Session No. 706

# Individual Fit Testing of Hearing Protectors: A Case Study

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After more than 35 years of federal regulation, noise-exposed workers continue to lose hearing in otherwise compliance hearing conservation programs. One of the key problems has been hearing protection device (HPD) performance. Research indicates that most workers do not receive protection indicated by the labeled noise reduction rating (NRR) value, resulting in OSHA "discounting" the labeled NRR by an arbitrary amount. Even this approach has not proven to align field HPD performance expectations with actual experience.

One approach to address this dilemma is individual fit testing of HPD. An innovative approach to testing individual hearing protector performance was tested on more than 60 steel mill workers. A specially adapted version of the hearing protector used regularly by each subject was provided, including a specially designed and engineered sound bore. Using software driven data collection and noise generation systems, including a dual-element measurement microphone, noise was measured inside and outside the HPD while in the subject was in a pink noise sound field. The difference between the exterior and interior measurements yielded a measure of noise reduction. Additional compensation algorithms were applied by the software to equate the measured values with gold-standard real ear attenuation at threshold (REAT) values, yielding personal attenuation ratings (PAR) for each individual.

## Protocol

The system used for testing was E-A-Rfit™ (Aearo Technologies, Indianapolis, IN, www.e-a-rfit.com). It consists of:

1. A customized computer speaker with a circuit board including data acquisition firmware and pink noise generator
2. Dual-element microphone
3. Data storage and display software

E-A-Rfit uses a specially prepared earplug as a surrogate for the HPD used by the worker on a regular basis. Standard issue HPD are probed with a specially selected tube and coupling. Tubing was selected:

1. To allow free passage of acoustic signal through the tube,
2. To not interfere with normal use of the plug (rolling to appropriate size for insertion, etc.)
3. To reject noise from the free field.

The effect of the tube was carefully studied and compensated for in PAR calculations. Sample of probed HPD and measurement microphone are shown in Exhibit 1.

Subjects entered the test area (an office in the manufacturing complex) and selected the type of HPD they used regularly. They inserted the plugs as they normally would, and after allowing for expansion of the HPD as appropriate, the test commenced.

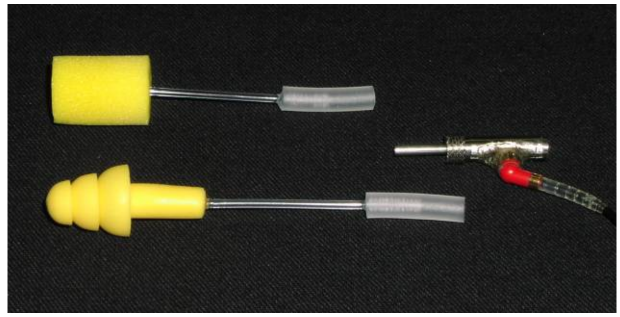

**Exhibit 1. Probed HPD and E-A-Rfit microphone**

Technicians attached the coupling of the probed HPD to the microphone tip. The microphone was held in place by a magnetic clip attached to the temple of the subject's eyewear or safety glasses (see exhibit 2). Approximately 85 dB pink noise was generated by the E-A-Rfit speaker; simultaneous noise measurements were then taken by the system in the free field (external microphone) and of the residual noise beneath the inserted HPD though the probe tube (internal microphone).

