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Noise exposure impact in a manufacturing environment: A hearing conservation program needs assessment

Jill Diesman

NOISE EXPOSURE IMPACT IN A MANUFACTURING ENVIRONMENT: A HEARING CONSERVATION PROGRAM NEEDS ASSESSMENT

by

Jill Diesman

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Department of Speech and Hearing

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Approved by: William Clark, Ph.D., Independent Study Advisor
Carl Bohl, D.Sc., Independent Study Advisor

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ABSTRACT: ***Purpose.*** This study was conducted to 1) evaluate the impact of occupational noise exposure on employees hearing levels and 2) examine the role that a hearing conservation program plays in addressing the problem and preventing permanent hearing loss. ***Design/Method.*** Baseline and subsequent audiometric tests results of a hearing conservation program examined over a 5-year period. Students in the graduate training program at the Central Institute for the Deaf performed the audiometric thresholds for the Lighthouse for the Blind personnel. Plant operations included the filling of both pressurized and non-pressurized liquid containers and processing paper into a usable format for computer printers. The audiometric results were compared to Annex B of the American National Standard Institute (ANSI) S3.44-1996. ***Findings.*** While agreements were found between the hearing levels of the test subjects and control populations at the critical frequencies for noise induced hearing loss (NIHL) some findings indicated differences in low frequency hearing levels. These differences are not attributed to work place noise exposure. Test methods and test environments may be the cause of these differences. The hearing conservation program effectively addresses the occupational noise hazard problem.

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Introduction

Noise-induced hearing loss has been identified as the major contributor to occupational-related injuries (Bergstrom and Nystrom, 1986). In the report, Combatting Noise in the 90's, Dr. William Clark stated, "Approximately 25% of this nation's industrial work force that is, over 6 million men and women continue to be exposed to hazardous noise" (1991, p.29). Compounding this problem, Behrens and Brackbill (1993) found a significant discrepancy in employee perception of hearing loss risk versus actual risk.

Occupational-related hearing impairment is a socioeconomic hazard to the workforce. In addressing the economic and social costs, the International Institute of Noise Control Engineering (1997) found that these costs include, "not only financial compensation or damages that must be paid, and the reduced enjoyment of everyday life for those with a hearing loss, but also less quantifiable factors such as reduced productivity, increased stress, disturbed speech communication and risk of accidents for a large number of workers" (p.203).

Government agencies and professional organizations, such as Occupational Safety and Health Administration (OSHA), American Speech Language and Hearing Association (ASHA), National Institute on Occupational Safety and Health (NIOSH), Environmental Protection Agency (EPA), American National Standards Institute (ANSI) and the

American Conference of Governmental Industrial Hygienist (ACGIH) has established standards designed toward minimizing the impact of occupational noise exposures. However, an effective hearing conservation program is difficult to ensure success because of variations in regulatory criteria, test methods, and enforcement.

The purpose of this study is two-fold. First, was to evaluate the impact of occupational noise exposure on employees hearing levels. Second, examine the role that a hearing conservation program plays in addressing the problem and preventing permanent hearing loss?

Review of Literature

A comprehensive review of existing knowledge was conducted in order to 1) determine the extent of occupational hearing loss risk, 2) define measures to increase the effectiveness of the hearing conservation program, and 3) review the literature to provide control data for this study.

A consistent pattern in the study findings was noted. In particular, researchers overwhelmingly concur that weaknesses exist in both method of testing and implementation of hearing conservation programs.

Robinson (1985) examined several variables, including noise exposure levels, age, individual susceptibility, and potential pathological components. He concluded that without standardization, skewed findings could be expected. Samuels et al. (1985) found that correlation components often included in mean exposure level measurement-time,

date and location of sampling, can result in inconsistent findings.

Equally problematic are variances in regulatory criteria, negligence in government and corporate enforcement of regulations, and development and facilitation of health conservation programs. Again, inconsistencies in enforcement prove to impede the reduction of occupational noise-induced hearing loss.

In one study (1991) Clark and Lambert found a lack in optimum success of the OSHA 29CFR 1910.95 standard (Appendix 2) because of 1) poor implementation and enforcement of standards by governing agencies, 2) a lack of standardized noise exposure and enforcement criteria and 3) the need for educational programs.

Another problem, inconsistency in criteria, was examined by Anderson, et. al (1997). In cooperation with Ford Motor Company, they studied ACGIH versus OSHA criteria. Findings suggested a 9.2% increase in mandated employee participation in hearing conservation programs. Similarly, Petrick, et al. (1996) found a 36% increase in mandatory hearing conservation program participation based on ACGIH criteria versus OSHA standards at IBM.

With these factors in mind, this study utilizes Annex B of the American National Standards Institute (ANSI S3.44-1996) as well as data collected from the Lighthouse for the Blind personnel by the Central Institute for the Deaf over a five-year period.

Design and Methodology

Audiometric testing of employee's threshold hearing levels from Lighthouse for the Blind manufacturing plant personnel was conducted. Lighthouse for the Blind provides employment opportunities for a population that is visually impaired. Some of these people may have additional neurological deficits. The employees manufacture paper products and fill containers.

Design

The audiometric data was compiled and categorized for analysis. Results were then compared to Annex B of ANSI S3.44-1996 to determine if there were significant differences.

Methodology

Determining the reliability of the test methods was difficult. The measurement technique was consistent with the equipment that was used, but the sample populations varied from the controls. For example, the sample population was sight impaired and some had other neurological disorders. Other factors include duration exposure, exposure levels, and test room environments. However, management from the Lighthouse for the Blind indicated that they meet OSHA standards.

The percentile distribution of hearing levels was determined by using Statistica and the data was graphically represented by using Kaleidograph. Annex B of ANSI S3.44-1996 data was used for comparison.

Sample Population

Because of the small number of test subjects, it was determined that data collected by Central Institute for the Deaf over a five-year time period would provide more useful data for analysis. Subsequent sample (test 3 for males and test 2 for females) was selected based on highest quantity of tested sample population.

BASELINE SAMPLE

Defined Group (Age and Gender)	**Quantity**
Male:	
30 yrs.	**31**
40 yrs.	**33**
50 yrs.	**22**
60 yrs.	**14**
Total Male	**100**
Female:	
30 yrs.	**10**
40 yrs.	**16**
50 yrs.	**06**
60 yrs.	**06**
Total Female	**38**
TOTAL BASELINE SAMPLE POPULATION	**138**

SUBSEQUENT SAMPLE

Defined Group (Age and Gender)	Quantity
Male: (Test Group#3)	
30 yrs.	**12**
40 yrs.	**12**
50 yrs.	**10**
60 yrs.	**08**
Total Male	**42**
Female: (Test Group#2)	
30 yrs.	**05**
40 yrs.	**08**
50 yrs.	**02**
60 yrs.	**05**
Total Female	**20**
TOTAL SUBSEQUENT SAMPLE POPULATION	**62**

Discussion

Designing a noise study to accurately determine cause and effect is difficult because having comparable control populations to evaluate test results is almost impossible. "Individual susceptibility to the audiometric effects of age, noise, and the combination, not to mention the extraneous factors, is well known to vary. One could say, with justification, that the most striking characteristic is indeed this very variability and it is this which arouses difficulties and controversy when we resort, of necessity, to hypothesis" (Robinson, 1976, p.383-384).

