

**Abstract**

**Ambient Noise Levels in the Audiometric Test Rooms Used  
for Special Periodic Health Examination**

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**Objectives:** The ambient noise levels in the test rooms affect the workers 's hearing threshold. The present study was designed to assess the ambient noise levels in the test rooms to determine if valid hearing tests, both pure-tone air conduction and bone-conduction, could be performed in these environments.

**Methods:** In the present study, third octave band ambient noise sound pressure levels were measured in 124 audiometric test rooms used for clinical audiometry, and the results were compared with the ANSI third octave band maximum permissible ambient noise levels (MPANLs) for each test condition and frequency range.

**Results:** The ambient noise SPLs were highest in the lower frequencies, and this decreased as the frequency increased. For the " ears covered " condition, about 24.2% of the rooms were in compliance (pass) with the MPANLs for the 125-8000 Hz, 35.5% were in compliance for the 250-8000 Hz range and 55.6% were in compliance for the 500-8000 Hz range. For the " ears not covered " condition, only about 8.1% of the rooms passed for the 125-8000 Hz, 13.7% of the rooms passed for the 250-8000 Hz range and 34.7% of the rooms passed for the 500-8000 Hz range. All 124 rooms met the OSHA MPANLs.

**Conclusions:** The results of this study strongly indicate that clinical audiometry is being conducted in test rooms having unacceptable or excessive ambient noise levels.

**Key Words:** Ambient noise, Audiometric test rooms, Standards, Hearing

( , 2001).

가 (

, 1994).

가

, 1996

가

가

(KOSHA CODE H-

가

13-99, 1999)

(

1999).

. 1960

0 dB HL

가

(maximum

permissible ambient noise levels, MPANLs)

, 1977 1991

1999

(ANSI S3.1-1999)

가

(Occupational Safety and Health

Administration)

(OSHA, 1996)

1960

ANSI(American National Standards

1.

Institute)

. 1960

ANSI

10 dB HL

0 dB HL

가

115

2001 1

2003 9

ANSI

가

124

가

3

가

0 dB HL

40

1

가

가

2 ( )

ANSI S3.1-1999

2.

CAOHC(Council for Accreditation in Occupational Hearing Conservation)

가

(occupational

hearing conservationist; OHC)

(professional supervisor course)

가 가  
가 가

가  
(general linear model: GLM)  
(Two-way ANOVA)

Bruel & Kjaer (sound level meter, type 2260)

(booth )

1.2 m

LSD)

(least significance difference;

SPSS 10.0

dBA

1/3

125, 250, 500, 800, 1000, 1600, 2000, 3150, 4000, 6300 8000 Hz dB

SPL 125,

250, 500, 1000, 2000, 4000 8000 Hz 1.

(Occupational Safety and

Health Standards)

가 20 dB SPL

A 28.2 dBA

45.6 dBA 125

Hz 8000 Hz

0 dB HL 가

31.9, 22.5, 15.5, 11.4, 9.3, 8.5, 7.6

ANSI S3.1-1999(ANSI, 1999) 1/3

dB SPL , 20 dB SPL

(Appendix 1)

125 Hz 11 (8.9%), 250 Hz 54

(43.5%), 500 Hz 92 (74.2%), 1000 Hz 109

(87.9%), 2000 Hz 116 (93.5%), 4000 Hz

120 (96.8%), 8000 Hz 123 (99.2%)

(outdoor)

(non-sound

proof work environments)

1/3

1/3

125 Hz

8000 Hz 48.9, 41.1, 33.0, 27.8,

( )

27.5, 23.3, 21.3 dB SPL , 1/3

(OSHA) 500

(Appendix 2)(OSHA, 1996)

Hz 8000 Hz

(Appendix 2)

ANSI S3.1-1999

가

125 Hz 1000 Hz

(Table 1)(Fig. 1).

2.