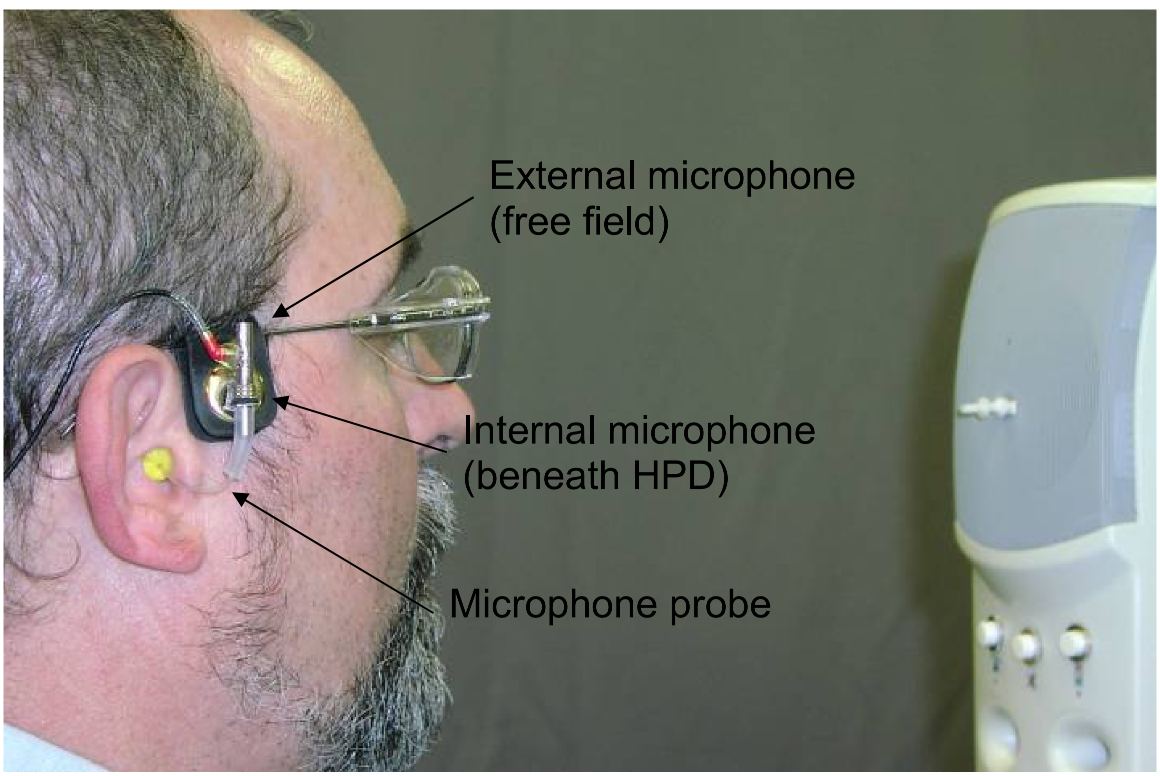


**Exhibit 2. E-A-Rfit system in use showing microphone location**

E-A-Rfit software calculated the difference between the internal and external measurements, yielding noise reduction of the HPD under test. Compensation algorithms were applied to address the impedance and resonant frequency of the occluded earcanal as well as other known constants to permit calculation of PAR, reflecting the personal attenuation rating or performance of the HPD under test as used by the individual.

Each ear was tested individually. Worst-performing octave bands for either ear were used to calculate binaural PAR. Subjects found to have insufficient PAR were to be recalled for further training, counseling and offer of different HPD much as a standard threshold shift (STS) follow-up is provided in industrial hearing conservation programs.

The products available for test were the E-A-R Classic®, an expandable polyvinyl foam earplug with an EPA noise reduction rating (NRR) of 29 dB; and the E-A-R Yellow Neon Blast®, an expandable polyurethane foam earplug NRR 33. See Exhibit 1 for examples of the prepared HPD.

No noise exposure data was available.

## Findings

Sixty-six subjects participated in the study as reflected below, with 43 subjects choosing Classic and 23 choosing Yellow Neon.

Subject PAR demonstrated bimodal distribution as reflected in Exhibit 3. Significant variability was found with both products tested; range (highest to lowest PAR) for the Classic was 26 dB PAR, and for the Yellow Neon was 24 dB PAR.

While wide variability in individual performance makes statistical analysis of individual findings questionable, general findings are summarized in Table 1.