While the goal of this study was not to illustrate the impact of variables and lack of standardization in hearing loss assessment and conservation programs, this researcher found that, as indicated by reviewed literature, it is indeed difficult to conduct a reliable, valid study. The inability to duplicate sample populations and test methods created a major barrier. Further, as pointed out by Robinson (1976), extraneous factors such as pre-existing conditions and other noise exposure (recreational, prior employment, etc.) were not available. Finally, because the source of data, Lighthouse for the Blind, did not provide information regarding their hearing conservation program, other than to state that they meet OSHA standards, assessing their hearing conservation program impact and needs was impossible.

Therefore, this study was most useful in illustrating the need for enforcement of regulations, audiometric testing, and conservation programs in order to reduce the negative impact of variables in effectively assessing occupational noise hazards.

Conclusions

Statistical findings of Baseline, Subsequent test, and Annex B data are provided (Appendix 4-12). In summary, the major consistent finding was that males and females at 500 and 1000 Hz exhibited hearing levels generally poorer than that of Annex B. However, OSHA allows for greater test environmental noise levels compared to ANSI: 3.1-1991 (appendix 3).

Significant confounding results were found in the analysis of the 30, 40 and 50 year-old female groups indicating poorer thresholds compared to Annex B. The lower frequencies of the baselines and subsequent tests are both poorer than those of the higher frequencies. The poorer thresholds in the higher frequencies varied between the baseline and subsequent test. Reasons for such a discrepancy could be due to normal test variance or the possibility that this group of subjects are of a different population compared to that of Annex B and have been previously exposed to noise.

Review of Findings

Males:

30 yrs. Both baseline and test 3 are poorer in the low frequencies between 500 and 2000 Hz but in the frequencies between 3000-6000 Hz (the frequencies known to be first effected by noise) Lighthouse for the Blind personnel fall within the same range of Annex B (Appendix 7).

40 yrs. In the frequencies between 500-2000 Hz the baseline and test 3 are poorer than Annex B and become slightly better beyond 3000 Hz (Appendix 8).

50 yrs. The baseline is approximately 10 dB poorer at 500-1000 Hz but from 2000-4000 Hz it becomes slightly better than Annex B. Test 3 averages around 5 dB poorer across all frequencies with the exception of 6000 Hz where it is slightly better when compared to Annex B (Appendix 9).

60 yrs. Annex B is a few dB better than both baseline and Test 3 in the lower frequencies (500-2000 Hz). However, in the frequencies first effected by noise the baseline and test 3 indicated better hearing than Annex B (Appendix 10).

Females:

30 yrs. The Baseline is approximately 5-10 dB poorer than Annex B across all frequencies. Test 2 is poorer at the frequencies between 500-3000 Hz but then becomes consistent with Annex B beyond 3000 Hz (Appendix 11).

40 yrs. Both baseline and test 2 indicate poorer low frequency hearing than Annex B with the exception of the baseline becoming consistent with Annex B at 4000 Hz and test 2 consistent at 6000 Hz (Appendix 12).

50 yrs. The Baseline is slightly poorer between the frequencies of 500-1000 Hz and then becomes consistent with Annex B at 2000-6000 Hz. However, test 2, compared to Annex B, is poorer and varies greatly. The hearing levels at 4000 Hz are poorer than would be expected (Appendix 13).

60 yrs. Both baseline and test 2 are slightly poorer than Annex B at 500 and 1000 Hz . Beyond 1000 Hz both test become consistently better than Annex B.

The hearing levels are better than expected when compared to 50 yr. old age group (Appendix 14).

A colleague, Christina Maroun, performed a companion study, Occupational Noise Exposure and Hearing Conservation: Analysis of a local Hearing Conservation Program. In this study Maroun utilized the same experimental paradigm but with a different manufacturing company, Berco Industries, and concluded similar results. Maroun stated "...that variance between tests could be a result of test retest reliability. Variation in data may be another explanation for shifts in hearing" (2000, p.20). In general, both studies indicate that the personnel at both Lighthouse for the Blind and Berco Industries are receiving adequate protection from noise exposure. As Clark (1998) has emphasized, "...it should be remembered that, unlike other diseases or injuries, noise-induced hearing loss is preventable. It can be avoided by reducing excessive exposure, or by protecting our ears during exposure" (Clark, 348). While preventive measures can be defined and implemented, their impact cannot be successfully assessed or validated without giving serious consideration to enforce regulating, measuring, and defining occupational noise exposure impact.

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APPENDIX 1

COMPONENTS OF A HEARING CONSERVATION PROGRAM

...KEYS TO SUCCESS

Evaluation Of Hearing Loss

Baseline

- Audiometric Measurement
  - Certified Technician
  - Standardized Audiometer Calibration
- Individual History
  - Pre-Existing
  - Recreational

Monitoring

- Annual Testing Of Employees (Per OSHA) Exposed To Equal Or Greater Than 85dB with 5dB Exchange
- Standardized Equipment/Method
- Documentation in Personnel Files
- Employee Consultation/Treatment Referral When Appropriate

Exposure Assessment

- Consider All Sounds
- Determine Number of Hours of 85dB+ Daily/Shift
- Periodically Reassess Work Environment For Exposure Changes

Components of Hearing Conservation program (Appendix 1 Cont.)

Exposure Reduction

- Rotate Work Assignments
- Consider Noise When:
  - Purchasing New Equipment
  - Modifying Environment
  - Hiring/Relocating Personnel
- Consider Sound & Vibration Isolation in Site Design
  - Use Acoustical Absorption Methods
- Ensure New Equipment Meets Codes/Regulations
- Periodically Review Noise Control Technology Advancements

Employee Education

Training

- Hearing Protection Devices - Use, Fitting, Care
- OSHA, NIOSH, State Regulations
- Annual Updates/Reviews Followed By Program Evaluation

Meetings

- Employee Educational Updates

Components of a Hearing Conservation Program (Appendix 1 Cont.)

Written Materials

- Orientation Packet
- Employee Handbook
- Posters, Handouts, Etc.

