Important Revision of ANSI S3.6-1989: ANSI S3.6-1996 American National Standard Specification for Audiometers

*Importante révision de l'ANSI S3.6-1989 : l'*American National Standard Specification for Audiometers ANSI S3.6-1996

by • par

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ABSTRACT

The American National Standard Specification for Audiometers is one of the most important documents in terms of defining the technical characteristics of audiometers and calibration procedures. In 1996, ANSI S3.6-1996, a revision of ANSI S3.6-1989, was published. A number of major changes, such as establishing the reference equivalent threshold sound pressure levels (RETSPLs) for insert earphones, sound field audiometry, and extended high-frequency testing were instituted in the new standard. This article briefly reviews changes in the new standard and its important impact on the use of audiometers for the profession of audiology.

ABRÉGÉ

L'*American National Standard Specification for Audiometers* est l'un des plus importants documents relativement à la définition des caractéristiques techniques des audiomètres et des méthodes d'étalonnage connexes. En 1996, l'ANSI S3.6-1996, révision de l'ANSI S3.6-1989, a été publiée. La nouvelle norme incorpore plusieurs changements importants, notamment l'établissement des RETSPL (niveaux de pression acoustique au seuil de l'équivalent de référence) pour écouteurs intra-auriculaires, l'audiométrie en champ sonore et le test fait à très hautes fréquences. Cet article donne un aperçu des changements et de leurs incidences éventuelles sur l'utilisation des audiomètres en audiologie.

KEY WORDS

audiometers • calibration • insert earphones • sound field

In all standards related to audiology, the American National Standard Specification for Audiometers, designated as ANSI S3.6, is perhaps one of the most important in terms of defining the requirements for various types of audiometers, signal sources, signal levels, transducers, and calibration procedures. Not only is this standard widely referred to in audiology, it has also been adopted by numerous juridical bodies to define audiometers in regulatory applications, such as in occupational hearing conservation (Occupational Health and Safety Act, 1981; Occupational Health and Safety Administration, 1983; Canadian Standards Association, 1986) and workers' compensation claims. ANSI S3.6 was first established by the American National Standards Institute (ANSI) in 1969 and was revised in 1989 and most recently in January 1996 (i.e., ANSI S3.6-1996). Taking 20 years before the first revision and then seven years for the second revision reflects in part how fast technology and knowledge in this field have advanced in recent years. The 1996 standard brings a number of major revisions and changes. This article briefly reviews these revisions and changes which are of special interest to audiologists.

With global applications of technical innovation, there has been a growing trend of promoting uniform standards throughout the world. ANSI S3.6-1996 is consistent with that trend: "Every attempt has been made to make this standard compatible and consistent with comparable standards published by the International Electrotechnical Commission (IEC) and the International Organization for Standardization (ISO)" (ANSI S3.6-1996, p.v). For example, in defining acoustic couplers for measurement of sound pressure levels, ANSI has officially accepted devices specified by IEC. The IEC 318 artificial ear (International Electrotechnical Commission, IEC 318, 1970), along with the NBS 9A coupler, is designated as one of two devices to calibrate supra-aural earphones. The IEC 711 ear simulator (International Electrotechnical Commission, IEC 711, 1981) is recommended by ANSI for the calibration of insert earphones in addition to the HA-1 and HA-2 couplers.

The most noticeable revision is the adoption of various data standardised by ISO. For instance, reference equivalent threshold sound pressure levels (RETSPLs) using an occluded ear simulator and HA-1 or HA-2 coupler for insert earphones are adopted from ISO 389-2. The correction values to the RETSPLs for calculating reference effective masking levels using narrow-band noise are from ISO 389-4. In sound field testing, the RETSPLs for binaural listening are from ISO 389-7.

The entire interim RETSPLs for circumaural earphones for extended high frequency testing are from ISO 389-5. The incorporation of the international standards permits one to designate any audiometer calibrated to this ANSI standard as "ANSI/ISO Hearing Level" as opposed to "ANSI Hearing Level" with the old ANSI S3.6-1989 standard.

The second major change in the standard is more stringent tolerances for various technical aspects of audiometer performance (see Table 1). For example, the maximum permissible harmonic distortion of audiometers in the 1989 standard for air conducted signals was 3% compared to 2.5% in the new standard. Tolerances for frequency accuracy are decreased from ±3% to ±1% for Type 1 audiometers, ±2% for Type 2 audiometers, and ±3% for Types 3, 4, and 5 audiometers. Furthermore, tolerances for accuracy of sound pressure levels (SPLs) have been extended to cover a wider frequency range. In the 1996 standard, output SPLs of earphones, bone vibrators, or loudspeakers shall differ by no more than ± 3 dB from the indicated values from 125 through 5000 Hz, compared with 125 through 4000 Hz in the 1989 standard, and by no more than ± 5 dB at 6000 Hz and higher, compared with only 6000 and 8000 Hz. These more stringent tolerances have a bearing on how one calibrates audiometers. For example, although this standard does not specify what types of sound level meters should be used in calibrations, a more precise one will be needed (e.g., Type 0 or 1) to meet these strict tolerances.