( )

(supra-aural earphone)

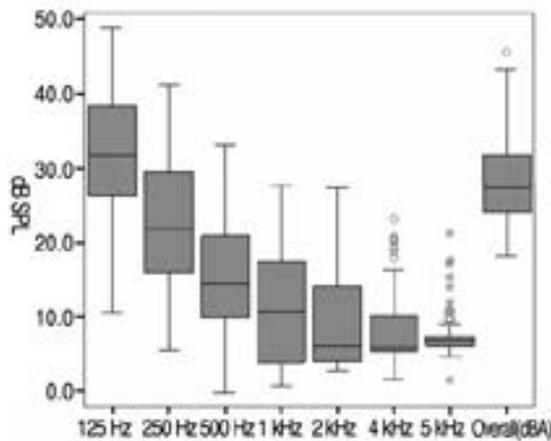
(ears covered) 0 dB HL 가

**Table 1.** Ambient noise levels of test rooms

n=124

	Octave Band Interval, Hz							dBA
	125	250	500	1000	2000	4000	8000	
Mean	31.9	22.5	15.5	11.4	9.3	8.5	7.6	28.2
Standard Deviation	8.4	8.2	8.1	8.0	6.6	4.9	3.1	5.6
Maximum	48.9	41.1	33.0	27.8	27.5	23.3	21.3	45.6
Number of rooms where measurements were ≥ 20 dB	113 (91.1)	70 (56.5)	32 (25.8)	15 (12.1)	8 (6.5)	4 (3.2)	1 (0.8)	116 (93.5)
Number of rooms where measurements were < 20 dB	11 (8.9)	54 (43.5)	92 (74.2)	109 (87.9)	116 (93.5)	120 (96.8)	123 (99.2)	8 (6.5)

\* unit: sound pressure levels (SPLs), measured on 1/3 octave band



**Fig. 1.** 95% CI of ambient noise levels of test rooms

(ANSI S3.1-1999,  
Appendix 1) , 가  
125 Hz 8000 Hz 125 Hz  
77 (62.1%), 250 Hz 70 (56.5%), 500 Hz  
45 (36.3%), 1000 Hz 15 (12.1%)  
(0.8%)  
가 250 Hz 8000  
Hz 125 Hz 45  
(36.3%), 250 Hz  
8000 Hz  
가 500 Hz 8000 Hz  
125 Hz 10

(8.1%), 250 Hz 29  
(23.4%), 500 Hz  
가 125 Hz  
8000 Hz 2000 Hz  
125 Hz 8000 Hz  
94  
(75.8%), 250 Hz 8000 Hz  
80 (64.5%), 500 Hz 8000  
Hz  
55  
(44.4%) 0 dB HL  
가 (Table 2).  
(ears not covered) 0 dB HL  
가  
가 125 Hz 8000  
Hz 125 Hz 106 (85.5%), 250  
Hz 89 (71.8%), 500 Hz 71 (57.3%),  
1000 Hz 47 (37.9%), 2000 Hz 32  
(25.8%), 4000 Hz 35 (28.2%), 8000 Hz  
14 (11.3%)  
가 250 Hz

8000 Hz (62.1%), 250 Hz (71.8%), 8000 Hz 125 Hz 30 (24.2%), 250 Hz 42 (34.1%), 500 Hz 77 89 가 500 Hz 3. 가 125 Hz 8000 Hz 8000 Hz 250 Hz (Table 2).

**Table 2.** Percent and number of test rooms failed in ANSI S3.1-1999 MPANLs

n=124

Octave Band Interval*	MPANLs, freq.(%) for EC			MPANLs, freq.(%) for ENC		
	125-8000	250-8000	500-8000	125-8000	250-8000	500-8000
125	77 (62.1)	45 (36.3)	10 ( 8.1)	106 (85.5)	77 (62.1)	30 (24.2)
250	70 (56.5)	70 (56.5)	29 (23.4)	89 (71.8)	89 (71.8)	42 (34.1)
500	45 (36.3)	45 (36.3)	45 (36.3)	71 (57.3)	71 (57.3)	71 (57.3)
1000	15 (12.1)	15 (12.1)	15 (12.1)	47 (37.9)	47 (37.9)	47 (37.9)
2000	-	-	-	32 (25.8)	32 (25.8)	32 (25.8)
4000	-	-	-	35 (28.2)	35 (28.2)	35 (28.2)
8000	-	-	-	14 (11.3)	14 (11.3)	14 (11.3)
Overall Octaves†	94 (75.8)	80 (64.5)	55 (44.4)	114 (91.9)	107 (86.3)	81 (65.3)

MPANL: maximum permissible ambient noise levels, EC: ear covered, ENC: ear not covered

