

ANSI/ASA S3.35-2010
(Revision of ANSI S3.35-2004)

Reaffirmed by ANSI May 21, 2015
Reaffirmed by ANSI June 5, 2020



AMERICAN NATIONAL STANDARD

Method of Measurement of Performance Characteristics of Hearing Aids Under Simulated Real-Ear Working Conditions



ANSI/ASA S3.35-2010

Accredited Standards Committee S3, Bioacoustics

Standards Secretariat
Acoustical Society of America
35 Pinelawn Road, Suite 114 E
Melville, NY 11747-3177

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

The Acoustical Society of America (ASA) is an organization of scientists and engineers formed in 1929 to increase and diffuse the knowledge of acoustics and to promote its practical applications.



AMERICAN NATIONAL STANDARD

**Method of Measurement of Performance
Characteristics of Hearing Aids Under Simulated
Real-Ear Working Conditions**

Secretariat
Acoustical Society of America

Approved February 25, 2010 by:
American National Standards Institute, Inc.

Abstract

This standard describes techniques used to measure hearing aids under simulated conditions of real ear use. The need for such a standard arises from the importance of including the acoustical variations in the performance data that are caused when hearing aids are worn. For example, the diffraction of the body and head of a hearing aid wearer on incident sound can significantly change the input sound pressure to a hearing aid microphone. For the purpose of these measurements, a suitable manikin and ear simulator are used to represent a typical hearing aid wearer. Acoustical requirements of the test space as well as how the manikin is positioned with respect to the sound source are given. Two methods are presented by which to control the level of the incident sound field at the location of the hearing aid on the manikin during the testing. Procedures are provided to obtain the insertion gain, or the amount by which the hearing aid changes the eardrum sound pressure in the ear simulator of the manikin relative to that in the unaided condition. Procedures are also provided to obtain the directional response of the manikin as a function of azimuth and elevation of the sound source, with and without the assistance of a hearing aid, and to calculate the directivity index from the directional response. The gains obtained with a hearing aid are distinguished by whether the unaided manikin gain is included in (simulated real-ear aided gain) or subtracted from (simulated insertion gain) the aided gain.

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, trade associations, organizations with a general interest, and government representatives). The standards are published by the Acoustical Society of America as American National Standards after approval by their respective Standards Committees and the American National Standards Institute.

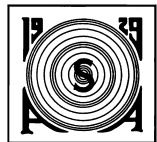
These standards are developed and published as a public service to provide standards useful to the public, industry, and consumers, and to Federal, State, and local governments.

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 an American National Standard 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.



Acoustical Society of America
ASA Secretariat
35 Pinelawn Road, Suite 114E
Melville, New York 11747-3177
Telephone: 1 (631) 390-0215
Fax: 1 (631) 390-0217
E-mail: asastds@aip.org

© 2010 by 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 U.S. 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

1	Scope	1
2	Normative references	1
3	Terms and definitions	2
4	Test equipment.....	6
4.1	Data acquisition.....	6
4.2	Test space.....	6
4.3	Sound source	7
4.4	Manikin	8
4.5	Ear simulator	8
4.6	Equipment for the measurement of simulator sound pressure level.....	8
4.7	Equipment for automatic sweep frequency recording.....	9
4.8	Equipment for measurement of free field sound pressure level	9
4.9	Equipment for measurement of directional response	9
5	Test conditions	10
5.1	Choice of test point.....	10
5.2	Ambient conditions	10
5.3	Manikin	11
5.4	Location of the hearing aid.....	11
5.5	Normal operating conditions for the hearing aid when no other conditions are prescribed..	11
6	Measurements.....	12
6.1	General.....	12
6.2	Adjustment of the reference SPL	12
6.3	Simulated insertion gain	13
6.4	SREA90 measurements.....	14
6.5	Directional characteristics	15
7	Charts	20
7.1	Frequency response and directivity index charts.....	20
7.2	Directional response charts (polar plots).....	20
	Annex A (normative) Higher density measures of directional characteristics	21
A.1	Introduction.....	21
	Annex B (informative) Justification of directivity index measurement method	24
B.1	Introduction.....	24
B.2	Diffuse sound field.....	26
B.3	Simulated diffuse sound field	26
	Annex C (informative) Directivity index averages.....	36
C.1	Introduction.....	36
C.2	Speech perception weighting	36
C.3	Unweighted average	38