Hearing Protection

- Mandatory Protection For Personnel
  - Maximum 85dBA
  - Consider Safety Hazards of Reduced Audibility
- Disciplinary Action for Non-Compliance
- Annual Hearing Protection Device Quality Assessment
- Periodic Review of New Hearing Protection Technology

APPENDIX 2

OSHA/NIOSH (Standards Compliance Summary)

OSHA (29CFR 1910.95)	NIOSH
✓Protection	
+90dBA/5dB Ex	+85dBA/3dB Ex
✓Controls	
+TWA 90dBA	+85dBA
-140dB Peak Impact	
✓Program & Monitoring	
✓Monitoring Results Notification	
+85db TWA/5dB Ex	3dB Ex
✓Audiometric Testing	
85dBA+ Available	Mandatory
Certified Tech	Certified Tech
Recommends Certification (20 hrs. of Training)	Not Exempted By MicroProcess Audiometers

OSHA/NIOSH (Appendix 2 Cont.)

✓Baseline Audiogram

Within 6 months (1yr - mobile van)	Within 30 days
14-hour Absence of Environment Noise	No Substitute w/protection
Adjust Per Annual	

✓Audiogram Evaluations

85dBA TWA+/5dB Ex	3dB Ex
Annual	
Baseline Comparison	-5% STS
STS 10dB @ 2K,3K,4K	15dBx2 Same
	Ear &Frequency
21day STS Notification	Immediate Notification

✓Test Requirements

Each Ear @ 500,1K,	And 8K Hz
2K,3K,4K,5K,6K Hz	
ANSI S3.6-1969	ANSI S3.6-1996
Functional Calibration Daily	

OSHA/NIOSH (Appendix 2 Cont.)

✓Test Requirements (Cont.)

Acoustical Check Annual

Thorough Calibration 2yrs

✓Protection

85dBA+ TWA Available	85dBA+ Mandatory
Attenuate to 90dBA or 85dBA w/STS	85dBA

✓Training

85dBA+ TWA

Annual Repeat/Update

✓Record keeping

Employee Info

Current Date & Last Date

Examiner Name

Date of Last Calibration

Test Room Noise Level

Retain While Employed	30 Years Post

APPENDIX 3

Appendix D of 29 CFR 1910.95 OSHA: Environments Inside Audiometric Test Rooms versus ANSI Environments Standards

Sound Pressure Level (dB)	**Octave-Band Center Frequency (Hz)**				
	500	1000	2000	4000	8000
Appendix D	40	40	47	57	62
ANSI (3.1- 1991)	19.5	26.5	28	34.5	43.5

Source: American National Standards Institute, Inc. (1996).

Appendix 4 Noise Exposure Impact

The Difference Between Annex B and Baseline Audiograms from Lighthouse for the Blind

Annex B of ANSI 3.44-1966

Hearing Threshold Level dB (re: ANSI S-3.6)

Frequency Hz.	Age (Years) 30			40			50			60		
	Fractiles 0.9	0.5	0.1	0.9	0.5	0.1	0.9	0.5	0.1	0.9	0.5	0.1
Males												
500	-1	7	15	0	8	19	1	10	21	2	12	26
1000	-5	0	10	-4	3	15	-3	5	16	-2	6	21
2000	-4	2	13	-3	4	19	-2	8	28	0	10	43
3000	-1	9	30	2	13	41	5	19	51	9	30	62
4000	-1	10	38	4	17	50	8	26	54	12	36	68
6000	8	18	48	11	24	62	17	31	62	22	46	80
Females												
500	-1	6	15	0	7	19	1	10	23	4	14	29
1000	-6	1	9	-5	2	13	-4	4	16	-2	7	21
2000	-6	0	10	-4	2	13	-2	6	23	0	8	29
3000	-4	4	13	-2	6	18	0	9	26	6	16	37
4000	-5	4	16	-4	6	18	-1	9	26	4	17	43
6000	3	12	25	5	15	31	8	20	45	15	29	57

Lighthouse for the Blind Baseline Tests

Hearing Threshold Level dB (re: ANSI S-3.6)

Frequency Hz.	Age (Years) 30			40			50			60		
	0.9	0.5	0.1	0.9	0.5	0.1	0.9	0.5	0.1	0.9	0.5	0.1
MALES		31			33			22			14	
500	5	15	25	10	15	30	10	20	30	10	15	35
1000	0	5	25	10	15	30	10	15	35	5	15	25
2000	0	5	25	10	15	30	10	15	35	5	15	25
3000	0	10	20	0	10	25	5	7	40	0	15	35
4000	0	10	25	5	15	40	10	15	40	10	25	55
6000	0	15	25	5	20	55	15	30	50	15	32	65
FEMALES		10			16			6			6	
500	10	17	30	5	12	30	17	25	5	5	17	25
1000	2	12	17	5	12	30	10	12	15	10	12	15
2000	2	10	17	0	5	25	5	5	15	5	5	15
3000	0	10	22	0	10	20	5	10	15	5	10	15
4000	0	10	20	0	5	15	10	12	20	10	12	20
6000	2	15	32	5	20	30	5	12	25	5	12	25

Appendix 4 Noise Exposure Impact

The Difference Between Annex B and Baseline Audiograms from Lighthouse for the Blind

The Difference Between Annex B
and Lighthouse for the Blind Baseline Tests
Hearing Threshold Level dB (re: ANSI S-3.6)

Frequency Hz.	Age (Years) 30			40			50			60		
	0.9	0.5	0.1	0.9	0.5	0.1	0.9	0.5	0.1	0.9	0.5	0.1
MALES												
500	-6	-8	-10	-10	-7	-11	-9	-10	-9	-8	-3	-9
1000	-5	-5	-15	-14	-12	-15	-13	-10	-19	-7	-9	-4
2000	-4	-3	-12	-13	-11	-11	-12	-7	-7	-5	-5	18
3000	-1	-1	10	2	3	16	0	12	11	9	15	27
4000	-1	0	13	-1	2	10	-2	11	14	2	11	13
6000	8	3	23	6	4	7	2	1	12	7	14	15
FEMALES												
500	-11	-11	-15	-5	-5	-11	-16	-15	18	-1	-3	4
1000	-8	-11	-8	-10	-10	-17	-14	-8	1	-12	-5	6
2000	-8	-10	-7	-4	-3	-12	-7	1	8	-5	3	14
3000	-4	-6	-9	-2	-4	-2	-5	-1	11	1	6	22
4000	-5	-6	-4	-4	1	3	-11	-3	6	-6	5	23
6000	1	-3	-7	0	-5	1	3	8	20	10	17	32

Appendix 5 Noise Exposure Impact

The Difference Between Annex B and Test 3 for Lighthouse for the Blind Males
Annex B of ANSI 3.44-1966

Hearing Threshold Level dB (re: ANSI S-3.6)

