ANSI/ASA S3.44-2016/Part 1 / ISO 1999:2013 (MOD)
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AMERICAN NATIONAL STANDARD

Acoustics – Estimation of Noise-induced Hearing Loss – Part 1: Method for Calculating Expected Noise-induced Permanent Threshold Shift (a modified nationally adopted international standard)

ANSI/ASA S3.44-2016/Part 1 / ISO 1999 :2013 (MOD)

Accredited Standards Committee S3, Bioacoustics

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ANSI/ASA S3.44-2016/Part 1 / ISO 1999:2013 (MOD)
(Revision of ANSI S3.44-1996)

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Secretariat:

Acoustical Society of America

Approved on March 4, 2016 by:

American National Standards Institute, Inc.

Abstract
ANSI/ASA S3.44-2016/Part 1/ISO 1999:2013 (MOD) specifies a method for calculating the expected noise-induced permanent threshold shift in the hearing threshold levels of adult populations due to various levels and durations of noise exposure; it provides the basis for calculating hearing disability according to various formulae when the hearing threshold levels at commonly measured audiometric frequencies, or combinations of such frequencies, exceed a certain value. This modified standard allows an equivalent effective level (EEL), with a different exchange rate, to be substituted for $L_{EX,8h}$.

The measure of exposure to noise for a population at risk is the noise exposure level normalized to a nominal 8 h working day, $L_{EX,8h}$, for a given number of years of exposure. ANSI/ASA S3.44-2016/Part 1/ISO 1999:2013 (MOD) applies to noise at frequencies less than approximately 10 kHz which is steady, intermittent, fluctuating, or irregular. Use of ANSI/ASA S3.44-2016/ISO 1999:2013 (MOD) for sound pressures exceeding 200 Pa (140 dB relative to 20 μPa) is recognized as extrapolation.

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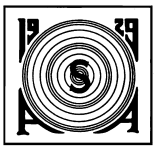

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Foreword

[*This Foreword is for information only and is not a part of the American National Standard* ANSI/ASA S3.44-2016 / ISO 1999:2013 (MOD) American National Standard Acoustics – Estimation of Noise-induced Hearing Loss – Part 1: Method for Calculating Expected Noise-induced Permanent Threshold Shift. *As such, this Foreword may contain material that has not been subjected to public review or a consensus process. In addition, it does not contain requirements necessary for conformance to the standard.*]

This standard comprises a part of a group of definitions, standards, and specifications for use in bioacoustics. It was developed and approved by Accredited Standards Committee S3 Bioacoustics, under its approved operating procedures. Those procedures have been accredited by the American National Standards Institute (ANSI). The Scope of Accredited Standards Committee S3 is as follows:

> *Standards, specifications, methods of measurement and test, and terminology in the fields of psychological and physiological acoustics, including aspects of general acoustics which pertain to biological safety, tolerance and comfort.*

This standard is the modified national adoption of ISO 1999:2013 *Acoustics – Estimation of noise-induced hearing loss*, which was prepared by ISO/TC 43. The adoption of this standard revises and replaces ANSI S3.44-1996 (R 2006) *American National Standard Determination of Occupational Noise Exposure and Estimation of Noise-Induced Hearing Impairment*. The 8-h equivalent continuous A-weighted sound pressure level ($L_{EX,8h}$) is used throughout this standard, for example, to calculate the median noise-induced permanent threshold shift (NIPTS). However, the NIPTS values were derived from databases in which the daily occupational exposure was from a generally constant level for an 8-h working day; these data are of no value in estimating the hazard of noises that vary in level and in exposure time. For these intermittent and fluctuating noises, the equation defining $L_{EX,8h}$ implies a 3-dB increase in allowed exposure level when exposure time is halved. This trading ratio is called a 3-dB exchange rate. In contrast, the current regulation of the Occupational Safety and Health Administration requires a 5-dB exchange rate. There is controversy in the literature regarding the most accurate exchange rate for predicting NIPTS. Accordingly, this standard allows an equivalent effective level (EEL), with a different exchange rate, to be substituted for $L_{EX,8h}$. It is the responsibility of the user to define EEL and to justify its use. An informative annex (Annex E) has been added to assist the reader with applying a different exchange rate.