Figures

Figure 1 — Manikin geometrical references.....	3
Figure 2 — Coordinates for angles of azimuth and elevation	4
Figure 3 — Two examples of positioning equipment for the measurement of directional response	10
Figure 4 — Example of connection of hearing aid sound outlet to the ear simulator	12
Figure 5 — Locations of sound sources in the frame of reference of the manikin.....	15
Figure 6 — An example polar plot of directional response	20
Figure B.1 — Free-field responses of linear directional arrays up to second-order. The free-field directional response is symmetric about the measurement axis.	24
Figure B.2 — Calculated directional response of microphone arrays in close proximity to a rigid sphere the approximate diameter of a human head. The arrays are located on the right side of the sphere ($\theta = 90^\circ$), oriented parallel to the measurement axis ($\theta = 0^\circ$).	25
Figure B.3 — An array of sound sources in the reference plane	27
Figure B.4 — Errors in simulated real-ear aided directivity index using assumed symmetry	28
Figure B.5 — Examples of geometric solids which produce uniform source distributions.....	28
Figure B.6 — Aligned-zone array	29
Figure B.7 — Worst-case zone-array error for omnidirectional microphone.....	30
Figure B.8 — Worst-case zone-array error for first-order array	30
Figure B.9 — Worst case zone-array error for second-order array	31
Figure B.10 — Measured difference in SREADI when measured using a high density reference source array and recommended 48 source semi-aligned array	32
Figure B.11 — Effect of elevation error in aiming the hearing aid	33
Figure B.12 — Error in second-order cardioid directivity index due to directional array aiming error and source elevation errors.....	34
Figure B.13 — Error in 5 microphone array directivity index due to directional array aiming error and source elevation errors.....	35

Tables

Table 1 — Elevation and azimuth angles and power weights for calculating the directivity index	17
Table A.1 — Power weights for several increments of elevation angle	23
Table C.1 — Weights for calculating articulation index or speech intelligibility index weighted directivity index.....	37

Foreword

[This Foreword is for information only, and is not a part of the American National Standard ANSI/ASA S3.35 – 2010 American National Standard Method of Measurement of Performance Characteristics of Hearing Aids Under Simulated Real-Ear Working Conditions].

This standard comprises one 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, shock and vibration, which pertain to biological safety, tolerance and comfort.

This standard is a revision of ANSI S3.35-2004, which has been technically revised. The 2004 edition was amended to include methods of measuring the directional response due to sound from various elevation and azimuth angles of incidence, both in an unaided manikin ear and in a simulated aided real ear, and the calculation of the directivity index from a spherical integration of the directional response. The directivity index is considered to be of value in predicting the speech intelligibility performance of hearing aids in noisy situations. This 20XX edition has been revised in Annex B to describe the directional arrays used to justify the directivity index measurement method specified in this standard and to improve some graphics.

This standard is comparable to IEC/TR 60118-8:2003.

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

C.A. Champlin, *Chair*
D.A. Preves, *Vice-Chair*

S.B. Blaeser, *Secretary*

Acoustical Society of America	C.A. Champlin
.....	M.D. Burkhard (Alt.)
American Academy of Audiology	D. Ostergren
.....	S. Gordon-Salant (Alt.)
American Academy of Otolaryngology, Head and Neck Surgery, Inc.	R.A. Dobie
.....	L.A. Michael (Alt.)
American Industrial Hygiene Association	T.K. Madison
.....	D. Driscoll (Alt.)
American Speech-Language-Hearing Association (ASHA)	L.A. Wilber
.....	V. Gladstone (Alt.)
Beltone/GN Resound	S. Petrovic
Council for Accreditation in Occupational Hearing Conservation (CAOHC)	L.D. Hager
.....	J.A. Mann (Alt.)
ETS – Lindgren Acoustic Systems	S. Dunlap
.....	D. Winker (Alt.)

