Inter-laboratory Comparison of Three Fit-Test Systems with Laboratory Real-Ear Attenuation at Threshold Measurements

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Disclaimer: The findings and conclusions in this report are those of the authors and do not necessarily represent the views of the National Institute for Occupational Safety and Health.
Investigators

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  – Claire Collard-Johnson, AuD - Tester

• Michael & Associates
  – Kevin Michael, PhD - Tester

• Honeywell Safety Products
  – Robert M. Ghent, AuD - Tester
Purpose

• To conduct a round-robin test of hearing protector fit-testing systems
• To obtain comparative data on attenuation
  – Assessed at three different laboratories
  – Assessed on four different systems
  – Maintaining the fit of the earplug across all systems
Research Questions

• How well do fit-test measurements correspond to REAT testing done in the laboratory (i.e., compared to the ANSI standard test method)?

• How well do fit-test measures obtained on different systems correspond to each other?
  – HPD Well-Fit by NIOSH
  – FitCheck by Michael & Associates
  – VeriPRO by Honeywell
Participating Laboratories

- NIOSH – Cincinnati
- Honeywell
- Michael & Associates

NIOSH HPD Well-Fit

Michael & Associates
FitCheck

VeriPRO - From Howard Leight®
Experimental Design

- 20 normal-hearing subjects in each lab
- Howard Leight Airsoft earplug (NRR=27)
- Test order was randomized across fit-test systems and the fitting condition (open-ear or occluded) was counterbalanced
- Earplug fit was maintained for all of the tests
- Two trials
## Experimental Design

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<th>Trial</th>
<th>Unhighlighted fields = open runs; Highlighted fields = occluded</th>
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A-weighted Attenuation

\[
\text{Aweight Atten} = 10 \log_{10} \sum_{f=250}^{4000} 10^{L_{Af}} - 10 \log_{10} \sum_{f=250}^{4000} 10^{L_{Af}-\text{Atten}_f}
\]

- Start with 100 dB in each band
- Apply corrections; Obtain overall A-wtd level
- Subtract attenuation for each band
- Sum to obtain overall protected A-wtd level
- Difference = A-weighted attenuation
Comparison of Tests across Systems and Trials

A-weighted Attenuation (dBA)

Trial 1

Trial 2

WellFit, ANSI, FitChk, VPro-R, VPro-L
Differences between Fit-Test System and ANSI Method

• Frequency by Frequency evaluation
• Each subject’s test is compared to the ANSI Method for the same fit:
  \[ \Delta A_{wtAtten} = A_{tten_{FAES}} - A_{tten_{ANSI}} \]
• 95% Confidence interval of the mean difference for each fit-test system
  – MATLAB normfit function
Frequency Specific Differences between Fit-test System and ANSI Laboratory Method

- **FitCheck**
- **HPD Well-Fit**
- **VeriPRO Left**
- **VeriPRO Right**

- **Honeywell**
- **Michael & Associates**
- **NIOSH**

**FitTest Attenuation - ANSI Attenuation**

**Frequency kHz**
Results

• Significantly different results from the three laboratories
  – attributable to the Subject’s experience
  – attributable to the Tester’s experience
• Both HPD Well-Fit and FitCheck demonstrated high agreement with the ANSI S12.6 laboratory test method
• A-weighted attenuations measured with VeriPRO were significantly different from the ANSI results in two of the labs
Additional Research

• Do non-Bekesy methods require practice to yield better results?
  – Loudness Balance differs significantly from the Bekesy Paradigm for ANSI/FitCheck and Method of Adjustment in HPD Well-Fit

• In FitCheck and HPD Well-Fit, a poor fit in either ear ruins the attenuation.

• In VeriPRO, acceptance of a poor Loudness Balance Test ruins the attenuation.
Conclusions

• HPD Well-Fit and FitCheck demonstrate +2 dB agreement with the ANSI method.
• VeriPRO tended to underestimate the ANSI attenuation.
• None of the systems overestimated the attenuation.
• Training in the paradigm is important before fit-testing.