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AMERICAN NATIONAL STANDARD

DETERMINATION OF OCCUPATIONAL NOISE EXPOSURE AND ESTIMATION OF NOISE-INDUCED HEARING IMPAIRMENT

ANSI S3.44-1996

Accredited Standards Committee S3, Bioacoustics

Standards Secretariat
Acoustical Society of America
120 Wall Street, 32nd Floor
New York, New York 10005-3993

The American National Standards Institute, Inc. (ANSI) is the national coordinator of voluntary standards development and the clearing house in the U.S. for information on national and international standards.

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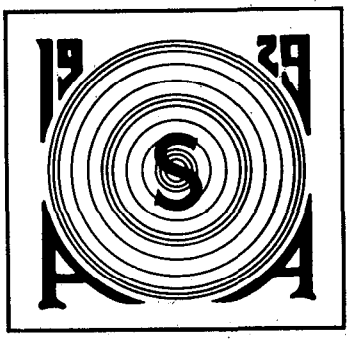

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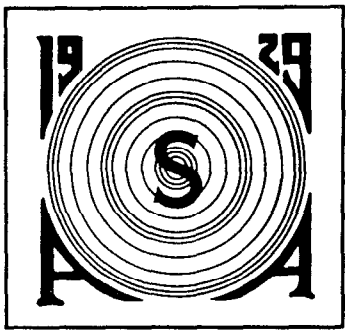

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Foreword

[This Foreword is for information only and is not an integral part of the *American National Standard Determination of Occupational Noise Exposure and Estimation of Noise-Induced Hearing Impairment, ANSI S3 44-1996*.]

This standard is an adaptation of the international standard ISO 1999:1990(E), which was prepared by Technical Committee ISO/TC 43, Acoustics, as a technical revision of the first edition (ISO 1999:1975)

This adaptation as an American National Standard was prepared by S3/WG58. Unlike the international standard, this standard allows assessment of noise exposure using a time/intensity trading relation other than a 3-decibel increase per halving of exposure time. Annexes A to G are for information only.

Annex A gives the procedure for calculating the age-related hearing threshold levels for an otologically normal population (highly screened) in accordance with ISO 7029

Annex B gives one example of the age-related threshold levels for an unscreened population of a typical industrialized society

Annex C gives another example of a data base screened to exclude only industrial noise exposure and separated not only by age and gender, but also by race (white and black).

Annex D gives an example of selected values of the hearing threshold levels of a specific unscreened population, which, when used with the procedures of the standard, results in approximately the same risk of hearing handicap as that predicted by the first edition of the international standard, ISO 1999:1975.

Annex E describes an example of hearing risk assessment using this standard

Annex F presents tables with examples of NIPTS as a function of exposure time (10, 20, 30, and 40 years) and daily A-weighted sound exposure (3.64×10^3, 1.15×10^4, 3.64×10^4, and 1.15×10^5 Pa^2 s), or equivalent continuous A-weighted sound pressure levels of 85, 90, 95, and 100 dB for a nominal 8 h working day for six frequencies (0.5, 1, 2, 3, 4, and 6 kHz) and three fractiles (0 1, 0.5, and 0.9). A table for NIPTS averaged across the frequencies 0.5, 1, 2, 3 kHz is also provided.

Annex G consists of a bibliography

This standard was developed under the jurisdiction of Accredited Standards Committee S3, Bioacoustics, which has the following scope:

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

At the time this standard was submitted to Accredited Standards Committee S3, Bioacoustics, for final approval, the membership consisted of:

T Frank, *Chair*
R. F. Burkard, *Vice Chair*
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U. S. Army Audiology and Speech Center	R Danielson, Ph D
U. S. Army Human Engineering Laboratory (USHEL)	G Garinther
	G R Price (*Alt*)
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	L Marshall (*Alt*)

Individual experts of the Accredited Standards Committee S3, Bioacoustics, were:

J. R Bareham
S J Barry
R W Benson
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R. L McKinley
J D Royster
H E von Gierke
D E. Wasserman
L. A Wilber
W. A Yost
R W. Young

Working Group S3/WG58, Hearing Conservation Criteria, which assisted Accredited Standards Committee S3, Bioacoustics, in the preparation of this standard, had the following membership:

Daniel L. Johnson, Chair

William Melnick Julia D. Royster Larry H. Royster

When preparation of this standard was begun, **Juergen Tonndorf** (now deceased) was working group chair His efforts were carried forward and are acknowledged by the publication of this standard.

