NIOSH SURVEY OF OCCUPATIONAL NOISE AND HEARING:

1968 to 1972

by

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The occupational noise and hearing survey (ONHS) was begun in 1968 by the U. S. Public Health Service as a long-range project of what was then called the National Noise Study, with operations based at the Bureau of Occupational Safety and Health in Cincinnati, Ohio. With the creation of the National Institute for Occupational Safety and Health (NIOSH) in December 1970, the survey program was continued by the Noise Section of the NIOSH Physical Agents Branch.

The aim of the occupational noise and hearing survey was to characterize noise exposure levels in a variety of industries, to describe the hearing status of workers exposed to such noise conditions, and ultimately to establish a relationship between occupational noise level and hearing loss that would be applicable to general industry. The survey program was publicized at industrial hygiene conferences and through a variety of other means. Interested companies were invited to request that they be included in the study. All plants that requested noise and hearing evaluations were considered. Certain priority considerations were applied, however. The existence of factory or occupational noise conditions having critical relevance to criteria, and the presence of a work force presenting a wide range of years of exposure to such noise were the main factors. Initial discussions with plant management or union officials and preliminary walk-through noise surveys provided the basis for making such judgments.

Principally four types of data were collected during the course of a noise and hearing survey at a given plant. These included noise measurements, background personal-occupational information, medical and otologic data, and audiometric data. These data were obtained during the normal work day with minimal hindrance to plant function or operation. Members of the survey team took noise level readings at different points in the plant and took tape recordings for subsequent laboratory analysis of noise characteristics. A questionnaire form was used to obtain information bearing on each worker's job history, military service, hobbies, and medical history pertinent to ear abnormalities and hearing difficulty. An otoscopic inspection of the ears was made, usually just after the questionnaire was completed. Measurements of the hearing levels for pure-tone frequencies in the right and left ears of the workers were accomplished in a mobile audiometric test van.

The plan of the study was to concentrate on workers in noisy areas. An attempt was made to test the entire work force at plants having a total of less than 500 employees. In larger plants sampling and selection were done on a random basis. All participation in the hearing survey was strictly voluntary, however all workers selected for the study were strongly encouraged to participate. Although the study concentrated upon noise exposed workers, employees from each plant who worked in offices or other quiet work areas were also included in the survey in order to obtain control data.

The noise and hearing data were sorted and analyzed so as to illuminate the relationship between occupational noise levels and hearing losses in worker groups classified by number of years of occupational noise exposure and by employee age. This report, which provides background information and results of statistical analysis, is intended to complement the data analysis that has already been published in the NIOSH document: "Criteria for a Recommended Standard. . . Occupational Exposure to Noise".

Dr. Alexander Cohen served as Chief of the National Noise Study, and led the occupational noise and hearing survey from the time of its inception until the establishment of the Physical Agents Branch. Herbert H. Jones served as Associate Chief of the National Noise Study and later as Chief of the Physical Agents Branch. Other staff members who participated in the survey during 1968 to 1972 included Thomas Anania, Joseph R. Anticaglia, M.D., Paul Carpenter, Earl Carroll, Stephen Cordle, Terry L. Henderson, Ph.D., Bruce Margolis, Ph.D., Barry L. Lempert, B. Thomas Scheib, Mark Schmidek, and Daryl P. Ting.

I. NOISE SURVEY

I-1. Equipment and Calibration

Surveys of environmental noise levels were made using a variety of sound level meters and other instruments. Although efforts focused upon determination of single, representative dBA levels, measurements were also made to determine noise spectra in octave and third-octave bands, statistical distribution of noise levels, temporal characteristics of fluctuating noises, peak pressures of impact or impulsive sounds, repetition rate and duration of impact sounds, directional or position-dependent characteristics, and durations of noise bursts. The following electronic instruments were used at various times during the survey:

Bruel-Kjaer Sound Level Meters:

Types 2203, 2204, 2204S, 2205

Bruel-Kjaer Octave Filter Sets; Type 1613

Bruel-Kjaer Piston phones; Type 4220

General Radio Sound Level Meter; Type 1565-A

General Radio Calibrator; Type 1562

Nagra III Full-track Magnetic Tape Recorder

General Radio Impact Noise Analyzer; Type 1556-B

Bruel-Kjaer Level Recorder; Type 2305

Bruel-Kjaer Statistical Distribution Analyzer; Type 4420

General Radio 1926 Real-Time Spectrum Analyzer

Tektronix Storage Oscilloscope; Type 564B, with Camera

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Calibration routine: Sound level meters were acoustically calibrated at least once on each day measurements were made. Usually an acoustical calibrator was carried with each sound level meter, and used to provide a calibration check before each measurement series. Battery voltage levels were checked frequently. All of the sound level meters used in the study were found to be quite reliable and consistent, seldom requiring adjustment of more than 1/4 dB. Each tape recording included a pistonphone-generated test tone and a voiced announcement of the attenuator setting of the sound level meter for subsequent calibration of laboratory analysis instruments during playback. Instruments used to measure peak pressure of impact sounds were calibrated using a 127 dB-peak pistonphone tone (124 dB-RMS).

I-2. Noise Measurement Procedures

Noise level samples were taken in order to assess the daily noise exposures of those workers included in the study. A preliminary occupational noise survey often provided the information needed to develop a sampling schedule. Such a survey was a part of the initial inspection of a plant for which a noise and hearing survey had been requested. The following items were obtained, when possible, in each area of a plant: (1) Location and type of operation or work performed; (2) General noise characteristics (e.g., impulsive, steady-state, low frequency, etc.); (3) Temporal characteristics (continuous, fluctuating, intermittent, etc.); (4) Overall noise levels using the "A", "C" and "linear" scales of the sound level meter.

