Boothless technologies create new opportunities for hearing assessment and conservation

Testing Hearing Outside Constraints of Traditional Sound Booths

https://health.mil/News/Articles/2021/07/08/Mobile-hearing-test-system-enables-quicker-diagnosis-treatment

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Wireless Automated Hearing Test System

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Disclaimer

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The content presented is solely the responsibility of the authors and does not necessarily represent the official views of the National Institutes of Health nor of the Department of Defense.

I work for the company that developed the WAHTS, and the views expressed in this presentation are my own.

Outline

1. Hearing Conservation
2. Regulations
3. Traditional Technologies
4. Boothless Audiometry
5. Opportunities
6. Conclusion

Objective of Hearing Conservation

Prevent the occurrence and reduce the progression of occupational noise-induced hearing loss

Basic program components*:

- noise exposure monitoring
- engineering and administrative controls (e.g., reducing the noise at the source, limiting exposure to hazardous noise)
- audiometric evaluations
- use and fit of hearing protection devices
- education and motivation
- record keeping
- program evaluation and audit

*https://www.cdc.gov/niosh/topics/noise/preventhearingloss/hearlosspreventprograms.html

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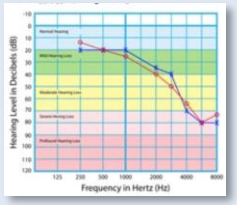
Terminology

Hearing Screening	Occupational Hearing Test*	Hearing Protector Fit Test
Quickly identify potential hearing loss	Determine sensitivity of a listener's hearing in each ear	Measure the attenuation an individual achieves
• "Pass" or "Refer" result for more hearing testing or medical care • Screening protocols dependent on the purpose of the screening	• Identifies hearing thresholds which are the "softest" a person can hear 50% of the time at each test frequency • Results presented as an audiogram  • Typically tests fewer frequencies than a diagnostic clinical test	• Results in "Personal Attenuation Rating" (PAR) • Fit testing has been shown to improve individuals' ability to properly train, fit and wear hearing protectors

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**Also referred to as "audiometric monitoring"*
Ideally, monitoring identifies noise induced hearing loss (NIHL) early

Occupational Hearing Services

	For:	Administered by:
Hearing Screening	DOT truck/bus drivers and pilots • Whisper Test is pass/refer • Threshold acceptance criteria	• Anyone
Pure-Tone Threshold Testing	Monitoring hearing thresholds of workers exposed to noise	• Certified or Trained Technician* • Audiologist
Hearing Protector Fit Testing	Verifying hearing protectors provide adequate protection+	• Anyone
Diagnostic Audiometry (Air, Bone, Speech Testing)	• Investigation of possible work-related hearing loss • Worker's compensation claim evaluations	• Audiologist

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**Supervised by licensed audiologist or physician*
+Can also check for over protection

What Happens to the Tests

1 Results Aggregated

In software

2 Audiograms Reviewed

By audiologist or physician

- Flag invalid test (e.g. noise-exposed just before a baseline exam) and schedule retest
- Identify *Standard Threshold Shift (STS)* and schedule a retest within 30-days
- Confirm *STS* and determine if work related and potential need to report hearing loss to regulatory agency

3 Diagnostic Test (air, bone, speech)

- Results combined with other information(e.g., noise exposure history, work history, hearing protector use fitting and use history) to determine if the hearing loss is work-related and requires recording/reporting on the illness/injury forms

4 If Hearing Loss Identified as Work-Related

- Employee has an option of filing a separate worker's compensation claim, or some companies automatically send them for that investigation

Be aware, this is overly simplified!

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Regulations

Federal agencies have requirements and guidelines regarding hearing conservation programs and fitness for duty

OSHA 1910.95: Noise Regulation for General Industry*

OSHA 1904.10: Recording Criteria for Occupational Hearing Loss Cases

MSHA 30 CFR Part 62: Noise Enforcement Policy

DOT: FCMSA, FAA, FRA: Each have their own requirements

NIOSH publishes recommended exposure limit (REL) and guidelines for preventing hearing loss

DOD 6055.12: Hearing Conservation Program

Additionally, there are 22 OSHA-approved state plans covering private, state and local workers, and 6 plans covering state and local workers

**Exempts agriculture and oil & gas industries, and construction is covered under a noise exposure standard but has yet to provide a hearing conservation rule: 29 CFR 1926.52*

Training & Professional Organizations

CAOHC®
Council for Accreditation in Occupational Hearing Conservation

- **Trained Audiometric Technician**
- **Course Director**
- **Professional Supervisor**

