levels (MPANLs)

The passive attenuation of the WAHTS allows the system to be used to accurately test hearing in environments with ambient noise. Table 1 shows the maximum permissible ambient noise levels (MPANLs) calculated for the WAHTS in accordance with Annex A of ANSI S3.1-1999 (R2018).

Table 1. WAHTS MPANLs derived per ANSI S3.1-1999 (R2018).

Frequency (Hz)	Ears uncovered† (dB SPL)	WAHTS attenuation (dB)	**WAHTS MPANLs (dB SPL)**
125	29	30.6	**59.5**
250	21	31.6	**52.7**
500	16	37.5	**53.6**
1000	13	39.5	**52.7**
2000	14	34.5	**48.8**
4000	11	36.0	**47.1**
8000	14	36.9	**50.4**

†These are the most stringent levels when testing from 125 to 8000 Hz. If testing is limited to 250 or 500 Hz and above, additional noise is permitted in the 125 and 250 Hz octaves. [Additional details in ANSI S3.1-1999 (R2018)]

The passive attenuation of the WAHTS headset results in greater MPANLs in the low frequencies (Table 1 and the dark blue bars in Figure 4). Greater MPANLs mean that audiometric testing can be completed with higher amounts of ambient room noise. Ambient room noise tends to be low frequency in energy[1] and can interfere with testing and result in false low frequency hearing loss. The WAHTS MPANLs outperform other transducers at 250, 500 and 1000 Hz, making the WAHTS ideal for boothless audiometry, where ambient room noise is a concern.

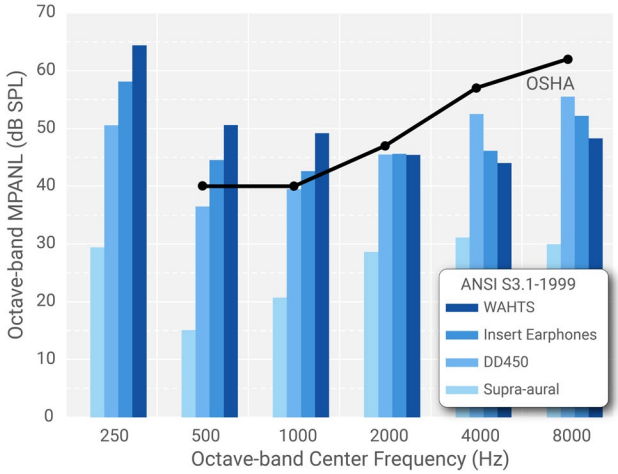

Figure 4. MPANLs calculated according to ANSI S3.1 Annex A.3 and OSHA MPANLs from §1910.95 Appendix D.

WAHTS attenuation at lower frequencies enables the system to be used in locations that would normally exceed OSHA MPANLs. An OSHA letter of interpretation, October 11, 2022, permits using the ANSI S3.1 derived MPANLs for occupational hearing testing; enabling the WAHTS to be used in locations no other transducer can currently be used in.

Reference Equivalent Threshold Sound Pressure Levels (RETSPLs)

Because the WAHTS uses its own integrated transducers, it is necessary to establish RETSPLs. Two independent RETSPLs studies were performed in accordance with ISO 389-9:2009. Data from the studies were combined to yield the RETSPLs provided in Clavier et al., 2022[3]. Additional studies have demonstrated that thresholds obtained with the WAHTS integrated transducer do not introduce more significant threshold shift (STS) rates, addressing a common concern when changing transducers in a hearing conservation program. Sheffield et al., reported a 5% positive STS rate with the Benson CCA audiometer within a sound booth, and a 4% positive STS rate using the WAHTS without a sound booth[4].

Clinical Validation

The WAHTS has been extensively studied in the literature. In 2017, Meinke et al. used the WAHTS to test industrial workers' hearing at a worksite and compared results with those obtained by standardized, automated audiometry in a mobile sound booth. Results demonstrated excellent test re-test reliability using the WAHTS, and comparable thresholds between the WAHTS and the automated mobile van audiometer[1]. In a recent presentation at the National Hearing Conservation Association (NHCA), no differences were found between thresholds measured using the WAHTS and thresholds measured using the Benson CCA audiometer[4]. Additional examples of obtaining accurate thresholds in non-traditional test environments include a school setting[5] and assessment of acute acoustic trauma by the U.S Department of Defense and UK Defence[6,7].

Conclusion

In summary, the WAHTS is a modern hearing test system that meets ANSI and IEC specifications for audiometers. The high passive attenuation of the headset makes the WAHTS both an audiometer and sound booth in one small compact unit. Although the system may already be used in environments that meet the OSHA MPANLs, the OSHA letter of interpretation enables the WAHTS to be used in higher noise environments, making it the most competitive boothless solution on the market. The WAHTS has been extensively studied in the literature and repeatedly demonstrates that it yields accurate and reliable hearing thresholds outside of the sound booth. The WAHTS is a clinically valid system, which is well suited for boothless audiometry.

References

[1] Meinke D, Norris J, Flynn B, Clavier O. Going Wireless and Booth-less for Hearing Testing Industry. *Int J Audiol*. 2017; 56(SUP1):41-51.

[2] Brungart D, Schurman J, Konrad-Martin D, Watts K, Buckey J, Clavier O, Jacobs P, Gordon S, Dille M. Using tablet-based technology to deliver time-efficient ototoxicity monitoring. *Int J Audiol*. 2018; 57(SUP4):78-86.

[3] Clavier O, Norris J, Hinckley D, Martin W, Yuan J, Brungart D, Schurman J, Kulinski D, Larsen E, Mehraei G. Reference equivalent threshold sound pressure levels for the Wireless Automated Hearing Test System. *Journal of Acoustical Society of America*. 2022; 152(1):601-608.

[4] Sheffield B, Kulinkski D, Bugtong V, Schurman J, Brungart D, Merkley J. Using Boothless Audiometry in the clinic (and out) to Enhance Hearing Readiness. NHCA podium presentation, 2022.

[5] Magro I, Clavier O, Mojica K, Rieke C, Eisen E, Fried D, Stein-Meyers, Fellows A, Buckey J, Saunders J. Reliability of tablet-based hearing testing in Nicaraguan school children: A detailed analysis. *Otology and Neurotology*. 2020; 41(3):299-307.

[6] Barr L. Mobile hearing test system enables quicker diagnosis, treatment. The official website of the Military Health System. https://health.mil/News/Articles/2021/07/08/Mobile-hearing-test-system-enables-quicker-diagnosis-treatment. Published July 8, 2021. Accessed June 16, 2022.

[7] Lee J, Bowley D, Miles J, Muzaffar J, Poole R, Orr L. The Downrange Acoustic Toolbox: An Active Solution for Combat-Related Acute Acoustic Trauma. *Journal of Special Operations Medicine*. 2020; 20(4):104-111.