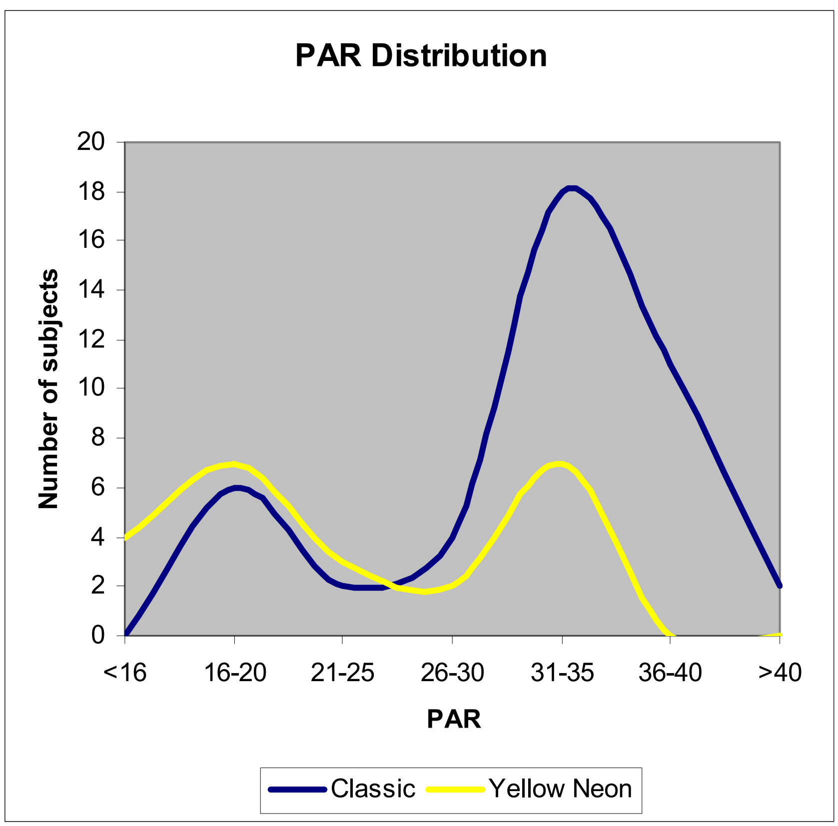


**Exhibit 3. PAR Distribution**

| *Product* | *NRR* | ***Mean PAR*** | *SD* | *Range* | *Subjects with PAR exceeding NRR* |
|---|---|---|---|---|---|
| Classic | 29 | **29.8** | 6.8 | 26 (16 dB PAR to 43 dB PAR) | 35 of 43 (81%) |
| Yellow Neon | 33 | **23.0** | 8.5 | 24 (10 dB PAR to 34 dB PAR) | 6 of 23 (26%) |

**Table 1. General findings**

OSHA, when comparing the effectiveness of HPD to application of noise control in hearing conservation, requires a 7 dB correction to address spectral uncertainty and 50% "derating" of the labeled NRR value (CPL 02-02-035 - CPL 2-2.35A - 29 CFR 1910.95(b)(1), Guidelines for Noise Enforcement; Appendix A:

http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=DIRECTIVES&p_id=1548

PAR results were compared to the "derated" OSHA value as below.

| *Product* | *NRR* | *OSHA derated Value* | *Subject Status* | *Minimum PAR* |
|---|---|---|---|---|
| Classic | 29 | 11 *(29-7)/2* | All subjects outperformed | 16 |
| Yellow Neon | 33 | 13 *(33-7)/2* | 3 subjects underperformed | 10 |

**Table 2. Comparison of Summary PAR to Derated OSHA NRR**

## Sufficiency

Without detailed exposure data, sufficiency (comparison of protection achieved with HPD to noise exposure) could not be determined for individual users. Comparison of PAR to target protected level, however, provides estimates of maximum time-weighted average (TWA) exposure allowable to achieve safe protected level for individuals. Findings demonstrate that proper use of standard HPD can provide sufficient protection even in high noise exposure levels, but that individual variability in performance overrides any statistically-based conclusion.

| *Product* | *Mean PAR* | *Standard Deviation* | *"Safe to" with Target Protected Level of 80 dB* | *84$^{th}$ Percentile (minus one standard deviation* |
|---|---|---|---|---|
| Classic | 29.8 | 6.8 | 109 dB TWA | 103 dB TWA |
| Yellow Neon | 23.0 | 8.5 | 103 dB TWA | 94 dB TWA |

**Table 3. Sufficiency to Target Protected Level of 80 dB TWA**

## Throughput

Time required for testing is an important consideration when providing individual fit testing for large numbers of noise-exposed workers. E-A-Rfit stamps each test with date and time from Windows®; Example is provided in  Exhibit 4. Elapsed time was calculated by subtracting the earliest time stamp from the latest time stamp (all data was collected on the same day). The difference was divided by the number of tests provided, yielding a per-test estimate of throughput. No account was taken for efficiency (workers late to testing, scheduling difficulties, technician or worker breaks, etc.).

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**TESTING REPORT**

**Employee Name:** [redacted]
**Test Date: 6/11/2007 8:50:12 AM**
**Company:** [redacted]

**TECHNICIAN INFORMATION**

| Last Name | First Name | Code | Software Version |
|---|---|---|---|
| [redacted] | | | 3.0.1.1 |

**EXPOSURE LEVEL**

| A-Weighted Exposure Level (dB) | C-Weighted Exposure Level (dB) |
|---|---|
| Not Available | Not Available |

This report documents a Follow Up that was Successful.

**Exhibit 4. Example Date/Time Stamp**

The earliest date stamp was 6:10 AM; the latest, 11:33 AM. Elapsed time was 323 total minutes, yielding a per-test average time of 4.9 minutes per subject.

## Conclusions

Individual fit testing was found to be viable and of value to the company. Individual assessment of HPD performance assists in determining work-relatedness of hearing loss for worker compensation claims and other applications. Identification of individual users who may benefit from additional training use of HPD or selection of alternate HPD may facilitate better protection of those workers from occupational noise exposure than unmanaged selection and use protocol.

Findings demonstrate that even single standard HPD can be sufficiently protective in relatively high noise exposure conditions for well trained and motivated workers.

“Derating” HPD attenuation values is an inappropriate approach to estimate actual protection attained by workers when individual fit testing technology is available. Individual fit testing provides a superior means of determining actual protected exposure and assessing sufficiency.

Individual fit testing of HPD was found to be useful and viable for this company.