American Board of Audiology®
BOARD CERTIFIED IN AUDIOLOGY

ASHA CERTIFIED
CERTIFICATE OF CLINICAL COMPETENCE

- **Licensed Audiologist**
  - M.S., M.A., Au.D. , Ed.D. Sc.D., Ph.D.,
  - Certified by the American Board of Audiology or the American Speech-Language Hearing Association
  - Both typically require passing the national praxis exam

NHCA
National Hearing Conservation Association

- **Multidisciplinary Organization focused on Hearing Conservation**

Traditional Booth Setup

Sound booth to block background sound

Audiologist with audiometer and computer interface

Patient inside sound booth with wired connection from headset to audiometer

Traditional Test Locations

Fixed installation of sound booths

Mobile sound booths

Traditional Test Equipment

Sound booths

Single

Multiple

Mobile

Audiometers

Diagnostic

Portable Diagnostic

Computer Controlled*

**Support automated threshold testing*

Transducers

Supra-aural

Circumaural

Insert

Boothless Audiometry

- Innovation driven by:
  - Mobile devices: *portability* and *connectivity*[*]
  - COVID-19: forced many booths to either halt or operate at significantly reduced capacity
- Many products are simply taking equipment used in the booth outside the booth and monitoring the background (ambient) noise

[*]*Even if internet not required for operation, devices and software have made it easier to transfer results once connection becomes available again*

Constraints

- Measuring accurate hearing thresholds require the listener's attention and focus
- Background noise poses two problems:
  1. Limits the ability to test quiet stimuli, and
  2. Distracts listener

Background (or Ambient) Noise

- Measured with a sound level meter (SLM)

  *SLMs meet different accuracy requirements indicated by "Class" (or "Type")**

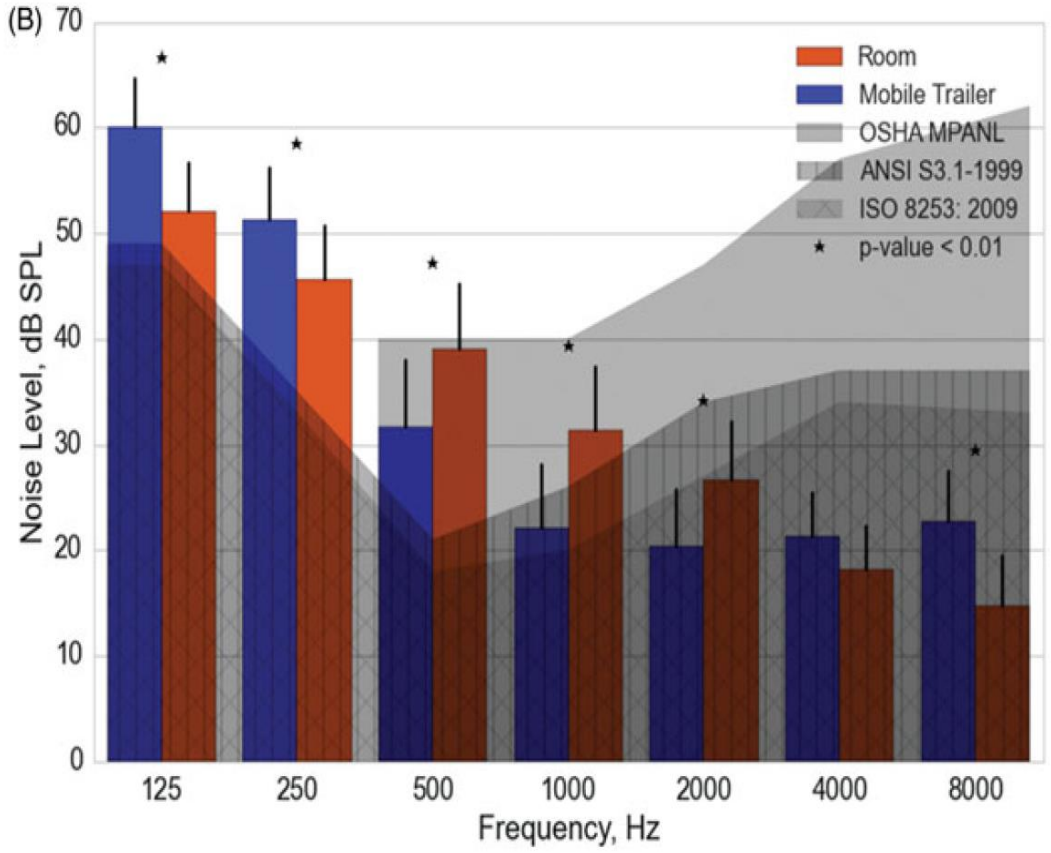
- Important to verify levels are sufficiently quiet to meet applicable standard

