

April 22, 2002

Reaffirmed by ANSI
May 18, 2007

Reaffirmed by ANSI
June 18, 2012

ANSI S3.5-1997
Revision of
ANSI S3.5-1969 (R 1986)

Reaffirmed by ANSI
July 12, 2017

Reaffirmed June 5, 2020

American National Standard
**Methods for Calculation
of the Speech Intelligibility Index**

Secretariat
Acoustical Society of America

Approved 6 June 1997
American National Standards Institute, Inc.

Abstract

This Standard defines a method for computing a physical measure that is highly correlated with the intelligibility of speech as evaluated by speech perception tests given a group of talkers and listeners. This measure is called the Speech Intelligibility Index, or SII. The SII is calculated from acoustical measurements of speech and noise. This standard is **not** a substitute for ANSI S3.2-1989 (R 1995) *American National Standard Method for Measuring the Intelligibility of Speech over Communication Systems*.

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.

The use of American National Standards is completely voluntary. Their existence does not in any respect preclude anyone, whether he or she has approved the standards or not, from manufacturing, marketing, purchasing, or using products, processes, or procedures not conforming to the standards.

NOTICE: This American National Standard may be revised or withdrawn at any time. The procedures of the American National Standards Institute require that action be taken periodically to reaffirm, revise, or withdraw this Standard.



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

Telephone: +1 212 248 0373
Telefax: +1 212 248 0146
E-mail: asastds@aip.org

© 1998 by the Acoustical Society of America. This Standard may not be reproduced in whole or in part in any form for sale, promotion, or any commercial purpose, or any purpose not falling within the provisions of the Copyright Act of 1976, without prior written permission of the publisher. For permission, address a request to the Standards Secretariat of the Acoustical Society of America.

Contents

	Page
Foreword	ii
1 Scope, purpose, and applications	1
2 References	1
3 Definitions	2
4 Methods for calculating Speech Intelligibility Index, SII	9
5 Methods for determining input variables for SII calculation procedures	11
6 General relation between the intelligibility of received speech and the Speech Intelligibility Index	16
Annexes	
A SII for individuals with hearing loss	17
B Transferring SII to speech intelligibility	17
C Examples of SII computations	21
Tables	
1 Critical band SII procedure—frequencies, band importance function, standard speech spectra, internal noise, hearing threshold levels, and free-field to eardrum transfer function	3
2 Equally-contributing (17 band) critical-band SII procedure	4
3 One-third octave band SII procedure	5
4 Octave band SII procedure	5
B.1 Critical band importance functions for various speech tests	18
B.2 One-third octave band importance functions for various speech tests	19
B.3 Octave band importance functions for various speech tests	19
C.1 Worksheet for octave band SII calculation example	21
C.2 Worksheet for one-third octave band SII calculation example	22

Foreword

[This Foreword is for information only and is not an integral part of ANSI S3.5-1997 *American National Standard Methods for Calculation of the Speech Intelligibility Index*.]

This Standard defines a method for computing a physical measure that is highly correlated with the intelligibility of speech under a variety of adverse listening conditions, such as noise, filtering, and reverberation. It is a major revision of ANSI S3.5-1969 (R 1986), *American National Standard Methods for the Calculation of the Articulation Index*. The most important changes in the present version of the Standard relate to the need to provide a general framework into which various methods for determining the input variables of the Speech Intelligibility Index model (e.g., the equivalent speech spectrum level, the equivalent noise spectrum level, and the equivalent hearing threshold level) can be incorporated. For some applications these methods already exist (e.g., the modulation transfer function for determining the apparent speech-to-noise ratio in reverberation), while others still may be developed in future revisions of this Standard. In addition, the generality of the Standard has been extended to include various measurement points (e.g., free-field for architectural acoustics or eardrum for telephony). The other changes of the Standard are due to new data which have been accumulated since 1969 for various parameters and procedures used in the calculations. These new data include spread of masking, standard speech spectrum level, and relative importance of various frequencies to speech intelligibility. Finally, the name has been changed from the Articulation Index to the Speech Intelligibility Index (SII). In this Standard, *speech intelligibility* refers to how well an individual understands speech.

It should be noted that SII should **not** be used as a substitute for determining speech intelligibility as described in ANSI S3.2-1989 (R 1995), *American National Standard Method for Measuring the Intelligibility of Speech over Communication Systems*.

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 was as follows:

T. Frank, *Chair*
R.F. Burkard, *Vice Chair*
A. Brenig, *Secretary*

Acoustical Society of America	T. Frank
	R.F. Burkard (<i>Alt.</i>)
American Academy of Otolaryngology	G.A. Gates
Head and Neck Surgery, Inc.	L.A. Michael (<i>Alt.</i>)
American Industrial Hygiene Association	L.H. Royster
	J.F. Meagher (<i>Alt.</i>)