Frequency Hz.	Age (Years) 30			40			50			60		
	Fractiles 0.9	0.5	0.1	0.9	0.5	0.1	0.9	0.5	0.1	0.9	0.5	0.1
Males												
500	-1	7	15	0	8	19	1	10	21	2	12	26
1000	-5	0	10	-4	3	15	-3	5	16	-2	6	21
2000	-4	2	13	-3	4	19	-2	8	28	0	10	43
3000	-1	9	30	2	13	41	5	19	51	9	30	62
4000	-1	10	38	4	17	50	8	26	54	12	36	68
6000	8	18	48	11	24	62	17	31	62	22	46	80

Lighthouse for the Blind Test 3 for Males

Hearing Threshold Level dB (re: ANSI S-3.6)

Frequency Hz.	Age (Years) 30			40			50			60		
	Fractiles 0.9	0.5	0.1	0.9	0.5	0.1	0.9	0.5	0.1	0.9	0.5	0.1
MALES												
500	10	15	30	10	20	55	12	20	45	5	22	25
1000	5	10	35	5	17	45	10	17	60	5	15	30
2000	0	5	55	5	10	45	2	17	70	5	10	40
3000	0	5	55	0	10	45	12	20	62	5	20	45
4000	0	10	50	5	12	40	10	30	62	5	32	55
6000	0	15	50	5	20	60	10	27	65	15	40	65

The Difference Between Annex B
and Lighthouse for the Blind test 3 for Males
Hearing Threshold Level dB (re: ANSI S-3.6)

	Age (Years) 30			40			50			60		
	Fractiles											
MALES	0.9	0.5	0.1	0.9	0.5	0.1	0.9	0.5	0.1	0.9	0.5	0.1
500	-11	-8	-15	-10	-12	-36	-11	-10	-24	-3	-10	1
1000	-10	-10	-25	-9	-14	-30	-13	-12	-44	-7	-9	-9
2000	-4	-3	-42	-8	-6	-26	-4	-9	-42	-5	0	3
3000	-1	4	-25	2	3	-4	-7	-1	-11	4	10	17
4000	-1	0	-12	-1	5	10	-2	-4	-8	7	4	13
6000	8	3	-2	6	4	2	7	4	-3	7	6	15

Appendix 6 Noise Exposure Impact

The Difference Between Annex B and Test 2 from Lighthouse for the Blind Females
Annex B of ANSI 3.44-1966

Hearing Threshold Level dB (re: ANSI S-3.6)

Frequency	Age (Years)											
Hz.	30			40			50			60		
	Fractiles											
	0.9	0.5	0.1	0.9	0.5	0.1	0.9	0.5	0.1	0.9	0.5	0.1
Females												
500	-1	6	15	0	7	19	1	10	23	4	14	29
1000	-6	1	9	-5	2	13	-4	4	16	-2	7	21
2000	-6	0	10	-4	2	13	-2	6	23	0	8	29
3000	-4	4	13	-2	6	18	0	9	26	6	16	37
4000	-5	4	16	-4	6	18	-1	9	26	4	17	43
6000	3	12	25	5	15	31	8	20	45	15	29	57

Lighthouse for the Blind Test 2 for Females

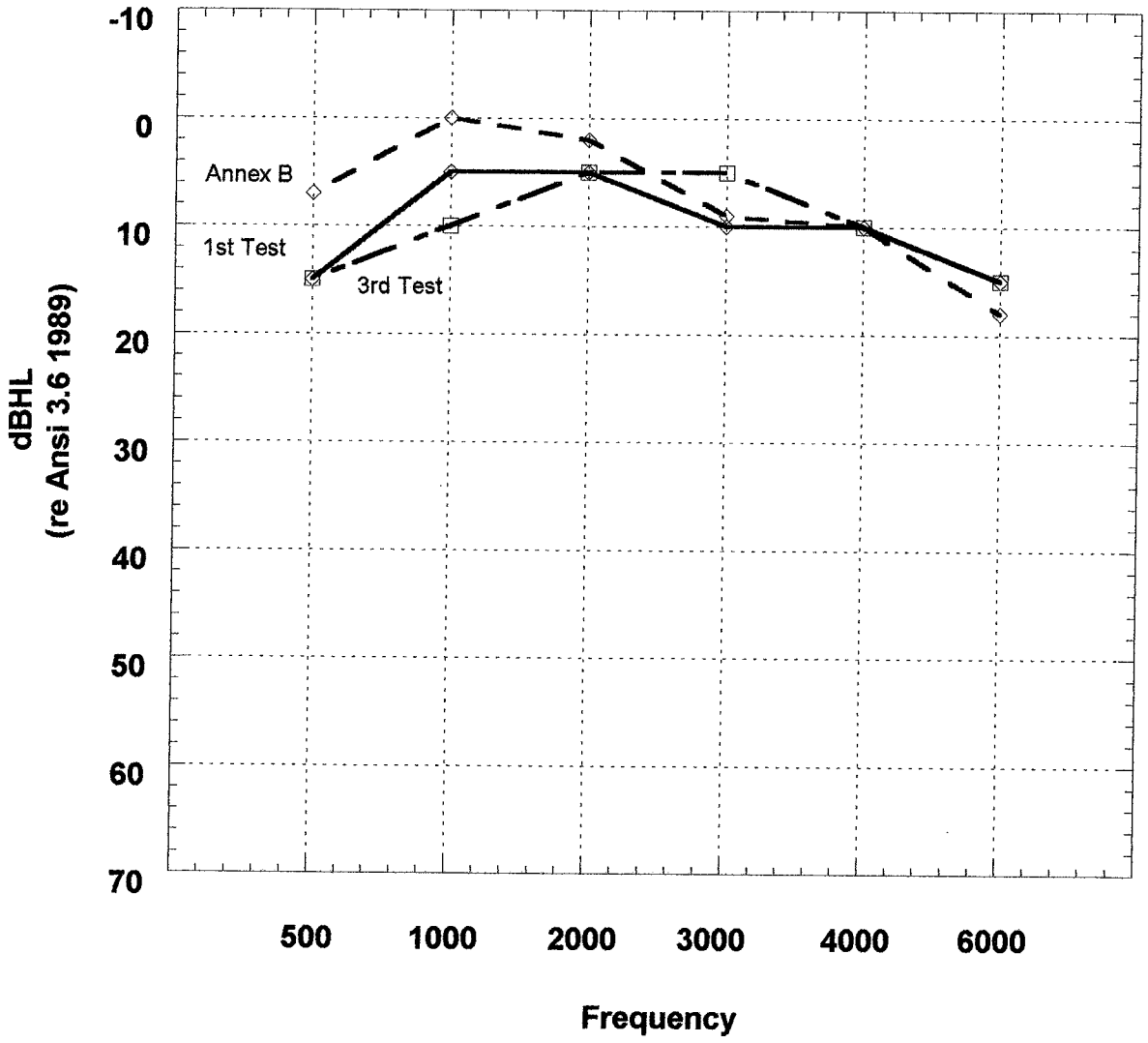
Hearing Threshold Level dB (re: ANSI S-3.6)