Etymotic Research, Inc.	M.C. Killion
Food and Drug Administration	J.K. Kane
.....	S-C Peng (Alt.)
Frye Electronics, Inc.	G.J. Frye
.....	K.E. Frye (Alt.)
G.R.A.S. Sound & Vibration	B. Schustrich
Hearing Industries Association	T.A. Victorian
.....	C.M. Rogin (Alt.)
National Electrical Manufacturers Association, Signaling Protection & Communication Section (NEMA – 3SB)	J. McNamara
.....	R. Reiswig (Alt.)
National Hearing Conservation Association	T. Schulz
National Institute for Occupational Safety and Health (NIOSH)	M. Stephenson
.....	W.J. Murphy (Alt.)
National Institute of Standards and Technology	V. Nedzelnitsky
.....	R. Wagner (Alt.)
National Park Service	G.R. Stanley
.....	K. Fristrup (Alt.)
Natus Medical, Inc.	Y. Hekimoglu
.....	P. Becke (Alt.)
Ocean Conservation Research	M. Stocker
Quest Technologies, Inc.	M. Wurm
.....	P. Battenberg (Alt.)
Starkey Laboratories	D.A. Preves
.....	T. Burns (Alt.)
U.S. Air Force	R.L. McKinley
.....	B. Simpson (Alt.)
U.S. Army Aeromedical Research Lab	W. Ahroon
U.S. Army CERL	D.K. Delaney
.....	M.J. White (Alt.)
U.S. Army Research Laboratory, Human Research and Engineering Directorate	T.R. Letowski
.....	P. Henry (Alt.)
University of Cincinnati Animal Audiology Clinic/Bioacoustics Lab	P.M. Scheifele
.....	D.K. Brown (Alt.)

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

J.R. Bareham	A.J. Campanella	H. Teder
A.J. Brammer	K.D. Kryter	L.A. Wilber
R.F. Burkard	R.L. McKinley	W.A. Yost
	P.D. Schomer	

Members of S3/WG48, Hearing Aids, who actively assisted Accredited Standards Committee S3, Bioacoustics, in the development of this standard, were:

D. Preves, Chair

D. Warren, S3.35 Sub-group Co-Chair

O. Saltykov, Sub-group Co-Chair

J. Anderson	A. Gebert	G. Ravn
S. Armstrong	A. van Halteren	L. Revit
R. Brennan	M. Killion	R. Schulein
T. Burns	J. Kane	C.J. Struck
W.A. Cole	B. Kruger	A. Talaslian
J. DaBell	F.M. Kruger	T.A. Victorian
B. Fedor	V. Nedzelitsky	R. Wagner
G.J. Frye	S. Petrovic	

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, 35 Pinelawn Road, Suite 114E, Melville, New York 11747-3177. Telephone: 631-390-0215; FAX: 631-390-0217; E-mail: asastds@aip.org

Introduction

Measuring methods that take into account the acoustical influence of the wearer on the performance of hearing aids are important, particularly when the results are to be used to assist in the fitting of hearing aids. The information obtained using this document is likely to be more relevant to the fitting of hearing aids than that provided by specification documents such as ANSI/ASA S3.22-2009.

The methods specified in this document require a device such as a manikin to simulate the presence of the wearer.

American National Standard

Method of Measurement of Performance Characteristics of Hearing Aids Under Simulated Real-Ear Working Conditions

1 Scope

The purpose of this standard is to describe test methods which include the acoustical effects of a simulated median adult wearer on the performance of a hearing aid.

Measurements made under simulated real-ear aided working conditions may be divided into two classes:

- Direct simulated real-ear aided measurements, which determine the sound pressure developed by a hearing aid in an ear simulator for a given free-field input sound pressure.
- Insertion measurements, which determine the difference between the sound pressures developed in the ear simulator with and without a hearing aid in place.

Such measurements attempt to determine the actual acoustical assistance that a hearing aid gives to a user.

The test methods described in this document are not intended for quality control.

The results obtained under simulated real-ear aided conditions may differ substantially from results obtained on an individual person due to anatomical and physiological variations of heads, torsos, pinnae, ear canals, and eardrums.

The methods recommended in this standard give information on the measurement of the following parameters that are considered important for the evaluation of the performance of a hearing aid as normally worn, and for which simulated real-ear aided conditions are considered essential:

- insertion gain
- real-ear aided output sound-pressure level for 90 dB input sound-pressure level
- directional characteristics.

Test methods described in this standard are conducted with hearing aids set in linear, non-adaptive, mode.

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 referenced document (including any amendments) applies.