ASA/ANSI S12.71-2018

AMERICAN NATIONAL STANDARD

Performance Criteria for Systems that Estimate the Attenuation of Passive Hearing Protectors for Individual Users

Secretariat:

Acoustical Society of America

Approved on May 7, 2018:

American National Standards Institute, Inc.

Abstract

This standard pertains to systems intended to estimate the attenuation of hearing protection devices (HPDs) obtained by individual wearers in actual practice. Such systems are designated field attenuation estimation systems (FAESs). This standard provides a classification of FAESs and specifies performance criteria. It also details the evaluation methodology and statistical calculations to be performed on such systems in order to state the uncertainty associated with the individual attenuation estimates that they provide, and specifies a method for computing a personal attenuation rating (PAR). FAES-derived data do not replace the attenuation values from ANSI/ASA S12.6 or the insertion-loss data from ANSI/ASA S12.42, nor are such data suitable for labeling the attenuation of HPDs.

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ANSI/ASA S12.71-2018

Accredited Standards Committee S12, Noise

Standards Secretariat
Acoustical Society of America
1305 Walt Whitman Road, Suite 300
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Foreword

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> *Standards, specifications, and terminology in the field of acoustical noise pertaining to methods of measurement, evaluation, and control, including biological safety, tolerance, and comfort, and physical acoustics as related to environmental and occupational noise.*

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Introduction

Background

For many years a standard has existed for measuring the hearing protector attenuation achieved by groups of test subjects in a laboratory setting, the most recent embodiment of which is ANSI/ASA S12.6. Data from that method have been commonly used for rating and labeling the noise attenuation of hearing protection devices (HPDs). However, the laboratory method does not address a key question, namely, "What amount of protection can, or is, a given individual actually getting from his/her HPD?" To do so, manufacturers have developed a variety of field attenuation estimation systems (FAESs), colloquially referred to as "fit test systems," that can be used for measurements at the workplace. What has been lacking is a national standard that provides guidance on standardizing important performance aspects and data outputs from the various FAESs in order to facilitate selection of systems and application of the test results.

FAESs generally provide data in terms of a single-number personal attenuation rating (PAR). A PAR is computed for one or more fits of the HPD by an individual in a manner similar to the computation of the hearing-protector manufacturers' labeled attenuation values that are derived from laboratory test data for groups of subjects. Examples of labeled values are the Noise Reduction Rating (NRR) as required by the U.S. Environmental Protection Agency (1979) and the Noise Level Reduction Statistic for use with A-weighting (NRS_A) as specified in ANSI/ASA S12.68. Although the various FAESs have the same purpose and produce attenuation values that are presented in similar ways to one another, the underlying technology used to estimate attenuation and compute PARs can differ dramatically. It can range from psychophysical tests to objective microphone measurements, and from systems that calculate PAR in a manner analogous to the NRS_A as defined in ANSI/ASA S12.68, to others that simply indicate a pass/fail answer based on achieving a minimum required attenuation value. The various types of FAESs are described and categorized in this standard.

PARs are based on measurements at a single point in time and provide a more direct estimate of the protection that a given individual is expected to receive from her or his HPD than does average data from a group of laboratory subjects. However, PARs are still not based upon *in situ* measurements for actual wearers and the exposures they experience during their work shifts. Thus, PARs reflect what a wearer can achieve and has been shown to achieve, not necessarily what s/he truly achieves on a day-to-day basis.

Applications for FAESs and the specification of uncertainty

FAESs may be used to train the employee to better fit her or his HPD and also to train the trainer in that process. However, users may also wish to apply FAES results together with an organization's noise-exposure policies to estimate whether a worker is obtaining adequate protection from existing HPDs, or to assign HPDs based upon noise exposures. Though some FAESs currently exist that can estimate the attenuation provided by earmuffs, the usual focus of FAESs is the measurement of earplug performance. This is not only because correct fit and insertion of most earplugs requires more skill and is more variable than for earmuffs, and therefore more in need of assessment, but also because for most FAESs, personal attenuation can be more readily estimated for earplugs than for earmuffs. Earplug assessments can be accomplished, for example, by using a circumaurally mounted transducer to present a test signal, which of course is not possible when earmuffs are to be tested.

Properly estimating noise attenuation also requires an assessment of uncertainty. Measurement uncertainty may differ between the various systems. For the end user to most accurately apply FAES data an explicit statement of uncertainty should be provided. Good measurement practice (where a measurement is understood to consist of the measurement itself, its margin of error, and the confidence level—that is, the probability that the measurand is within the margin of error) dictates the provision of such

uncertainty estimates. Uncertainty values also facilitate a comparison of the precision and accuracy of differing FAESs.

Sources of uncertainty

Three presumed-independent principal sources of uncertainty are considered in the computation of PAR from measured FAES data (Berger et al., 2011).

- Measurement uncertainty, sometimes called prediction uncertainty, pertains to the difference between the FAES prediction of attenuation and the value that would be measured for the same fit of the HPD by an accepted "gold standard," such as real-ear attenuation at threshold (REAT) per ANSI/ASA S12.6. Since REAT values contain their own uncertainty, a correction to the computation is included to account for this.