Frequency	Age (Years)											
Hz.	30			40			50			60		
	Fractiles											
	0.9	0.5	0.1	0.9	0.5	0.1	0.9	0.5	0.1	0.9	0.5	0.1
FEMALES												
500	15	20	30	5	22	35	15	27	40	10	15	20
1000	10	15	15	0	15	55	15	20	25	5	10	35
2000	5	10	15	0	5	30	10	12	15	0	5	40
3000	0	5	20	0	12	15	10	12	15	0	5	50
4000	0	5	15	0	12	25	20	22	25	5	15	45
6000	5	10	15	0	12	25	15	20	25	10	15	50

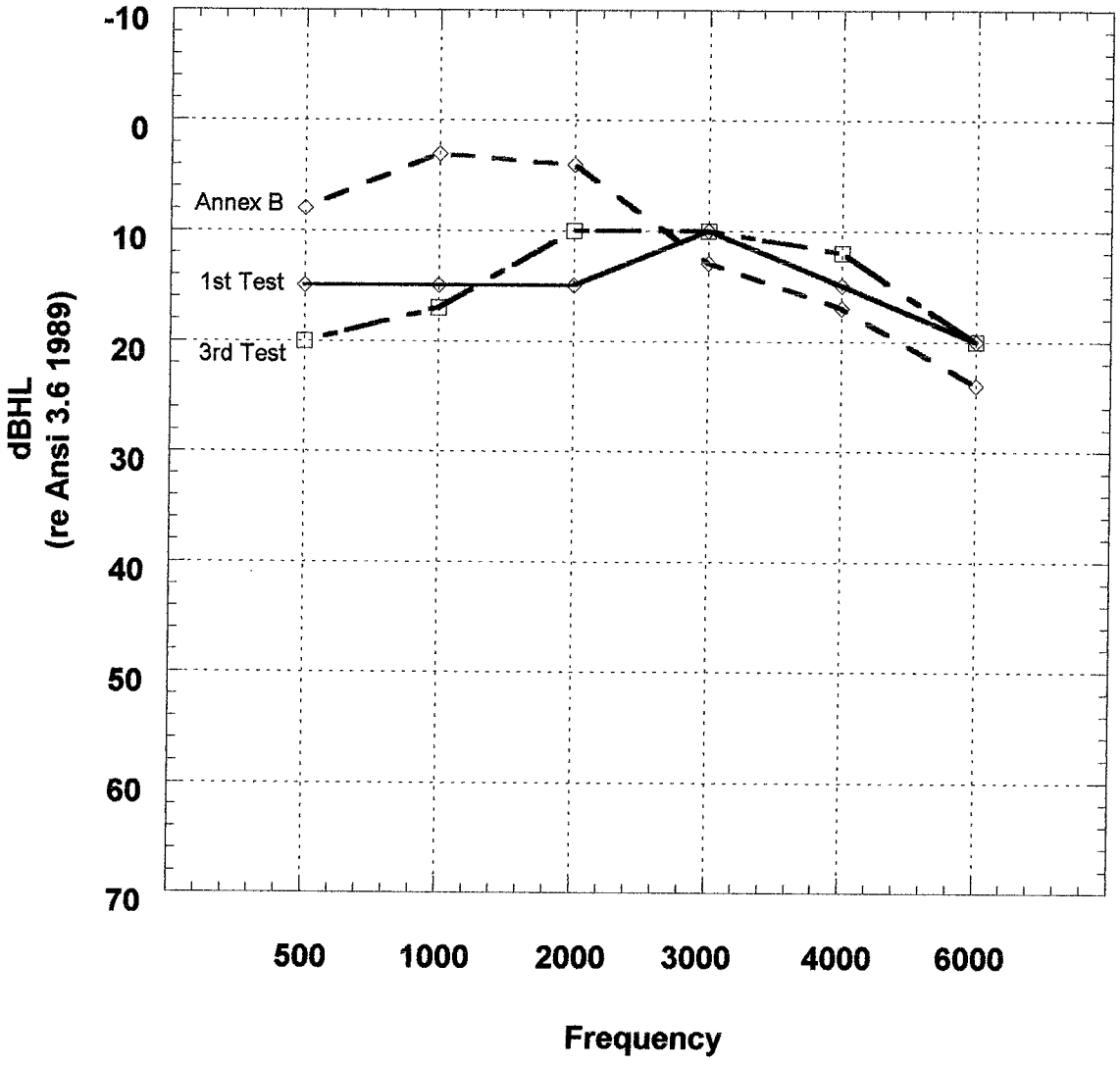
The Difference Between Annex B
and Lighthouse for the Blind test 2 for Females
Hearing Threshold Level dB (re: ANSI S-3.6)

	Age (Years)											
	30			40			50			60		
	Fractiles											
FEMALES	0.9	0.5	0.1	0.9	0.5	0.1	0.9	0.5	0.1	0.9	0.5	0.1
500	-16	-14	-15	-5	-15	-16	-14	-17	-17	-6	-1	9
1000	-16	-14	-6	-5	-13	-42	-19	-16	-9	-7	-3	-14
2000	-11	-10	-5	-4	-3	-17	-12	-6	8	0	3	-11
3000	-4	-1	-7	-2	-6	3	-10	-3	11	6	11	-13
4000	-5	-1	1	-4	-6	-7	-21	-13	1	-1	2	-2
6000	-2	2	10	5	3	6	-7	0	20	5	14	7