\* measured on one-third octave band

† greater than MPANLs at any frequency

**Table 3.** Summary of outdoor noise levels, percent and number of non-soundproof work environments failed in OSHA values

n=124, unit; dB SPL

Octave Band Interval	Mean	Median	SD	Maximum	OSHA MPANLs, freq.(%)
125	49.1	49.5	5.7	62.5	
250	47.8	47.5	7.7	63.4	
500	47.5	47.8	8.0	63.9	106 (85.5)
1000	43.3	44.4	7.6	58.5	86(69.4)
2000	40.5	41.0	7.6	56.2	27(21.8)
4000	37.3	36.8	7.1	54.4	-
8000	31.7	31.9	7.2	52.2	-
Overall Octaves*					107(86.2)
dBA	49.9	51.6	7.2	65.1	

\* measured on octave band

# greater than OSHA MPANLs at any frequency

A 49.9 dBA  
 125 Hz 8000 Hz  
 37.3, 31.7 dB SPL  
 65.1 dBA  
 49.1, 47.8, 47.5, 43.3, 40.5,  
 Hz, 250 Hz, 500 Hz  
 가  
 500 Hz 106 (85.5%), 1000Hz 86  
 (69.4%), 2000 Hz 27 (21.8%)  
 , 4000 Hz  
 (Table 3).  
 4.  
 (p<.05).  
 가 47.6% 8000 Hz 250 Hz  
 6.2%  
 (Table 4, Fig. 2).

**Table 4.** Ambient noise levels by type of test rooms

Octave Band Interval <sup>#</sup>	Booth in isolated examination room					p-value			R <sup>2</sup>	
	Yes			No		A	B	C		
	Commercially prefabricated		Custom-built n=47	Commercially prefabricated						Custom-built n=24
	Single-wall n=36	Double-wall n=6		Single-wall n=11						
125	28.2 (7.4)	16.3 (5.8) <sup>†</sup>	34.3 (6.2)	28.3 (7.1)	38.2 (6.8)	.000	.172	.187	.380*	
250	16.5 (5.1)	8.6 (4.4) <sup>†</sup>	25.7 (7.1)	17.6 (4.3)	29.5 (5.3)	.000	.067	.290	.476*	
500	9.8 (5.1)	3.4 (5.7) <sup>†</sup>	17.2 (7.8)	11.5 (3.3)	22.2 (5.5)	.000	.031	.280	.400*	
1000	6.2 (5.4)	4.7 (3.4)	13.0 (7.9)	3.5 (2.4)	17.3 (6.1)	.000	.678	.065	.324*	
2000	4.8 (2.1)	4.2 (1.3)	10.4 (6.3)	4.0 (1.9)	14.6 (7.6)	.000	.299	.117	.308*	
4000	6.1 (1.4)	5.8 (0.6)	9.6 (5.4)	5.5 (0.4)	10.5 (6.2)	.006	.922	.570	.150*	
8000	6.6 (1.0)	6.9 (0.2)	8.1 (3.2)	6.6 (0.5)	8.5 (4.8)	.160	.815	.760	.062	
dBA	24.7 (3.9)	21.1 (3.7) <sup>†</sup>	30.0 (4.4)	24.1 (3.1)	33.4 (4.6)	.000	.118	.023	.456*	

A: Type of audiometric room, B: Isolation of booth, C: Interaction between A and B

# unit: mean (standard deviation), sound pressure levels(SPLs), measured on one-third octave band

\* p <.05, by two-way ANOVA for significance of corrected model

†: p <.05, by post Hoc test of LSD F for difference of ambient noise levels between single- and double-wall booth

5.

가 가

125 Hz, 250 Hz (dBA) 가

1999 (supra-aural headphone) (ears covered testing) (ears not covered testing)

125 Hz 8000 Hz 250 Hz (p<.05). Hz 8000 Hz 500 Hz

39.9% 8000 Hz 125 Hz 8000 Hz (Table 5, Fig. 3) 1/3 (ANSI, 1999). 가 250 8000 500 8000