A third important revision to the standard is the RETSPLs for different types of earphones. In the new standard, the Western Electric 705A and Telex 1470A earphones are excluded, whereas the TDH 39 and TDH 49/50 earphones remain. A general type of earphone is included on the condition that it meets the characteristics specified by the standard. The earphone characteristics include specifications for material, shapes, and construction of cushions and physical forces of the headband. For example, the standard states that "the contour of the earphone in its cushion shall be such that when it is placed on the outer ear contact is made solely with the pinna and not with the surface of the skin covering the cranial bone located posterior to the pinna" (ANSI S3.6-1996, p.18). Earphones of similar types are labelled as "TDH Type".

The RETSPLs for TDH 39 earphones are those originally specified in the ANSI S3.6-1969 standard while those for the TDH 49/50 earphones are from Michael and Bienvenue (1977). The two sets of data provide SPL values for 11 centre frequencies mostly in one octave bands, while the TDH Type data adopted from ISO 389-1:1994 covers 23 centre frequencies in one-third octave bands. RETSPLs for pure tone and speech stimuli for supraaural earphones are presented in Table 2.

A fourth important change in the 1996 standard regards RETSPLs for insert earphones and sound-field testing. In 1989, the specifications for insert earphones were included in an appendix. Although the use of insert earphones has a history of nearly 50 years, they have only been commercially available since 1984. Since the last revision of the standard, there has been a great deal of research investigating and validating their clinical applications (Chertoff & Chen, 1996; Clarke & Roeser, 1988; Frank & Richards, 1991; Frank & Wright, 1990; Hall & Grose, 1994; Poulsen, 1991; Stuart, Stenstrom, Tompkins, & Vandenhoff, 1991; Valente, Potts, Valente, Vass, & Gebel, 1994; Van Campen, Sammeth, & Peek, 1990; Wright & Frank, 1992). Some of the studies have formed the basis for the development of ISO and ANSI standards (e.g., Frank & Richards). In 1994, ISO published its standard relating to insert earphones: ISO 389-2 Acoustic-Reference Zero for the Calibration of Audiometric Equipment - Part 2: Reference Equivalent Threshold Sound Pressure Levels for Pure Tones and Insert Earphones. For the first time, the ANSI has published reference threshold values for insert earphones in the 1996 standard.

Two insert earphones are standardised by ANSI with reference to their material and physical construction, calibration methods, and RETSPLs. They are the Etymotic ER-3A (Etymotic Research) and EARtone 3A (Cabot Safety Corporation). In order to establish uniform calibration procedures for the insert earphones, ANSI specifies three types of acoustic couplers: the IEC 711 occluded ear simulator, the ANSI S3.7 HA-2 acoustic coupler with rigid tube attachment, and the HA-1 coupler. The RETSPL values for 23 centre frequencies are

Table 1. Comparison of Some Tolerance Requirements for Audiometers Between ANSI S3.6-1989 and ANSI S3.6-1996 Standard.

Tolerances	1989	1996
Frequency Accuracy[a]		
Type 1	±3%	±1%
Type 2	±3%	±2%
Type 3, 4, & 5	±3%	±3%
Total Harmonic Distortion[b]	3%	2.5%
Frequency Response		
±3 dB	125 - 4000 Hz	125 - 5000 Hz
±5 dB	6000 & 8000 Hz	6000 Hz and higher

Notes. a. Tolerances for test signals generated by different types of audiometers.
b. Tolerances for air conduction signals from 125 up to 16000 Hz.

Table 2. Reference Equivalent Threshold Sound Pressure Levels (RETSPLs) (dB re 20 µPa) for Supra-aural Earphones.

	Supra-aural Earphone		
Frequency (Hz)	**TDH Type[a]**	**TDH 39**	**TDH 49/50**
	IEC 318	NBS 9A	NBS 9A
125	45.0	45.0	47.5
160	38.5		
200	32.5		
250	27.0	25.5	26.5
315	22.0		
400	17.0		
500	13.5	11.5	13.5
630	10.5		
750	9.0	8.0	8.5
800	8.5		
1000	7.5	7.0	7.5
1250	7.5		
1500	7.5	6.5	7.5
1600	8.0		
2000	9.0	9.0	11.0
2500	10.5		
3000	11.5	10.0	9.5
3150	11.5		
4000	12.0	9.5	10.5
5000	11.0		
6000	16.0	15.5	13.5
6300	21.0		
8000	15.5	13.0	13.0
Speech	20.0	19.5	20.0

Note. a.TDH Type or any supra aural earphone having the characteristics described in clause 9.1.1 or ISO 389 Part 1. From "ANSI S3.6-1996 American National Standard Specification for Audiometers," by American National Standard Institute, 1996, p. 18. Copyright 1996 by Acoustical Society of America. Reprinted with permission of the author.

presented in accordance with each type of the coupler in Table 3. It should be pointed out that the RETSPL values in this standard are different from those referred to in the 1989 standard and those provided by the manufacturers. In general, the values in the new standard specify lesser sound pressure levels for audiometric zero than the previous values by as much as 4 dB. The differences are due probably to the criteria for specifying normal hearing from data which the RETSPLs were derived from (T. Frank, personal communication, December 12, 1996).

