

Abstract

**Acoustic Calibration of Clinical Audiometers Used
for Special Periodic Health Examination**

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Objectives: Various problems are encountered during audiometric testing. Deviation from reference threshold levels for supra-aural earphones is often a serious problem when hearing levels are measured. This paper reports the acoustic calibration of clinical audiometers used for special periodic health examination.

Methods: ANSI S3.6-1996 Specification for Audiometers represents our most current and best resource for information regarding audiometers. The acoustic calibration was measured in 211 clinical audiometers and compared with the ANSI S3.6-1996 reference threshold levels for supra-aural earphones.

Results: Among 211 clinical audiometers, 56 (26.5%) exceeded the permitted deviation from reference threshold levels at any test frequency in ANSI S3.6-1996 for left supra-aural earphones, and 54 (25.6%) for right. An exhaustive calibration was required for 16 audiometers (7.6%) in both supra-aural earphones. The absolute difference in dB deviation from reference threshold levels by performed acoustic calibration at least annually were statistically significant at any test frequency ($p<.05$).

Conclusions: The results of this study strongly indicate that clinical audiometry is being conducted with pure-tone audiometers having unallowable sound pressure levels deviations for supra-aural earphones. The validity of audiometric hearing thresholds are significantly affected by these deviations from the acoustic calibration levels of audiometers. Therefore audiometer calibration need to be checked functionally daily and acoustically at least annually.

Key Words: Audiometer, Calibration, Standards

, 1996

1991
10% (C1)
가 (D1)
(, 1999). CODE H-13-99, 1999 (KOSHA, 2003)
(, 2003).

3000~6000 Hz

4000 Hz 가

International Electrotechnical Commission (IEC) 318(IEC, 1970) IEC 711(IEC, 1981), IEC 373(IEC, 1990) 1969
2 , 1989 1996
(ANSI S3.6-1996) . ANSI S3.6-1996 ISO 389-1(ISO, 1994)
(supra-aural ear-phone)

, 1999 가 가
가 가 1
가 가
가가

(, 2001).

가 (, 1994).

가

(acoustic calibration)

1.

가

2001 1 2003 9 , ANSI S3.6-1996
가 116 (ANSI, 1996) (reference threshold
211 (clinical levels)(Appendix 1)
audiometer) 가
3 40 (TDH 39 TDH 49/50)
1
125 Hz 5 dB, 250 Hz 3000 Hz 3
dB, 4000 Hz 4 dB, 6000 Hz 8000 Hz
500 Hz 8000 Hz 가 5 dB
가 , 가 가 가 (OSHA, 1996).
가 10 dB
10
(supra-aural ear- dB
phone)
TDH 39가 88 , TDH 49/50 123
5 dB
5 dB 가
2.
CAOHC (Council for Accreditation in 가 가
Occupational Hearing Conservation)
(occupational
hearing conservationist; OHC)
3.
(professional
supervisor course)
가 가 SPSS
(Version 10.0)
(artificial ear:
Bruel & Kjaer type 4152, Denmark) /
(sound level meter: Bruel & Kjaer
type 2260, Denmark)
(audiometer calibration system)
가 가
70 dB HL (125 Hz t-test ²-test
60 dB HL) 125 Hz 8000 Hz
1/1 1/2 (125, 250,
500, 1000, 2000, 3000, 4000, 6000, 8000 Hz)

1. ANSI S3.6
 / 125, 250, 500, 1000, 2000, 4000 8000 Hz
 2.0, 1.9, 1.6, 1.6, 1.8, 1.8, 2.7 dB
 , 1.9, 2.1, 1.7, 1.7, 1.8, 1.8, 2.6 dB
 125 Hz가 17.5 dB, 250 Hz 24.4 dB, 500 Hz 23.9 dB, 1000 Hz 25.4 dB, 2000 Hz 19.2 dB, 4000 Hz 14.0 dB, 8000 Hz 27.4 dB
 18.3, 24.1, 23.7, 24.1, 16.9, 13.7, 25.4 dB (Table 1).

1(3)

(Fig. 1).

2.

125 Hz 5 dB, 250 Hz 3000 Hz 3 dB, 4000 Hz 4 dB,

6000 Hz 8000 Hz 5 dB 가 (OSHA, 1996).

, 125 Hz 17 (10.5%), 250 Hz 35 (17.8%), 500 Hz 21 (10.3%), 1000 Hz 25 (11.8%), 2000 Hz 31 (14.7%), 4000 Hz 15 (7.1%), 8000 Hz 20 (9.8%) 10~20%

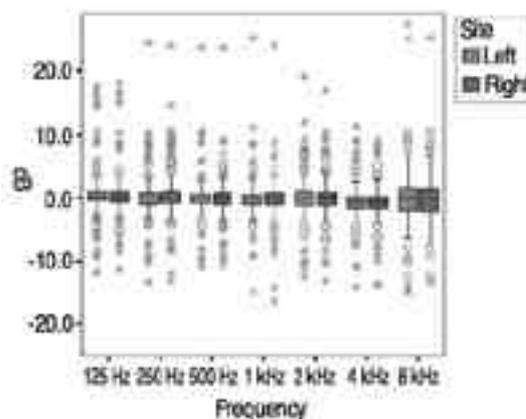


Fig. 1. Boxplots of measured sound levels deviated from reference threshold levels for supra-aural earphones.