Suggestions for improvements will be welcomed. They should be sent to the Accredited Standards Committee S3, Bioacoustics, at the Standards Secretariat in care of the Acoustical Society of America, 120 Wall Street, 32nd floor, New York, New York 10005-3993, USA. Telephone: (212) 248-0373; FAX: (212) 248-0146.-

AMERICAN NATIONAL STANDARD

Determination of Occupational Noise Exposure and Estimation of Noise-Induced Hearing Impairment

Secretariat
Acoustical Society of America

Approved 8 February 1996
American National Standards Institute, Inc.

ABSTRACT

The standard is an adaptation of the international standard ISO 1999:1990(E) of the same name. Unlike the international standard, this standard allows assessment of noise exposure using a time/intensity trading relation other than a 3-decibel increase per halving of exposure time. This standard presents, in statistical terms, the relationship between noise exposures and changes in hearing threshold levels for a noise-exposed population. This standard can also be applied to the calculation of the risk of incurring hearing handicap from sustained daily exposure to noise. Guidance is provided as to the measurement of noise exposure.

AMERICAN NATIONAL STANDARDS ON ACOUSTICS

The Acoustical Society of America (ASA) provides the Secretariat for Accredited Standards Committees S1 on Acoustics, S2 on Mechanical Vibration and Shock, S3 on Bioacoustics, and S12 on Noise These Committees have wide representation from the technical community (manufacturers, consumers, and general-interest representatives) The Standards are published by the Acoustical Society of America through the American Institute of Physics as American National Standards after approval by their respective Standards Committees and the American National Standards Institute

These Standards are developed and published as a public service to provide Standards useful to the public, industry, and consumers, and to Federal, State, and local governments.

Each of the accredited Standards Committees [operating in accordance with procedures approved by American National Standards Institute (ANSI)] is responsible for developing, voting upon, and maintaining or revising its own Standards. The ASA Standards Secretariat administers Committee organization and activity and provides liaison between the Accredited Standards Committees and ANSI After the Standards have been produced and adopted by the Accredited Standards Committees, and approved as American National Standards by ANSI, the ASA Standards Secretariat arranges for their publication and distribution

An American National Standard implies a consensus of those substantially concerned with its scope and provisions. Consensus is established when, in the judgment of the ANSI Board of Standards Review, substantial agreement has been reached by directly and materially affected interests. Substantial agreement means much more than a simple majority, but not necessarily unanimity Consensus requires that all views and objections be considered and that a concerted effort be made towards their resolution

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American National Standard

Determination of Occupational Noise Exposure and Estimation of Noise-Induced Hearing Impairment

0 Introduction

This Standard presents, in statistical terms, the relationship between noise exposures and the resulting "noise-induced permanent threshold shift" (NIPTS) in hearing. It provides procedures for estimating the hearing impairment due to noise exposure in screened populations free from auditory impairment other than that due to noise (with allowance for the effects of age) or in unscreened populations whose hearing capability has been measured or estimated at various ages. NIPTS is treated here as an additive term independent of other components of hearing threshold levels. It is zero in the absence of noise exposure, and, for any given noise exposure, it has a range of positive values representing the variability in noise-damage susceptibility among 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 acoustical signals, or appreciation of music may be impaired. With the exception of exposure to blast, high-impulse noise, and very high levels of steady noise, permanent impairment of the hearing organ takes time and is progressive over months, years, and 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 frequency, exposure level, and time, as well as individual susceptibility.

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. In doubtful individual cases, the data in this standard might provide an additional means for estimating the most probable causes in audiological diagnosis. In contrast, 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, the median NIPTS, etc., 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 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 except as indicated above.

The model of the development and progression of NIPTS in this standard is based on the data and methods of Passchier–Vermeer (see [G11] to [G13] and [G17]) and those of Robinson (see [G2] and [G14]), as combined by Johnson (see [G5] and [G6]). The data of Baughn (see [G1]), which were considered as part of the basis for the first edition (ISO 1999:1975), were omitted in the development of this standard.

