

Hearing Protection Fit-Testing: From Industrial Plants to Battle Fields

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Abstract

Individual hearing protection devices (HPD) are often the first line of defence against noise-induced hearing losses (NIHL) in occupational and military settings. Unfortunately, the attenuation offered by HPDs in the real world greatly differs from the laboratory ratings, for many reasons now well understood, mostly boiling down to the proper fit of a given HPD by an individual wearer. To better assess this fit and predict the effective individual attenuation, Field Attenuation Estimation Systems (FAES) have been developed over the years and are now paramount to many Hearing Loss Prevention Programs (HLPP). A new standard, ASA/ANSI S12.71, has even been recently adopted by the American National Standard Institute (ANSI) to specify how the FAES measurement uncertainty should be calculated, accounting for the fact that all FAES do not rely on the same measurement paradigms nor the same hardware.

With fit-testing being recommended for almost one decade as part of the best practices (NIOSH/NHCA/OSHA Alliance, 2008) and nowadays more and more widely adopted in industrial hearing conservation, it would be now a good time to review what currently limits its adoption for military settings. Three different areas are explored hereafter: what would make *FAES technologies* suitable for battlefields, what is the notion of *protection sufficiency* in armed forces and finally what are really the *administrative measures* that are available on the battlefield.

A. FAES Technologies

- Subjective vs Objective Measurement

While psychophysical paradigms (such as hearing threshold screening, loudness balance, etc.) are widely used for FAES in civilian occupational health and safety (see list in Voix et al., 2018), their suitability for assessment on the battlefield is questionable. Objective fit-testing approaches, such as Field-MIRE (Microphone in Real-Ear), featuring one external and one internal microphone, appear to be more suitable and seem to be adopted by most commercial products. Nevertheless, several electroacoustic measurements can be made to assess the proper fit and estimate attenuation of an HPD, ranging from difference in auto-spectrum between both microphones, to transfer function assessment, to impulse response identification and possibly even involving the measurement of the transfer function between the internal miniaturized loudspeaker and the internal microphone. All these methods have inherent advantages and drawbacks in terms of processing power, hence electrical consumption, and accuracy.

- In situ vs In vivo Measurement

While objective fit-testing systems currently commercialized for industrial use can give an accurate “snapshot” of what a given individual is getting from his HPD in the field, or “*in situ*”,

these systems are usually not designed for continuous measurement of the hearing protector attenuation during the whole duration of the exposure. In the case of exposure of military personnel, the continuous monitoring of the hearing protectors attenuation is key, as a periodic refit of the hearing protectors might be required. An “*in vivo*” measurement system could trigger such refit by notifying the wearer when suboptimal performances are being measured. A further consideration might also apply to *in vivo* measurement systems: when such systems use both an external and an internal microphone, not only can they monitor the fit and estimate the attenuation of the HPD, but they can also measure directly the protected exposure level of the worker, accounting for all variability in the sound field and in the HPD’s attenuation.

- Continuous vs Impulsive Noise Measurement

While many industries may have ambient noise levels that are fluctuating, these fluctuations are nothing compared to the magnitude of the impulse noise resulting from the use of firearms and explosives. The measurement, by objective F-MIRE fit-test systems, of high peak sound pressure levels is challenging on two aspects: it requires a very large dynamic range and sufficient headroom on the external microphone data acquisition chain, and it requires a very high sampling rate to capture the true “peak” value of the incoming sound wave. Both these requirements add to the cost and power consumption of a fit-test system designed for the battlefield.

B. Protection Sufficiency: what is adequate attenuation anyway?

Assuming that the technical limitations mentioned above were addressed and that a fit-test system could be designed to continuously monitor the fit of a given HPD and estimate both the HPD attenuation and the resulting protected exposure at the wearer’s ear, in both continuous and impulsive ambient sound, a critical question would remain unanswered: “What level of attenuation is required for that particular wearer?”. The underlying question being what the exposure limit should be for military noise and what the damage risk criteria are in the battlefield. Fit-testing on the battlefield can only be beneficial if safe but realistic limits and criteria are defined to protect the soldier’s ears.

C. Administrative Measures: really?

The deployment of an objective *in vivo* fit-testing system in civilian industrial settings create some serious practical challenges to the individuals in charge of the administration of Hearing Loss Prevention Programs. For example, what to do when a given worker has reached 99% of a daily noise dose by the middle of a workshift? Fortunately, occupational health and safety regulations in most regions have already addressed that issue, at least on a theoretical basis. Simply stated, the answer is often an administrative one: the workers should be assigned to new tasks, so that the cumulated noise exposure does not exceed the permitted limit. Obviously, it is something easier to do on a factory floor than on the battlefield...

Keywords: Fit-testing, noise dose, hearing protection devices, attenuation measurement.

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