	Octave bands (Hz)						
Criteria (dB SPL)	*125*	*250*	*500*	*1000*	*2000*	*4000*	*8000*
ANSI S3.1–1960	–	–	40	40	47	57	67
ANSI S3.1–1999 (R2018)	49	35	21	26	34	37	37
ISO 8253: 2010	47	33	18	20	27	34	33
OSHA (1983)	–	–	40	40	47	57	62
NHCA (1994)	–	–	24.5	26.5	28	34.5	43.5

- Many boothless systems integrate with sound level meters to monitor ambient noise levels

*See ANSI S1.4, IEC 60651 and IEC 61672

Background Noise in Practice



Green Room

Mobile Trailer

Meinke, et al. 2017

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Background Noise in Practice

Table 3. Threshold differences between wireless audiometry and audiometry in mobile trailer sound booth ($n = 40$ ears).

Frequency (Hz)	*500*	*1000*	*2000*	*3000*	*4000*	*6000*	*8000*	*All*
Average difference (dB)	−3.7	−0.5	−0.1	−0.7	−2.1	−5.5	−0.3	−1.3
SD (dB)	4.3	2.9	3.0	4.4	5.5	5.8	6.0	4.9

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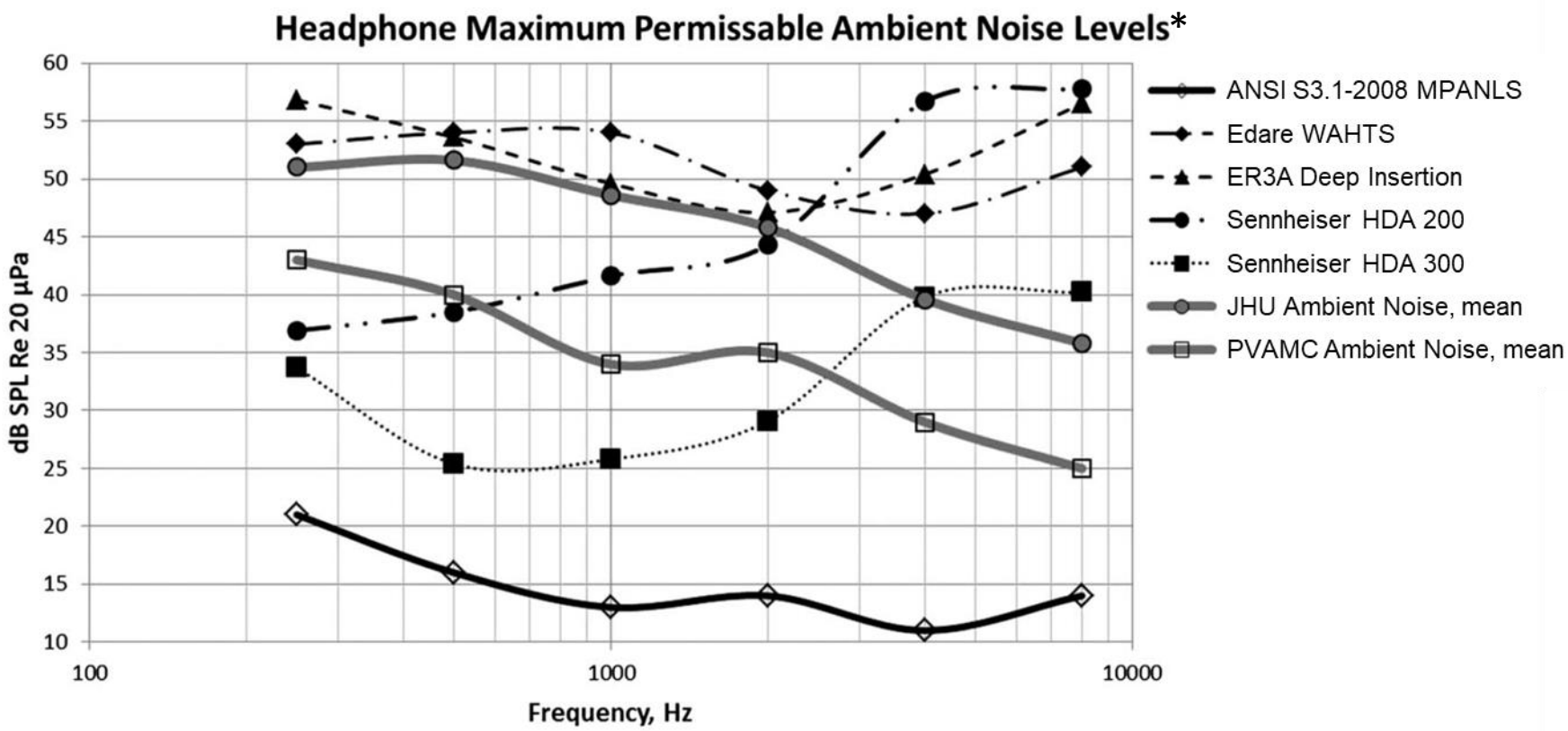
Meinke, et al. 2017