Table 1. Absolute difference compared to reference threshold levels for supra-aural earphones

unit: dB

Octave Band Interval	No.	Left Earphone			Right Earphone		
		Mean	S.D.	Maximum	Mean	S.D.	Maximum
125	162	2.0	3.3	17.5	1.9	3.1	18.3
250	197	1.9	2.9	24.4	2.1	3.2	24.1
500	204	1.6	2.6	23.9	1.7	2.5	23.7
1000	211	1.6	2.8	25.4	1.7	2.7	24.1
2000	211	1.8	2.5	19.2	1.8	2.4	16.9
4000	211	1.8	2.2	14.0	1.8	2.3	13.7
8000	204	2.7	3.5	27.4	2.6	2.8	25.4

56 (26.5%), 54 (25.6%) . 10 dB 4.
 가
 16 (7.6%) (Table 2).
 1
 3.
 8000 Hz
 125, 250, 500, 1000, 2000, 4000 8000 1
 Hz 1.3, 1.1, 0.9, 0.9, 0.9, 0.9, 1.4 가 (Table 4).
 dB 17.1, 11.4, 10.5, 10.7, 11.4,
 19.5, 28.8 dB 5 dB 가
 가 5 dB 1
 125 Hz 7 (4.3%), 250
 Hz 8 (4.1%), 500 Hz 5 (2.5%), 1000 1.0%(, 4000 Hz) 11.1%(, 250 Hz)
 Hz 3 (1.4%), 2000 Hz 6 (2.8%),
 4000 Hz 4 (1.9%), 8000 Hz 6 (2.9%)
 12.3%(, 4000 Hz) 26.2%(, 250
 Hz) (Table 5).
 가 5 dB
 19 (9.0%) (Table 3).

Table 2. Clinical audiometers above 10 dB or exceeding permitted deviation from reference threshold levels for supra-aural earphones

Octave Band Interval	No.	Permitted Deviation, dB	frequency (%)			
			Left Earphone		Right Earphone	
			permitted deviation	10 dB difference*	permitted deviation	10 dB difference*
125	162	± 5	17 (10.5)	7 (4.3)	16 (9.9)	6 (3.7)
250	197	± 3	35 (17.8)	4 (2.0)	38 (19.3)	6 (3.0)
500	204	± 3	21 (10.3)	5 (2.5)	30 (14.7)	2 (1.0)
1000	211	± 3	25 (11.8)	4 (1.9)	23 (10.9)	3 (1.4)
2000	211	± 3	31 (14.7)	5 (2.4)	29 (13.7)	4 (1.9)
4000	211	± 4	15 (7.1)	5 (2.4)	17 (8.1)	4 (1.9)
8000	204	± 5	20 (9.8)	8 (3.9)	23 (11.3)	5 (2.5)
Overall Octaves [†]	211		56 (26.5)	16 (7.6)	54 (25.6)	16 (7.6)

* indicate a deviation of 10 dB or more between the audiometer 's dial setting and its output

[†] greater than permitted deviation or 10 dB at any frequency

가
(2000)

가 가 가 가 가

Table 3. Difference deviated from reference threshold levels and above 5 dB difference between the right and left supra-aural earphone on the same output level

Octave Band Interval	No.	Difference on Right-Left Earphone Output, dB			Difference on Right-Left Earphone Output, freq. (%)	
		Mean	S.D.	Maximum	< 5 dB	5 dB
125	162	1.3	2.4	17.1	155 (95.7)	7 (4.3)
250	197	1.1	1.8	11.4	189 (95.9)	8 (4.1)
500	204	0.9	1.4	10.5	199 (97.5)	5 (2.5)
1000	211	0.9	1.2	10.7	208 (98.6)	3 (1.4)
2000	211	0.9	1.4	11.4	205 (97.2)	6 (2.8)
4000	211	0.9	1.7	19.5	207 (98.1)	4 (1.9)
8000	204	1.4	2.6	28.8	198 (97.1)	6 (2.9)
Overall Octaves	211				192 (91.0)	19 (9.0)*

* greater than 5 dB difference between the right and left supra-aural earphone output at any frequency

Table 4. Absolute difference deviated from reference threshold levels by performed acoustic calibration
mean (S.D.), dB

Octave Band Interval	No.	Left Earphone			Right Earphone		
		AC (+)	AC (-)	p-value	AC (+)	AC (-)	p-value
125	162	1.20 (2.24)	2.67 (3.83)	.003	1.00 (1.31)	2.65 (3.89)	.000
250	197	1.25 (1.64)	2.52 (3.57)	.001	1.60 (2.64)	2.51 (3.50)	.040
500	204	0.97 (0.99)	2.13 (3.37)	.001	1.12 (1.20)	2.15 (3.18)	.002
1000	211	0.94 (0.91)	2.23 (3.59)	.000	1.08 (1.02)	2.15 (3.42)	.002
2000	211	1.12 (1.04)	2.35 (3.18)	.000	1.17 (1.37)	2.32 (2.97)	.000
4000	211	1.28 (1.11)	2.26 (2.73)	.001	1.29 (1.19)	2.29 (2.86)	.001
8000	204	2.24 (2.97)	3.14 (3.87)	.063	1.95 (1.69)	3.10 (3.49)	.003

* AC: Acoustic calibration was performed at least once a year.