Audiologists have long been frustrated by the fact that there is little consensus on the parameters of sound field audiometry (e.g., Melnick, 1991; Walker, Dillion, & Byrne, 1984; Wilber, 1994). Lack of standardised test stimuli, varying acoustical environments, and calibration procedures often force audiologists to compromise the accuracy of testing. Although attempts were made by the ANSI in the 1960s to address some of these issues, such as specifying loudspeakers for sound field use (see Melnick, 1991), no agreement was reached. In the 1996 standard, the ANSI has established guidelines for some major aspects of sound field testing. This is a significant step forward and will certainly have a great impact on the practice of audiology. In the standard, the acoustic properties of test signals for sound field testing are defined as either frequency modulated (FM) tones or narrow-band noises. This is consistent with the recommendations made by many researchers (American Speech-Language-Hearing Association, 1991; Morgan, Dirks, & Bower, 1979; Stream & Dirks, 1974; Walker et al., 1984; Wilber, 1991). To ensure accuracy in calibration, speaker output SPLs are defined according to various angles with reference to the test participant. For example, at a specified distance, deviations should not be more than ±2 dB on the right-left and up-down positions, and ±1 dB in front and behind. Depending upon sound incidences, RETSPL values are given for three azimuths (e.g., 0, 45, and 90 degrees) for monaural listening and for zero degree azimuth for binaural listening. They are presented at 29 centre frequencies in one-sixth octave bands up to 16000 Hz.

Other changes include reference equivalent threshold force levels for bone conducted stimuli which were originally specified by ANSI S3.26-1981 American National Standard Reference Equivalent Threshold Force Levels For Audiometric Bone Vibrator. Now, they are incorporated into this standard along with the specifications of bone vibrators and related headbands. Two sets of the reference equivalent threshold force level data are presented for testing using mastoid and forehead placement. As a result, ANSI S3.26-1981 has been withdrawn from the present ANSI catalogue (Acoustical Society of America, Catalog 16-1997).

Finally, the standard revises types of audiometers. In the pure tone signal category, Type 6 audiometers which were previously listed as having no minimum facility requirement are deleted, while extended high-frequency audiometers are included. The interim RETSPLs and calibration procedures for extended high-frequency testing are provided in Annex C of ANSI S3.6-1996. In the speech signal category, three types of speech facilities are specified. The major differences among them are whether loud speakers or bone vibrators are equipped to transduce speech testing signals.

One concluding note, considering the importance of ANSI S3.6-1996, is the necessity to emphasise the fact that one should not treat it merely as a technical manual. It is not merely a compilation of numbers. Instead, it represents

Table 3. Reference Equivalent Threshold Sound Pressure Levels (RETSPLs) (dB re 20 µPa) for Insert Earphones.

	Coupler Type		
Frequency (Hz)	**Occluded Ear Simulator[a]**	**HA-2 with Rigid Tube[a]**	**HA-1**
125	28.0	26.0	26.5
160	24.5	22.0	22.0
200	21.5	18.0	19.5
250	17.5	14.0	14.5
315	15.5	12.0	15.0
400	13.0	9.0	10.5
500	9.5	5.5	6.0
630	7.5	4.0	4.5
750	6.0	2.0	2.0
800	5.5	1.5	1.5
1000	5.5	0.0	0.0
1250	8.5	2.0	1.0
1500	9.5	2.0	0.0
1600	9.5	2.0	1.5
2000	11.5	3.0	2.5
2500	13.5	5.0	4.5
3000	13.0	3.5	2.5
3150	13.0	4.0	2.5
4000	15.0	5.5	0.0
5000	18.5	5.0	1.5
6000	16.0	2.0	-2.5
6300	16.0	2.0	-2.0
8000	15.5	0.0	-3.0
Speech	18.0	12.5	12.5

Notes. a. RETSPL using an occluded ear simulator (ANSI S3.7, IEC 711) and HA-2 coupler with rigid tube attachment (ANSI S3.7) are from ISO 389-2.
b. The above values are valid when the end of the foam eartip or other eartip is inserted at a depth of 12 to 15 mm from the entrance to the ear canal. These values are based on a foam eartip having the length of 12 mm. From "ANSI S3.6-1996 American National Standard Specification for Audiometers," by American National Standard Institute, 1996, p. 20. Copyright 1996 by Acoustical Society of America. Reprinted with permission of the author.

state-of-the-art recommendations concerning audiometers and their application. Lack of understanding of the standard may compromise the quality of services provided by audiologists. Familiarity with ANSI S3.6-1996 American National Standard Specification for Audiometers allows one to ensure compliance with the standard. For more information, please refer to the standard. It is available from the Standard Secretariat, Acoustical Society of America, 120 Wall Street, 32nd Floor, New York, NY 10005-3993, USA.

Author Notes

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