**Table 5.** Noise reduction in dB by type of test rooms

Octave Band Interval*	Booth in isolated examination room					p-value			R <sup>2</sup>
	Yes			No		A	B	C	
	Commercially prefabricated	Custom-built	Commercially prefabricated	Custom-built					
	Single-wall n=36	Double-wall n=6	n=47	Single-wall n=11	n=24				
125	14.3 ( 7.2)	32.2 ( 9.1) <sup>†</sup>	8.9 ( 6.5)	20.3 (10.6)	7.0 (7.7)	.000	.209	.014	.399*
250	24.6 ( 7.4)	37.0 (11.6) <sup>†</sup>	16.8 ( 9.2)	27.9 (15.0)	14.8 (8.3)	.000	.721	.193	.271*
500	32.5 (10.0)	40.5 (12.5)	25.0 (10.9)	34.7 ( 6.1)	21.4 (7.3)	.000	.751	.212	.233*
1000	33.5 ( 9.6)	39.5 ( 7.3)	24.2 (11.0)	37.7 ( 6.0)	23.9 (6.5)	.000	.468	.406	.249*
2000	33.3 ( 6.5)	38.0 ( 2.5)	24.4 (11.5)	34.5 ( 4.7)	22.2 (8.0)	.000	.849	.525	.233*
4000	27.7 ( 7.2)	32.3 ( 5.3)	24.3 ( 7.7)	31.0 ( 5.8)	20.4 (6.3)	.001	.882	.085	.188*
8000	21.9 ( 6.3)	25.3 ( 4.6)	20.3 ( 6.6)	23.4 ( 6.4)	16.7 (4.3)	.031	.551	.149	.128
dBA	23.1 ( 8.2)	32.4 (11.1) <sup>†</sup>	19.4 ( 7.6)	30.4 ( 5.4)	17.3 (7.0)	.000	.115	.005	.247*

A: Type of audiometric room, B: Isolation of booth, C: Interaction between A and B

\* unit: mean (standard deviation), measured on one-third octave band

\* p <.05, by two-way ANOVA for significance of corrected model

†: p <.05, by post Hoc test of LSD F for difference of ambient noise levels between single- and double-wall booth

Hz 125 8000 Hz 가 1000 Hz  
 125-250 Hz 가 가  
 1/3 5 dB ,  
 1/1 1/3 (Frank, (1 ), 1000 Hz  
 2000).