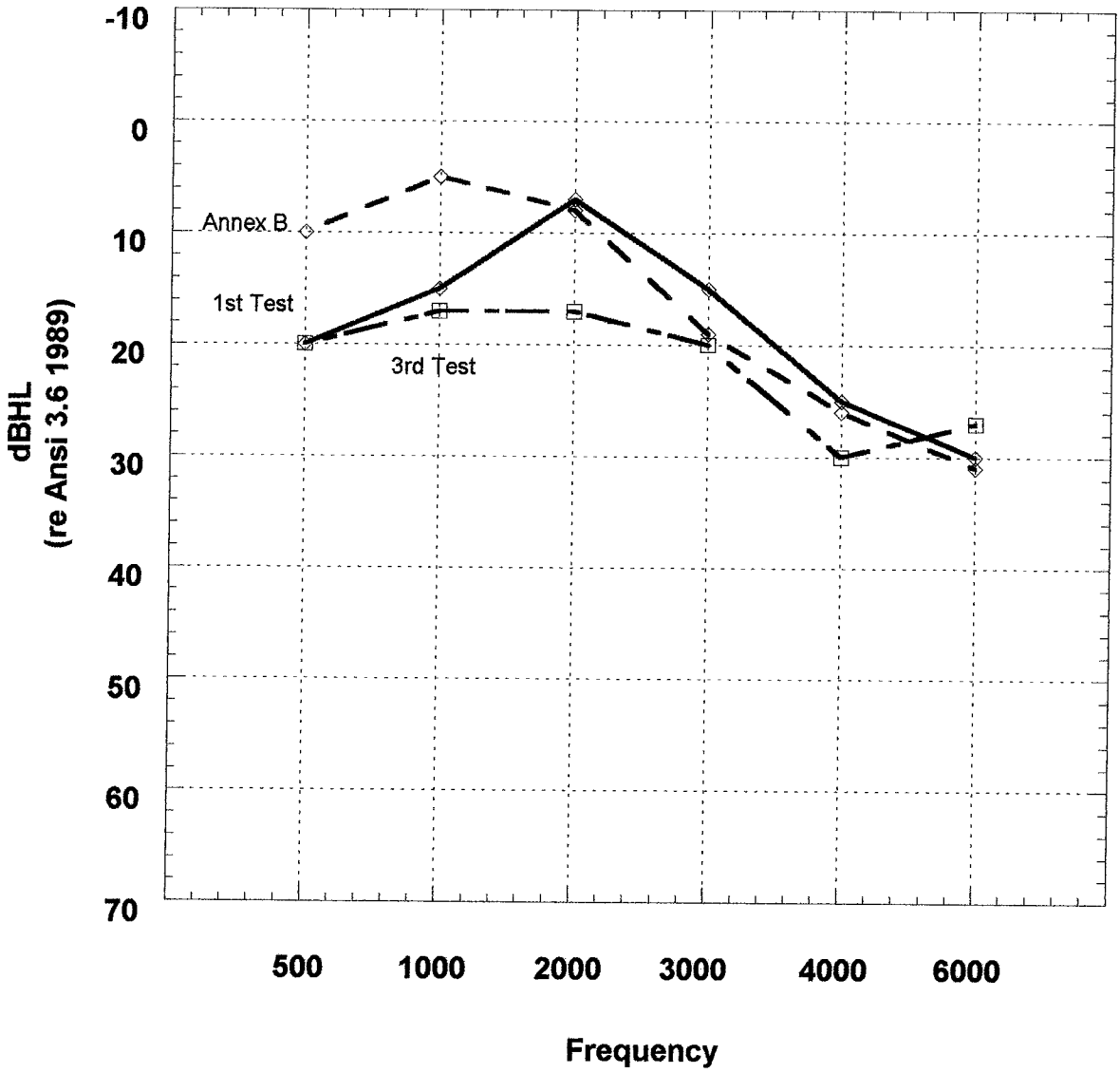
Appendix 7-Noise Exposure Impact
LHB Comparisons of Hearing Levels at the 50%tile for 30 Year Old Male Employees Utilizing the 1st and 3rd Tests and Annex B of Ansi S3.44-1996



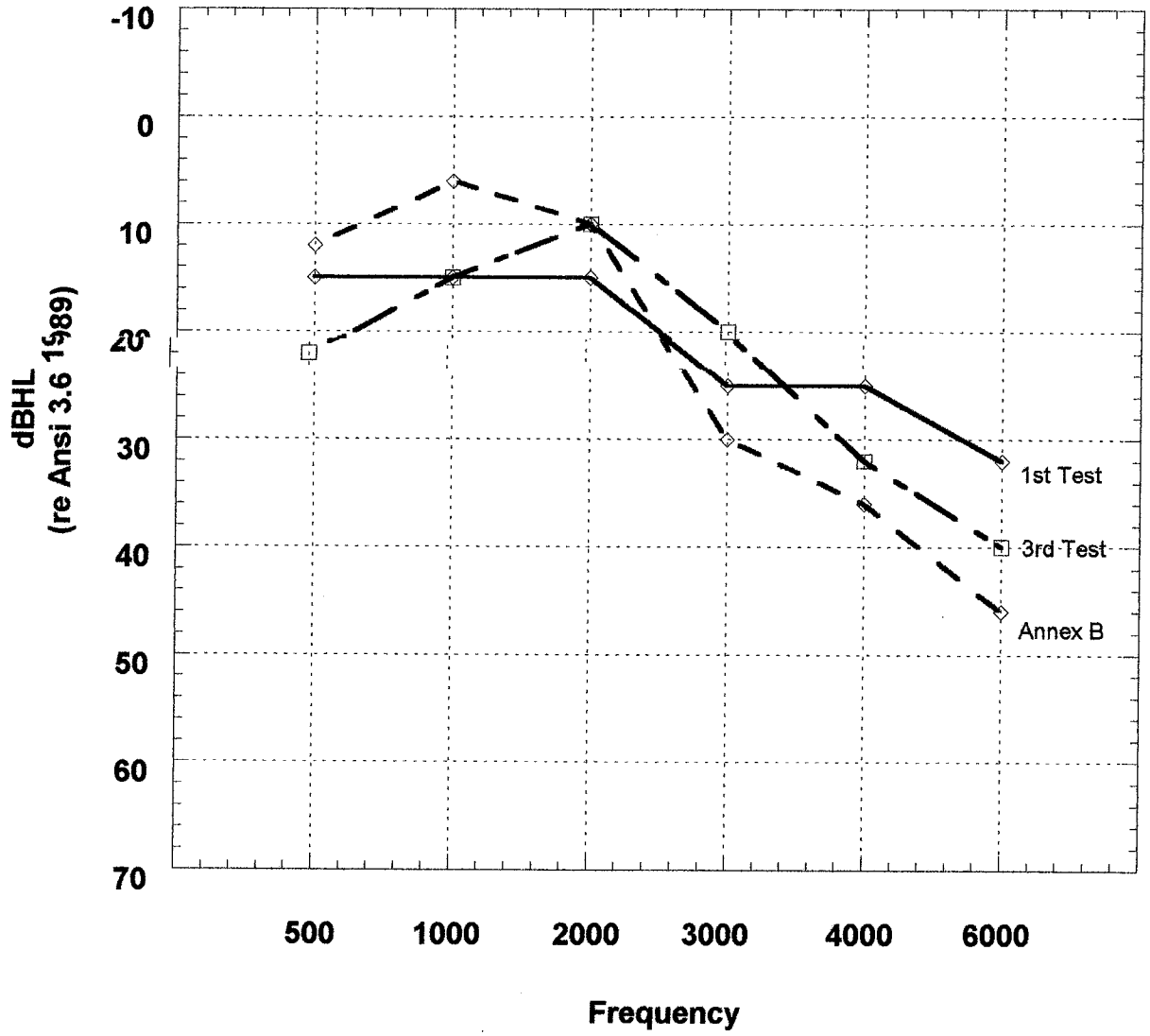
Appendix 8-Noise Exposure Impact
LHB Comparisons of Hearing Levels at the 50%tile for 40 Year Old Male Employees Utilizing the 1st and 3rd Tests and Annex B of Ansi S3.44-1996