- Fit uncertainty pertains to the variability in the fit of the HPD from one application to the next. It is substantially affected by the experimenter or user's skill, depending on whether experimenter or user fit is being assessed, and also by the fitting characteristics of the HPD that is being evaluated.

- Spectral uncertainty arises from using a PAR designed for subtraction from A-weighted sound level measurements in noises with different spectral content. There will be a variation between the protection predicted when using an octave-band calculation versus that achieved with a single-number approach (see ANSI/ASA S12.68).

Clause 8 specifies the method of computation of the three principal sources of uncertainty and how to integrate that into the calculation of PAR. For systems that employ a surrogate HPD, an additional source of potential error may be introduced by the use of a surrogate. This is addressed in Clause 10.

Features distinguishing FAESs and comparison to the standardized REAT procedure

This standard describes and categorizes the types of FAESs in Clause 4. Regardless of type, a key performance metric will be comparison of attenuation data estimated via the FAES to the REAT values resulting from ANSI/ASA S12.6. The FAES results may differ from REAT. This is to be assessed and reported in an uncertainty statement. Four additional issues that impact the various types of systems are listed below.

- The ambient noise in the test environment must be low enough to avoid masking psychophysical test signals or contaminating the results from objective systems.

- For systems employing a surrogate HPD, the fitting and usability of the modified HPD must be considered in order to limit its effect on the wearer's ability to fit the surrogate, as compared to the unmodified HPD.

- For systems requiring a psychophysical response, the hearing ability of those being tested must be sufficient to assure that they can hear the signals after attenuation by the HPD under test.

- The rapidity with which the test can be accomplished is also a factor to be considered since this will affect practical application of the FAES and also the ability to address and potentially ameliorate the problem of fit uncertainty by taking repeat measurements on repeated fits. Objective systems may provide more rapid data acquisition.

Application of FAES results – computation of PAR and pass/fail ratings

Though many FAESs can provide measurement results at one or more frequencies, the preferred output for most end users is a single-number rating, termed in this standard a PAR. The intention is to allow an

end user to take measurements and quickly make recommendations for individual wearers. Since employee exposure data are generally only available as A-weighted values, a single-number output is practical. However, for FAESs that also report personal attenuation data at individual octave-band frequencies, such values may be useful in an octave-band calculation to estimate wearer's protected noise exposure, especially for atypical or steeply sloping spectra.

Numerous single-number ratings have been devised, and indeed the various FAESs have heretofore computed their own single numbers with differing approaches. This standard provides a specified computational method analogous to the NRS_A per ANSI/ASA S12.68 to allow PARs to be compared across systems that do provide attenuation estimates.

For those systems that do not provide a PAR, but rather a pass/fail indication for use in a specified noise environment, this standard specifies a suitable statistic that shall be reported to provide guidance on the uncertainty associated with the pass/fail determination.

American National Standard

Performance Criteria for Systems that Estimate the Attenuation of Passive Hearing Protectors for Individual Users

1 Scope

This standard specifies methods of characterizing the performance of systems that estimate the real-ear attenuation provided by hearing protection devices (HPDs) on individual wearers. These systems are designated by this standard as field attenuation estimation systems (FAESs). The quality of the estimates is assessed by comparison of FAES data to those from the standard laboratory real-ear attenuation at threshold (REAT) procedure (ANSI/ASA S12.6) for the same fit of the device on an identical group of test subjects. This standard defines ways to quantify and state uncertainty (see JCGM 100:2008) for FAESs so that measurements can be compared among systems and to the standardized REAT procedure.

The criteria in this standard are intended to provide guidance to manufacturers of FAESs in the development of systems and the specification of their performance in a prescribed manner. A further goal is to assure that FAESs provide data that are both useful for estimates of the attenuation obtained by individual wearers and are comparable between systems. This standard does not apply to systems that measure a physical quantity that cannot be linked to an attenuation value.

This standard also specifies the procedures for computation of a personal attenuation rating (PAR) that provides a simple easy-to-apply single number that may be used together with A-weighted sound level measurements for hearing protector assignment.

FAES-derived data do not replace the attenuation data from ANSI/ASA S12.6 or the insertion-loss data from ANSI/ASA S12.42, nor are such data suitable for hearing-protector labeling purposes. FAESs that comply with this standard are not suitable to estimate attenuation for electronic hearing protectors in their active mode, nor for passive amplitude-sensitive HPDs for sound pressure levels above the point at which their level-dependent characteristics become effective. However, PARs may be used to estimate attenuation for passive and non-level-dependent HPDs for impulsive noises up to at least 170 dB peak sound pressure level.

2 Normative references

The following referenced documents are indispensable for the application of this standard. For dated references, only the edition cited applies. For undated references, the latest edition of the reference document (including any amendments) applies.

ANSI/ASA S1.1, *American National Standard Acoustical Terminology.*

ANSI/ASA S1.4/Part 1/IEC 61672-1, *American National Standard Electroacoustics – Sound Level Meters – Part 1: Specifications (a nationally adopted international standard)*.

ANSI/ASA S3.1, *American National Standard Maximum Permissible Ambient Noise Levels for Audiometric Test Rooms.*

ANSI/ASA S3.6, *American National Standard Specification for Audiometers.*