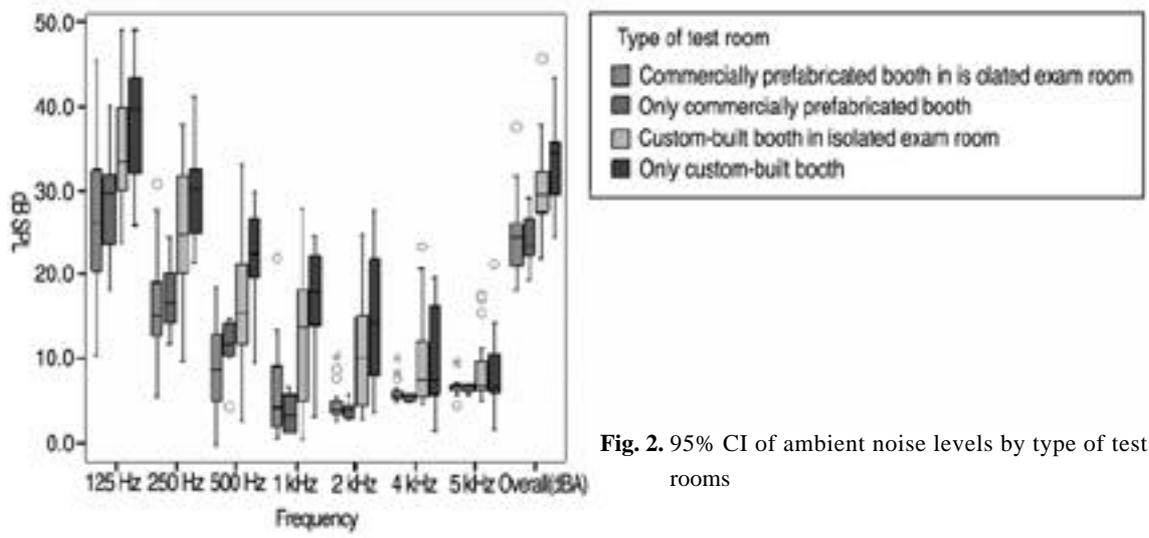


Fig. 2. 95% CI of ambient noise levels by type of test rooms

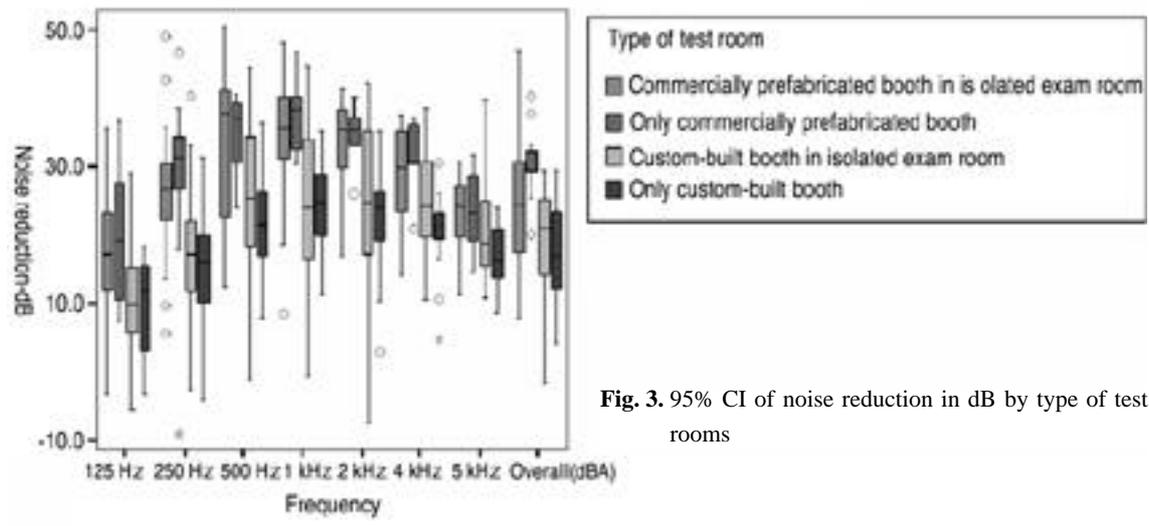


Fig. 3. 95% CI of noise reduction in dB by type of test rooms

Frank Williams(1994)

2

490

가

1981

(48 , 35%),

(38 , 28%),

(20 , 15%),

(30 , 22%)

136

1987

1992

Frank

Williams

0 dB HL

가

ANSI

(1993)

33%

가

(125-500 Hz)

Lankford Hopkins

(2000) 33

42.3 dBA(30-57 dBA)

가

125-8000 Hz 75.8%, 250-8000

Hz 64.5%, 500-8000 Hz 44.4%,

500 Hz

125-

0%, 1000 Hz

12%, 2000 Hz

8000 Hz 91.9%, 250-8000 Hz 86.3%, 500-

76%, 4000 Hz

85%, 8000 Hz

91%

8000 Hz 65.3%

Frank

가

Williams(1993)

2000 Hz

50%

가 가

10 dB

12 dB

(Frank

Williams,

(Wong , 2003)

1993).

. 1

500 Hz 44.8

가

dB, 1000 Hz 41.4 dB, 2000 Hz 38.1 dB, 4000

Hz 32.7 dB, 8000 Hz 28.1 dB 500 Hz

ANSI

, 1000-2000 Hz

Williams(1993)

ANSI

, 50%

. Frank

가

(non-soundproof

work environment)

49.9

가

dBA

가

1000 Hz

가 가

1

4000 Hz  
1000 Hz  
가 가 가  
1 2

ANSI S3.1  
(Kenyon, 1998)  
55 dBA 1000 Hz (Jacobson Jacobson, 1994; Rhoades  
가 10 dB 가 4000 Hz, 1998; Lee Kim, 1999)  
( , 3000 Hz  
2000). , 4000 Hz  
, 1000 Hz 가  
1 가 3, 4, 6, 8 kHz 50 dB  
80%