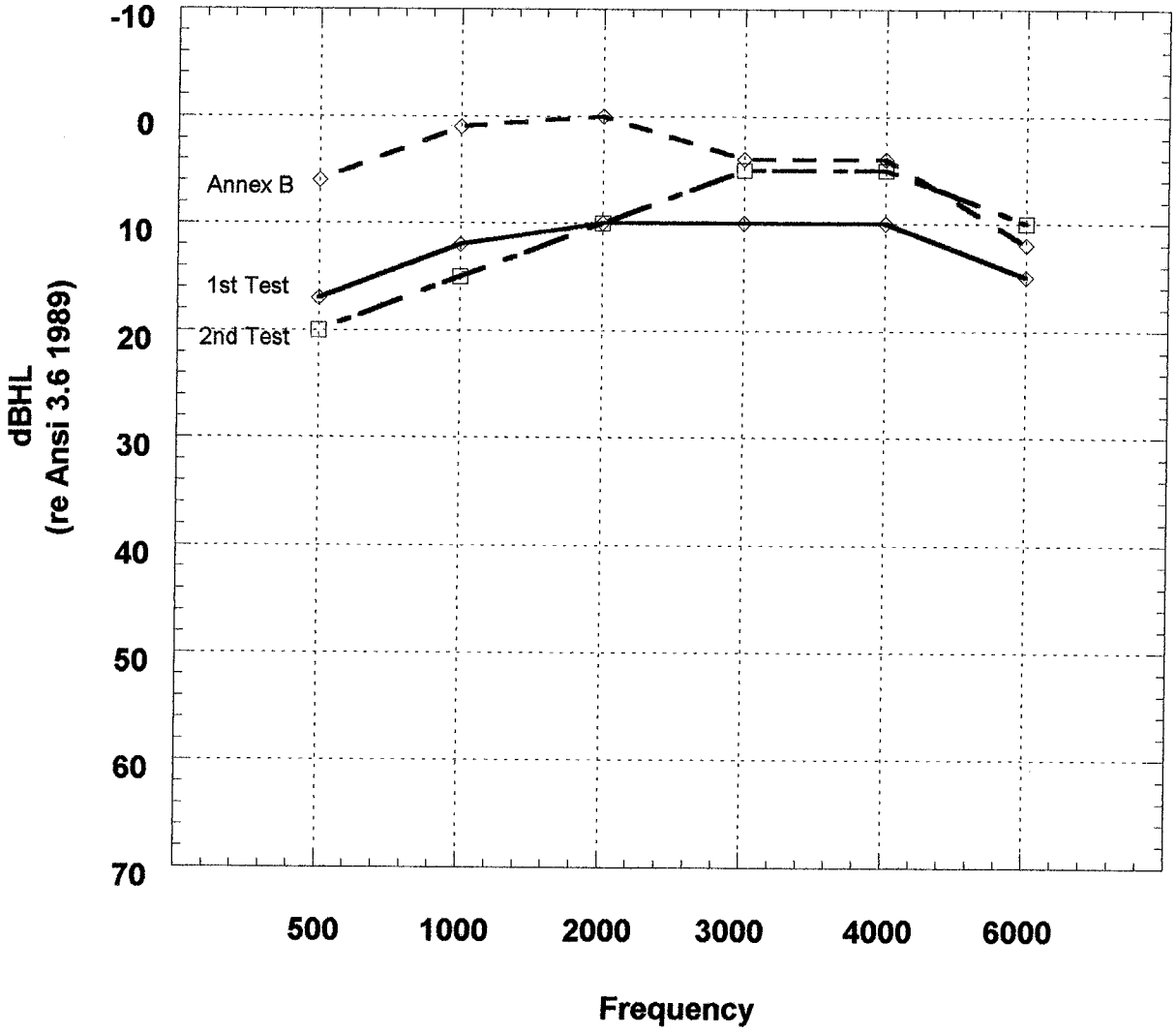
Appendix 9-Noise Exposure Impact
LHB Comparisons of Hearing Levels at the 50%tile for 50 Year Old Male Employees Utilizing the 1st and 3rd Tests and Annex B of Ansi S3.44-1996



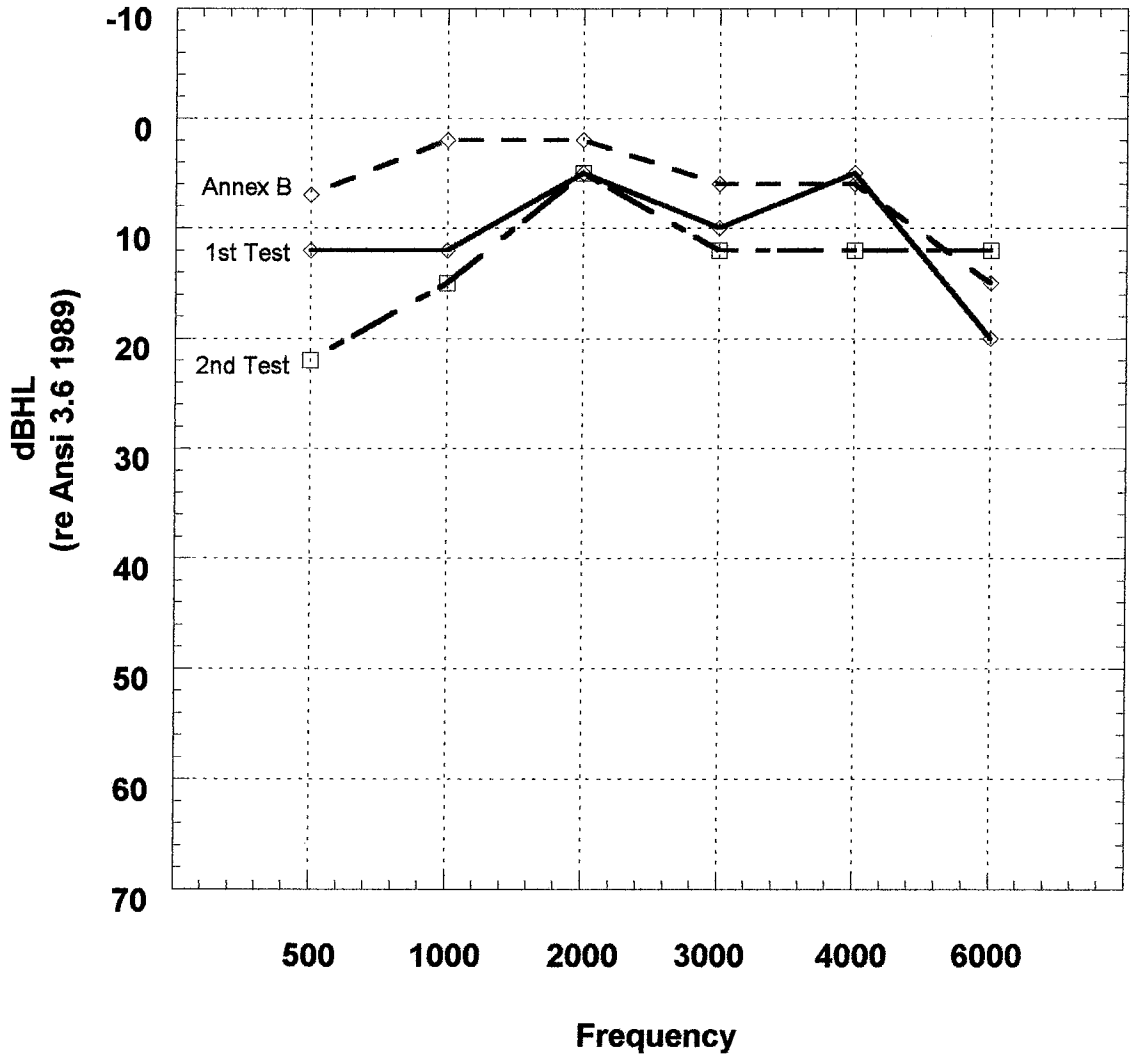
Appendix 10-Noise Exposure Impact
LHB Comparisons of Hearing Levels at the 50%tile for 60 Year Old Male Employees Utilizing the 1st and 3rd Tests and Annex B of Ansi S3.44-1996