American College of Occupational Medicine	P.J. Brownson J. Sataloff (<i>Alt.</i>)
American Otological Society, Inc.	R.F. Naunton
American Speech-Hearing-Language Association	J.D. Royster M.E. Thompson (<i>Alt.</i>)
AT&T	R.M. Sachs M.S. Mayer (<i>Alt.</i>)
Audio Engineering Society	R.H. Campbell M.R. Chial (<i>Alt.</i>)
Hearing Industries Association (HIA)	S. Armstrong C. Rogin (<i>Alt.</i>)
Industrial Safety Equipment Association (ISEA)	D.K. Shipp
Industrial Hearing Society	P. Mercola
National Institute of Standards and Technology	E.D. Burnett V. Nedzelnitsky (<i>Alt.</i>)
Power Tool Institute, Inc.	G. Resigno M. Brown (<i>Alt.</i>)
U.S. Air Force	R. McKinley
U.S. Army Aeromedical Research Laboratory	B. Mozo
U.S. Army Human Engineering Laboratory	G. Garinther G.R. Price (<i>Alt.</i>)
U.S. Army Walter Reed Army Medical Center Audiology and Speech Center	R.W. Danielson
U.S. Navy Environmental Health Center	J. Page L. Marshall (<i>Alt.</i>)

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

J. R. Bareham	R. S. Gales	H. E. von Gierke
S. J. Barry	W. J. Galloway	D. E. Wasserman
R. W. Benson	D. L. Johnson	L. A. Wilber
A. J. Brammer	K. D. Kryter	W. A. Yost
K. M. Eldred	R. L. McKinley	R. W. Young
L. S. Finegold	J. D. Royster	
J. L. Fletcher	E. S. Thalheimer	

Working Group S3/WG 79, Calculation of the Speech Intelligibility Index, which assisted Accredited Standards Committee S3, Bioacoustics, in the development of this Standard, had the following membership:

C. Pavlovic, *Chair*

R. Bilger	Z. Hou	G. Popelka
A. Boothroyd	T. Houtgast	C. Rankovic
D. Dirks	L. Humes	G. Studebaker
J. Dubno	C. Kamm	P. Zurek
G. Garinther	K. Kryter	

Suggestions for improvement will be welcomed. Send suggestions for improvement in writing to Accredited Standards Committee S3, Bioacoustics, in care of the ASA Standards Secretariat, 120 Wall Street, 32nd floor, New York, New York 10005-3993, USA, Telephone: + 1 212 248 0373; FAX: +1 212 248 0146; E-mail: asastds@aip.org.

American National Standard

Methods for Calculation of the Speech Intelligibility Index

1 Scope, purpose and applications

1.1 Scope

The predictions of this Standard apply to listening conditions where the input variables of the Speech Intelligibility Index (SII) model can be accurately estimated. The input variables include the equivalent speech spectrum level, the equivalent noise spectrum level, and the equivalent hearing threshold level. This includes the conditions where either speech or noise may not exist as directly measurable physical quantities (e.g., conditions where speech correlated noise is present, such as reverberated speech) but where equivalent speech spectrum level, equivalent noise spectrum level, and equivalent hearing threshold level can, nevertheless, be calculated. The predictions made by use of this Standard are correct only on the average, that is, across a group of talkers and a group of listeners of both genders. The scope of the Standard is limited to natural speech, otologically normal listeners, and communication conditions which do not include multiple, sharply filtered bands of speech or sharply filtered noise. In addition, the listeners should have no linguistic or cognitive deficiencies with respect to the language used.

1.2 Purpose

This Standard defines methods for computing a measure, called the Speech Intelligibility Index (SII), that is highly correlated with the intelligibility of speech under a variety of adverse listening conditions, such as noise masking, filtering, and reverberation. The SII is computed from acoustical measurements or estimates of speech spectrum level, from noise spectrum level, and from psychoacoustical measurements or estimates of hearing threshold level. Various frequencies contribute different amounts to speech intelligibility, and, within a certain range, a higher speech-to-noise ratio contributes to intelligibility. By measuring the

speech-to-noise ratio in each contributing frequency band and adding the results, the intelligibility of a speech communication system can be predicted.

1.3 Applications

SII procedures in this Standard consist of several parts. Clause 4 specifies calculation methods when the input variables (i.e., equivalent speech spectrum level, equivalent noise spectrum level, and equivalent hearing threshold level) are known. The application domain of this framework is quite general and extends to all listening conditions, within the scope of the Standard, where adequate methods for specifying these input variables exist.

Measurement and calculation procedures for specifying the input variables with which to calculate SII for a number of conditions encountered in practice, such as external noise masking, reverberant speech, monaural listening, and some conditions of binaural listening are provided in clause 5.

Extension of the SII calculation methods to individuals with hearing loss is contained in annex A. Annex B provides procedures for taking into account the content of speech materials in the assessment of speech intelligibility.

Examples of the basic SII computational procedures applied to octave and one-third octave frequency band procedures are contained in annex C.

2 References

The following Standards contain provisions which, through reference in this text, constitute provisions of this American National Standard. At the time of approval by the American National Standards Institute, Inc. (ANSI), the editions indicated were valid. Because Standards are revised from time to time, users should consult the latest version approved by the American National Standards Institute. For purposes of this Standard, the use of the latest revision of a referenced Standard is not mandatory. Information on recent editions is available from the ASA Standards Secretariat.

2.1 Normative references

[1] ANSI S3.2-1989 (R 1995) *American National Standard Method for Measuring the Intelligibility of Speech over Communication Systems*.