The normative portions of this standard are identical to that of ISO 1999:2013. In the informative annexes, errors were found in Tables A.3 and B.2 and equation C.10. These are noted as errata and should be changed in the next version of ISO 1999. The title is modified slightly to reflect the plan to develop an American National Standard as Part 2, under the title *American National Standard Acoustics – Estimation of Noise-Induced Hearing Loss – Part 2: Application of Correction(s) to Account for Age.* This Part 2 will not have an ISO counterpart. Also, in conformance with ANSI and ISO rules, the words "American National Standard" replace the words "International Standard" where they appear in the ISO document, decimal points were substituted in place of the decimal commas used in ISO documents, and American English spelling is used in place of British English spelling. All other additions and modifications are shown in a **bold blue font within a blue box** and are identified as U.S. Modifications.

At the time this Standard was submitted to Accredited Standards Committee S3, Bioacoustics for approval, the membership was as follows:

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P.B. Nelson, *Vice-Chair*

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Working Group S3/WG 58, Hearing Conservation Criteria, which assisted Accredited Standards Committee S3, Bioacoustics, in the development of this standard, had the following membership.

W.J. Murphy, Chair

R.A. Dobie	T.R. Letowski	C.L. Themann
H.J. Hoffman	P.B. Nelson	L.A. Wilber
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Suggestions for improvements of this standard will be welcomed. They should be sent to Accredited Standards Committee S3, Bioacoustics, in care of the Standards Secretariat of the Acoustical Society of America, 1305 Walt Whitman Road, Suite 300, Melville, New York 11747. Telephone: 631-390-0215; FAX: 631-923-2875; E-mail: asastds@acousticalsociety.org.

Introduction

This American National Standard presents, in statistical terms, the relationship between noise exposures and the "noise-induced permanent threshold shift" (NIPTS) in people of various ages. It provides procedures for estimating the hearing loss due to noise exposure of populations free from auditory impairment other than that due to noise (with allowance for the effects of age) or of unscreened populations whose hearing capability has been measured or estimated. NIPTS is treated here as an additive term independent of other components of hearing threshold levels. For any given noise exposure, it has a range of positive values representing the variability of noise-damage susceptibility between individuals of a population.

Persons regularly exposed to noise can develop hearing loss of varying severity. Due to this hearing loss, their understanding of speech, perception of everyday acoustic signals, or appreciation of music may be impaired. With the exception of exposure to blast, high-impulse noise and extremely high levels of steady noise, permanent impairment of the hearing organ takes time and is progressive over months, years, or decades of exposure. NIPTS is usually preceded by a reversible temporary effect on hearing called noise-induced "temporary threshold shift" (TTS). The severity of TTS and recovery from it depend upon exposure level and duration. For a single individual, it is not possible to determine precisely which changes in hearing threshold level are caused by noise and which changes are caused by other factors, although, in doubtful individual cases, the data in this American National Standard might provide an additional means for estimating the most probable causes in audiological diagnosis. However, for a large population exposed to a specific noise, changes in the statistical distributions of hearing threshold levels can be determined. Parameters, such as the mean NIPTS and the median NIPTS, can be used to describe differences in hearing threshold levels between two populations that are similar in all relevant respects except that one population has had a well-defined (usually occupational) noise exposure. Throughout this American National Standard, the term NIPTS is applied to changes in the noise-induced permanent threshold shift of statistical distributions of groups of people; it is not to be applied to individuals.

This American National Standard can be applied to the calculation of the risk of sustaining hearing loss due to regular occupational noise exposure or due to any daily repeated noise exposure. In some countries, hearing loss caused by occupational noise exposure can have legal consequences with respect to responsibility and compensation. The hearing threshold level at the various frequencies, at which a hearing impairment is deemed to exist (fence), depends not only on the hearing loss per se, but frequently on legal definitions and interpretations based on social and economic considerations. In addition, the definition of a hearing impairment depends on the quality of speech recognition desired, the average level of background noise, and with respect to the relative importance of the various frequencies, perhaps even on the language. Consequently, this American National Standard does not stipulate (in contrast to the first edition of ISO 1999) a specific formula for assessment of the risk of impairment, but specifies uniform methods for the prediction of hearing loss, which can be used for the assessment of impairment according to the formula desired or stipulated in a specific country. The results obtained by this American National Standard may also be used for estimating the permanent effects of noise on the perception of everyday acoustic signals, the appreciation of music, or the effect of one specific frequency not necessarily stipulated by a hearing impairment formula.