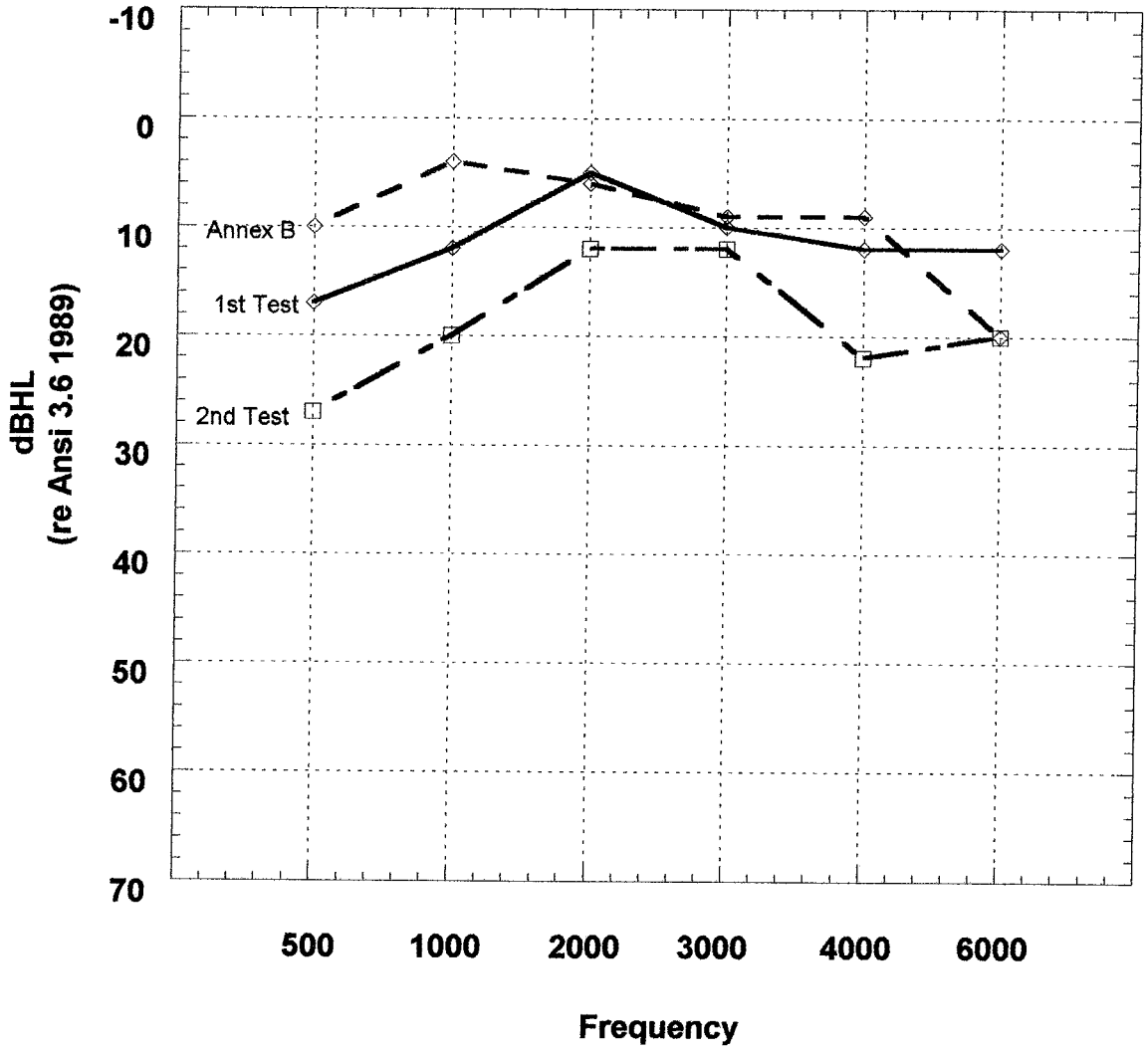
Appendix 11-Noise Exposure Impact
LHB Comparisons of Hearing Levels at the 50%tile for 30 Year Old Female Employees Utilizing the 1st and 2nd Tests and Annex B of Ansi S3.44-1996



Appendix 12-Noise Exposure Impact
LHB Comparisons of Hearing Levels at the 50%tile for 40 Year Old Female Employees Utilizing the 1st and 2nd Tests and Annex B of Ansi S3.44-1996



Appendix 13-Noise Exposure Impact
LHB Comparisons of Hearing Levels at the 50%tile for 50 Year Old Female Employees Utilizing the 1st and 2nd Tests and Annex B of Ansi S3.44-1996



Appendix 14-Noise Exposure Impact
LHB Comparisons of Hearing Levels at the 50%tile for 60 Year Old Female Employees Utilizing the 1st and 2nd Tests and Annex B of Ansi S3.44-1996