This standard can be applied to the calculation of the risk of sustaining hearing handicap due to regular occupational noise exposure or due to any daily repeated noise exposure. In some jurisdictions hearing handicap caused by occupational noise exposure can have legal consequences with respect to responsibility and compensation. The hearing threshold level for some combinations of audiometric frequencies at which a hearing handicap is deemed to begin, the "low fence," depends not only on the impairment *per se*, but frequently on legal definitions and interpretations based on social and economic considerations. In addition, the definition of a hearing handicap depends on the degree of speech intelligibility desired, the average level of background noise and, with respect to the relative importance of the various audiometric frequencies, perhaps even on the language spoken. Consequently, this standard does not stipulate a specific formula for assessment of the risk of hearing handicap, but specifies uniform methods for the prediction of hearing impairment, which can be used for the assessment of handicap according to the formula desired or stipulated in a specific jurisdiction. The results obtained by this standard may also be used for estimating the permanent effects of noise on the perception of everyday acoustical signals, the appreciation of music, or the effect on one specific frequency not necessarily stipulated by a hearing handicap formula, to the degree these depend on threshold.

Since noise-induced hearing impairment is the re-

sult of not only occupational noise exposure but also the total noise exposure of the population, it may be important to take into account the non-occupational exposure of individuals (during commuting to and from their jobs, at home, and during recreational activities). Only if this non-occupational exposure is negligible compared with the occupational exposure does this standard allow prediction of the occurrence of hearing impairment due to occupational noise exposure. Otherwise, this standard should be used to calculate the hearing impairment 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 impairment can then be estimated, if desired, by comparison with an appropriate reference population which exhibits comparable non-occupational noise exposure but without occupational noise exposure.

The selection of maximum tolerable or maximum permissible noise exposures, appropriate hearing conservation requirements, and specific formulas for handicap risk assessment or compensation purposes, requires consideration of ethical, social, economic, and political factors not amenable to standardization. Individual governmental and state agencies often differ in their interpretation of these factors which therefore are considered outside the scope of this standard. For the preceding reasons, this standard by itself does not comprise a complete guide for risk assessment and protection requirements and, for practical use, has to be complemented by regulations or codes of practice delineating the factors which are left open.

1 Scope, purpose, and applications

1.1 Scope

Based on the International Standard (ISO 1999:1990(E)), this standard specifies a method for calculating the expected noise-induced permanent threshold shift (NIPTS) in the hearing threshold levels of adult populations due to various levels and durations of noise exposure, as well as the total hearing levels resulting from NIPTS in combination with aging and other causes of hearing impairment. It provides the basis for calculating predicted hearing handicap according to various formulas when the hearing threshold levels at commonly measured audiometric frequencies, or combinations of such frequencies, exceed a certain value.

For the assessment of hearing impairment due to exposure to noise, formulas are presented to calculate the NIPTS for audiometric frequencies from 0.5 to 6 kHz for daily 8-h A-weighted sound exposure of 364 Pa^2 s to 1.15×10^5 Pa^2 s (equivalent continuous A-weighted sound pressure level for a normal 8-h working day from 75 to 100 dB or an equivalent effective level), and periods of exposure lasting from 0 to 40 years. Extrapolations to higher levels are not supported by quantitative data. The median values of NIPTS as well as the statistical distribution above and below the median value from the 0.05 to the 0.95 fractile are specified. The NIPTS predictions are the same for male and female populations.

NOTE 1—This standard does not specify frequencies, frequency combinations, or weighted combinations to be used for the evaluation of hearing handicap; nor does it specify a hearing threshold level ("low fence") which must be exceeded for hearing handicap to exist. Quantitative selection of these parameters is left to the user. However, because the American Academy of Otolaryngology-Head and Neck Surgery (AAO-HNS) recommends a handicap formula based on the average HTL of 0 5, 1, 2, and 3 kHz, a table of NIPTS for this frequency combination is included as part of Annex F.

NOTE 2—Although the NIPTS data are based on data assumed to stem from primarily occupationally noise-exposed populations, they may be used, with some caution, for estimating the effects of comparable non-occupational and combined exposures. The duration of total daily noise exposure should be stated.

To calculate predicted hearing threshold levels and the risk of acquiring hearing impairment or handicap due to noise exposure, the threshold of hearing of a non-noise-exposed population of comparable age has to be known. Since different criteria can be applied to the selection of this population, the standard allows for two possibilities illustrated by different data bases:

(a) an otologically normal population; that is, a highly screened data base (see ISO 7029), or

(b) any other population data base selected by the user of the standard as being appropriate.

The standard is based on statistical data and therefore shall not be used to predict or assess the hearing impairment or hearing handicap of individual persons except in terms of statistical probabilities.

1.2 Purpose

This standard provides procedures for estimating the hearing impairment due to noise exposure in a)