Since noise-induced hearing loss is the result not only of occupational noise exposure but also of the total noise exposure of the population, it may be important to take the non-occupational exposure of individuals (during commuting to and from their jobs, at home, and during recreational activities) into account. Only if this non-occupational exposure is negligible compared with the occupational exposure does this American National Standard allow prediction of the occurrence of hearing loss due to occupational noise exposure. Otherwise, it should be used to calculate the hearing loss to be expected from the combined (occupational plus non-occupational) total daily noise exposure. The contribution of the occupational noise exposure to the total hearing loss can then be estimated, if desired.

The selection of maximum tolerable or maximum permissible noise exposures and protection requirements, as well as the selection of specific formulae for impairment risk assessment or compensation purposes, require

consideration of ethical, social, economic, and political factors not amenable to international standardization. Individual countries differ in their interpretation of these factors and these factors are therefore considered outside the scope of this American National Standard.

For reasons given above, this American National Standard, by itself, does not comprise a complete guide for risk assessment and protection requirements, and for practical use, it has to be complemented by national standards or codes of practice delineating the factors which are here left open.

American National Standard

Acoustics — Estimation of Noise-Induced Hearing Loss – Part 1: Method for Calculating Expected Noise-Induced Permanent Threshold Shift (a modified nationally adopted international standard)

1 Scope

This American National Standard specifies a method for calculating the expected noise-induced permanent threshold shift in the hearing threshold levels of adult populations due to various levels and durations of noise exposure; it provides the basis for calculating hearing disability according to various formulae when the hearing threshold levels at commonly measured audiometric frequencies, or combinations of such frequencies, exceed a certain value.

NOTE 1 This American National Standard does not specify frequencies, frequency combinations, or weighted combinations to be used for the evaluation of hearing disability; nor does it specify a hearing threshold level (fence) which it is necessary to exceed for hearing disability to exist. Quantitative selection of these parameters is left to the user. All sound pressure levels stated in this American National Standard do not consider the effect of hearing protectors which would reduce effective exposure levels and modify the spectrum at the ear.

U.S. MODIFICATION: The prediction method presented is based primarily on data collected with essentially broadband steady non-tonal noise. The application of the data base to tonal or impulsive/impact noise represents the best available extrapolation. However, some users may wish to consider tonal noise and/or impulsive/impact noise about as harmful as a steady non-tonal noise that is approximately 5 dB higher in level. With tonal exposures, the pattern of hearing loss can differ so that the maximum NIPTS might not occur in the same spectral region as for broadband noise exposure.

The measure of exposure to noise for a population at risk is the noise exposure level normalized to a nominal 8 h working day, $L_{EX,8h}$, for a given number of years of exposure. This American National Standard applies to noise at frequencies less than approximately 10 kHz which is steady, intermittent, fluctuating, irregular. Use of this American National Standard for sound pressures exceeding 200 Pa (140 dB relative to 20 µPa) is recognized as extrapolation.

Formulae are presented to calculate the hearing loss, including statistical distribution, at a range of audiometric frequencies due to exposure to noise as a function of level of noise exposure and duration of exposure (in years). The formulae do not distinguish between male and female populations.

NOTE 2 Although the models of hearing loss are based on data assumed to stem primarily from populations exposed to occupational noise, they may be used, with some caution, for estimating the effects of comparable non-occupational and combined exposures.

NOTE 3 The prediction method presented is based primarily on data collected with essentially broadband, steady, non-tonal noise.

To calculate hearing threshold levels and the risk of acquiring hearing loss due to noise exposure, it is necessary to make use of a comparable population. This American National Standard contains a definition of a highly screened otologically normal population (in accordance with ISO 7029) and three examples of unscreened populations of three typical industrialized societies. The users of this American National Standard may choose a comparable population according to their particular requirements.