Background Noise Summary



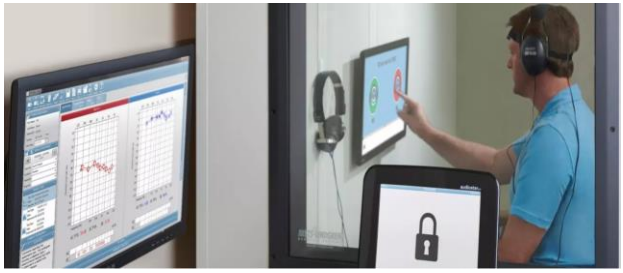
**Note that OSHA currently does not recognize the attenuation provided by the transducers*

Brungart, et al. 2018

Commercially Available Systems

hearX

KUDUwave™



gsi Grason-Stadler

BENSON MEDICAL INSTRUMENTS

SHOEBOX AUDIOMETRY

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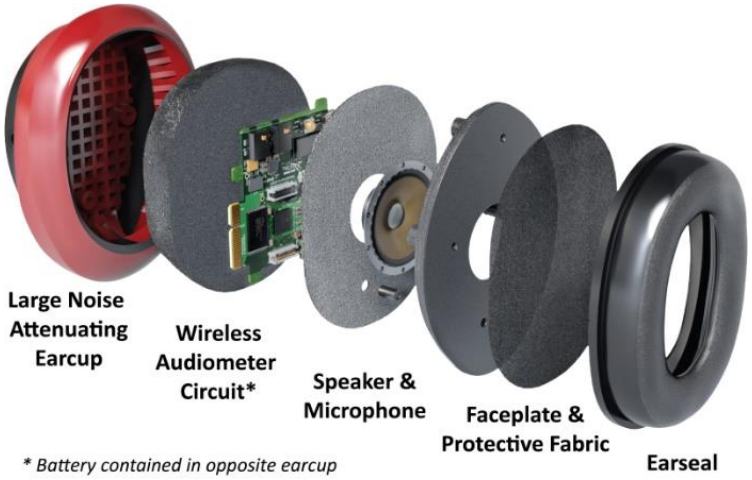
Refer to: Gates, Kathy, Quintin A. Hecht, Marjorie AM Grantham, Andrew J. Fallon, and Malisha Martukovich. "Hearing Health Care Delivery Outside the Booth." Perspectives of the ASHA Special Interest Groups (2021): 1-14.

What's a WAHTS?

Wireless audiometric headphones with embedded computing

- Calibration independent of mobile device
- Attenuation on par with single wall sound booth
- Intuitive headband
- No cables!



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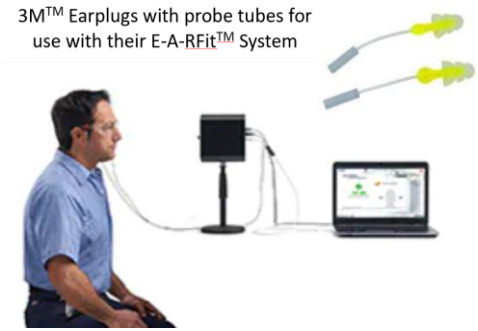
Opportunities to Verify Earplug Fit



3M E-A-Rfit

Fit-check Solo

Benson CCF-200

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Fit testing improves individual's ability to properly insert their hearing protectors and is an opportunity to train what a proper fit "feels like."

Federman, et al. 2021

"Individual fit-testing is recommended as best practice when possible"

DODI 6055.12, 2019

Opportunities with Teleaudiology

Connect licensed audiologists and physicians to conduct diagnostic tests, review results, and consult with remote patients

Opportunities in Treatment

Boothless audiometry can bring testing closer to injury enabling diagnosis and intervention

Lee, et al. 2021 The 'Downrange Acoustic Toolbox': An Active Solution for Acute Acoustic Trauma
https://health.mil/News/Articles/2021/07/08/Mobile-hearing-test-system-enables-quicker-diagnosis-treatment

Conclusions

- Occupational hearing conservation programs aim to protect individuals who are exposed to hazardous noise from developing noise-induced hearing loss and tinnitus
- New technologies for “boothless audiometry” and “fit testing” present opportunities to change how we test, educate, and help individuals *protect their hearing*

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