98.2%, 88.2%  
1 50 dB (cafeteria calibrat-  
ed noise) 5.2%,  
33.1%

2 (Kenyon, 1998). (distortion  
1000 Hz 30 dB HL, 4000 Hz 40 dB product otoacoustic emission; DPOAE)  
HL 1000 Hz 가 25 dBA 40 dBA  
가  
20 dB HL 가  
(DPOAE:noise ratio, D:N), 2f1-f2 noise  
level  
55-65 dBA D:N  
2 가 (Lee Kim, 1999).  
Rhoades (1998)  
0 dB HL 가 ANSI S3.1- (click-evoked  
1999 1000 Hz otoacoustic emission; CEOAE)  
, 50 dBA, 55 dBA, 60  
dBA , default mode mean  
whole wave 89.2%,  
50 dBA 85%, 55 dBA 65%, 60 dBA  
20% 가  
가 CEOAE QuickScreen Program  
CEOAE  
50-55 dBA

1000 Hz

가 가

2

가

가

0 dB HL

가

(stiffness),

( , , )

가

(flanking transmission)

: 2001 1 2003 9 115

가

124

가

0 dB

(Haughton, 2002).

HL 가 ANSI S3.1-1999(ANSI, 1999)

(supra-aural earphone) covered) 0 dB HL

(ears covered)

가

(supra-aural earphone)

Audiocup

Audio- (noise

가 500 8000 Hz

Mate

125 Hz 10 (8.1%), 250

reduction earphone enclosure)

Hz 29 (23.4%), 500 Hz 45 (36.3%),

(Frank , 1997).

1000 Hz 15 (12.1%) (0.8%)

500-8000 Hz

125 Hz 8000

Hz 78, 64, 50, 47, 49, 50, 56

125 Hz 8000 Hz

dB SPL

94

(75.8%), 250 Hz

8000 Hz

80

(64.5%), 500 Hz

8000 Hz

55

가 500-8000 Hz

(44.4%) 0 dB HL

가

thresholds, threshold repeatability, and attenuation values for passive noise-reducing earphone enclosures. *Am Ind Hyg Assoc J* 1997;58:772-8.

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Rhoades K, McPherson B, Smyth V, Kei J, Baglioni A. Effects of background noise on click-evoked otoacoustic emissions. *Ear Hear* 1998;19(6):450-62.

Wong TW, Yu TS, Chen WQ, Chiu YL, Wong CN, Wong AHS. Agreement between hearing thresholds measured in non-soundproof work environments and a soundproof booth. *Occup Environ Med* 2003;60:667-71.

가 가  
2 ( )  
가  
가  
2001;13(3):262-73.  
2000;  
4(2):109-16.  
1994;6(2):276-88.  
(KOSHA CODE H-13-99). , 1999.  
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Frank T, Greer AC, Magistro DM. Hearing

**Appendix 1.** One-third octave band maximum permissible ambient noise levels in ANSI S3.1-1999

unit : dBSPL

1/3 OB Intervals	Ears Covered <sup>a</sup>			Ears Not Covered <sup>b</sup>		
	125 to 8000 Hz	250 to 8000 Hz	500 to 8000 Hz	125 to 8000 Hz	250 to 8000 Hz	500 to 8000 Hz
125	30.0	34.0	44.0	24.0	30.0	39.0
250	20.0	20.0	30.0	16.0	16.0	25.0
500	16.0	16.0	16.0	11.0	11.0	11.0
1000	21.0	21.0	21.0	8.0	8.0	8.0
2000	29.0	29.0	29.0	9.0	9.0	9.0
3150	33.0	33.0	33.0	8.0	8.0	8.0
4000	32.0	32.0	32.0	6.0	6.0	6.0
6300	32.0	32.0	32.0	8.0	8.0	8.0
8000	32.0	32.0	32.0	9.0	9.0	9.0

<sup>a</sup>Supraural earphones<sup>b</sup>Nonoccluded bone conduction**Appendix 2.** Maximum allowable sound pressure levels (referenced to 20  $\mu$ Pa) inside audiometric testing rooms

Octave Band Center Frequency	500 Hz	1000 Hz	2000 Hz	4000 Hz	8000 Hz
OSHA Table D-1 <sup>a</sup>	40 dB	40 dB	47 dB	57 dB	62 dB
ANSI S3.1b	21 dB	26 dB	34 dB	37 dB	37 dB

<sup>a</sup>: OSHA. OSHA Regulations (Standards - 29 CFR): Occupational noise exposure. - 1910.95. Appendix D - Audiometric test rooms. OSHA, 1996.<sup>b</sup>: ANSI. American National Standard. Maximum permissible ambient noise levels for audiometric test rooms. ANSI S3.1-1999, New York, 1999.