500 Hz
 3000 Hz 3 dB, 4000 Hz 4 dB, 6000 Hz
 5 dB
 10 dB
 가
 1
 2
 (OSHA, 1996), (NIOSH)
 (OSHA)
 (OSHA, 1996), (NIOSH, 1998).
 1
 가
 가
 (biological check) ISO
 2000), 가 가
 1
 (acoustic (exhaustive calibration) 가
 calibration) (KOSHA CODE H-13-2003)
 10 dB (, 2003).

Table 5. Clinical audiometers exceeding permitted deviation from reference threshold levels by performed acoustic calibration

Octave Band Interval	No.	Left Earphone			Right Earphone		
		AC (+)	AC (-)	p-value	AC (+)	AC (-)	p-value
125	162	3 (4.2)	14 (15.6)	.021	2 (2.8)	14 (15.6)	.007
250	197	8 (8.9)	27 (25.2)	.003	10 (11.1)	28 (26.2)	.008
500	204	3 (3.2)	18 (16.4)	.002	6 (6.4)	24 (21.8)	.002
1000	211	3 (3.1)	22 (19.3)	.000	4 (4.1)	19 (16.7)	.004
2000	211	5 (5.2)	26 (22.8)	.000	5 (5.2)	24 (21.1)	.001
4000	211	1 (1.0)	14 (12.3)	.002	2 (2.1)	15 (13.2)	.004
8000	204	4 (4.2)	16 (14.8)	.017	3 (3.1)	20 (18.5)	.001
Overall Octaves [†]	211	13 (13.4)	43 (37.7)	.000	12 (12.4)	42 (36.8)	.000

* AC : Acoustic calibration was performed at least once a year.

[†] greater than permitted deviation at any frequency

10~20% , 25% 가 125 Hz 1.20 dB, 2.67 dB, 250 Hz 1.25 dB, 2.52 dB, 500 Hz 0.97 dB, 2.13 dB, 1000 Hz 0.94 dB, 2.23 dB, 2000 Hz 1.12 dB, 2.35 dB, 4000 Hz 1.28 dB, 2.26 dB

3~5 dB 가

5

가 125 Hz 3 , 14 , 250 Hz 8 , 27 , 500 Hz 3 , 18 , 1000 Hz 3 , 22 , 2000 Hz 5 , 26 , 4000 Hz 1 , 14 , 8000 Hz 4 , 16

5~10 dBHL

20 dB 가

1

, 10 dB 가 7.6%

3) ±1(가

가 5 dB 9.0% 가

가

1 가 :

: 2001 1 2003 9
 116 211 가 (audiometer)
 ANSI S3.6-1996 (ANSI, 1996)
 (reference threshold level)
 가
 :
 4000 Hz 15 (7.1%),
 250 Hz 38 (19.3%) 1
 56 (26.5%), 54 (25.6%)
 . 10 dB 가
 16 (7.6%)
 가 5 dB
 125 Hz 7
 (4.3%), 250 Hz 8 (4.1%), 500 Hz
 5 (2.5%), 1000 Hz 3 (1.4%), 2000 Hz
 6 (2.8%), 4000 Hz 4 (1.9%), 8000
 Hz 6 (2.9%)
 1
 가
 가
 :
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 가
 2000;4(2):154-62.
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 2001;13(3):262-73.

가.
 1999;32(1):30-9.
 가.
 1994;6(2):276-88.
 1.
 , 2000.
 (KOSHA CODE H-
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 1996.

Appendix 1. Reference threshold levels listed in ANSI S3.6-1996 for several audiometric transducers

Frequency	Supra-aural Earphone*		Insert Earphone [†]	Bone Vibrator [‡]
	TDH 39	TDH 49/50		
125	45.0	47.5	26.0	
250	25.5	26.5	14.0	67.0
500	11.5	13.5	5.5	58.0
1000	7.0	7.5	0.0	42.5
2000	9.0	11.0	3.0	31.0
3000	10.0	9.5	3.5	30.0
4000	9.5	10.5	5.5	35.5
6000	15.5	13.5	2.0	40.0
8000	13.0	13.0	0.0	
Speech	19.5	20.0	12.5	55.0

*in dB re: 20 μ Pa using NBS 9A coupler specified in ANSI S3.7-1995

[†]in dB re: 20 μ Pa for Etymotic ER-3A or EARtone 3A using HA-2 coupler with rigid tube specified in ANSI S3.7-1995

[‡]in dB re: 1 N, mastoid placement of Radioear B-71 using a mechanical coupler specified in ANSI S3.13-1987 (R 1993)