Microphone placement: To obtain representative and reliable exposure values,

noise level measurements were taken alongside workers in the course of their daily job routines. Care was taken to avoid positioning the microphone too close to a reflecting or shielding surface. In many cases a worker was asked to stand aside and the sound level meter was positioned at the point normally occupied by the worker's head. Several measurements were made of different locations to determine spatial dependence of noise levels. Estimates of the median and range of levels were recorded whenever the level showed significant variation with position.

Spectrum Measurements: Standard procedures included some measurement of typical noise spectra for each of the noise and hearing surveys in the series, either by field measurement of octave band levels or spectral analysis of recorded tapes, or both. Octave band analyses included bands with mid-frequencies of 31.5, 63, 125, 250, 500, 1000, 2000, 4000, and 8000 Hz. Recorded tapes were played back through an octave band filter set or through a third-octave band, real-time analyzer.

Sequential Sampling

Toward the latter part of the survey series, a technique was developed for making field measurements of dBA level at intervals of 15 seconds during a period of ten minutes. This technique was found to be very useful in those areas where the dBA level evidenced significant, random variations with time. The procedure is described briefly as follows: a compact, lightweight sound level meter is selected. A pocketwatch or wrist-watch having a large sweep-second hand is taped to the face of the sound level meter, either just above or just below the meter dial. The bottom

of the sound level meter is then positioned at the top end of an ordinary clipboard. The bottom edge of the clipboard is rested against the belt or hip of the person making the measurements. One hand is used to support the sound level meter/clipboard combination at an angle that is convenient for recording data on the clipboard with the other hand, and also positions the sound level meter for convenient viewing, pointed away from the person's body at an angle of about 45° above the horizontal. For measurements at 15 second intervals, the sound level meter deflection is noted at precisely each instant that the second-hand crosses 12, 3, 6, or 9 o'clock. The sound level at each instant is recorded by marking a dot at the appropriate location on a special histogram form attached to the clipboard. At the end of a measured 10-minute period, the histogram form will contain 40 dots. The form can be kept for subsequent analysis at a more convenient time or location. It is a fairly simple matter to obtain the mean, median, and quartile levels, and a good estimate can be made of the entire statistical distribution. This measurement technique was found to be quite successful, although a few precautions had to be observed to avoid biasing the data. Analysis of the data was greatly facilitated by programming a Monroe type 1766 electronic calculator to compute the mean and variance of the recorded levels, and also to compute the projected daily noise exposure factor according to the Walsh-Healey formula.

Tape Recordings: All tape recordings were made by connecting the signal output from a sound level meter to the input of the Nagra tape recorder. The sound level meter was set to "Linear" response. Tape

speeds of 15, 7-1/2, and 3-3/4 inches-per-second were used, depending upon the noise spectrum and the duration desired for the recording. The duration of most recordings ranged from 10 to 60 minutes, depending upon the nature of the noise source. In many cases tape recordings were made simultaneously with other field measurements. Tape recordings were used (a) to obtain octave and third-octave band spectra; (b) to obtain probability distributions of dBA level; (c) to provide a record of the repetition rate of impact sounds; (d) to obtain plots of dBA level vs. time for time-study analyses; and (e) to provide a cross check with field measurements.

Statistical Distribution Analysis: The Bruel-Kjaer type 4420 Distribution Analyzer, in conjunction with the type 2305 level recorder, was used to obtain the probability distribution of dBA levels over a selected time interval. Due to the bulk and weight of this equipment, it was not carried into the field; tape recordings were used.

Analysis for Impact Sounds: Whenever it was apparent that impact sounds were present, measurements of peak-pressure levels were made. If the impacts occurred so rapidly as to blend together, then the noise was regarded as being essentially continuous. The B & K 2204S Impact Meter was the primary instrument used to measure peak pressure levels.

I-3. Determination of Noise Exposure Patterns

In order to determine the daily noise exposure for a worker or worker group it was necessary to interview workmen and supervisors as to the typical workday pattern. In some cases time-study charts were prepared,

segmenting the workday into a succession of exposures at specific noise levels and for specified durations.

Discussions with both management and workmen were necessary to determine changes in workmen's noise exposures over the course of many years. Variations in occupational noise conditions, due to machinery replacement or relocation, or changes of job or location of workers, were necessary considerations.

II. HEARING SURVEY PROCEDURES

II-1. Equipment and Calibration

All audiometric testing was done in a Rudmose Audiometric Travel Lab Model RA-113. This audiometric van housed an acoustically isolated, sound-deadened chamber in which six persons could be tested simultaneously. The physical layout of the van is shown in Figure 1.

A Rudmose RA-108 pure tone, air conduction, six-man audiometer was used to present test tones at frequencies of 500, 1000, 2000, 3000, 4000, and 6000 Hz, first to the left ear and then to the right ear of e· a listener. The audiometric test sequence included 30 seconds at each test frequency. Each test subject, using a button switch, could control the loudness of the tone so as to oscillate about his threshold level with all such oscillations being traced on individual audiogram cards. Standard procedure included calibration of the audiometer by means of a Bruel-Kjaer artificial ear (Type 4152) and a Bruel-Kjaer precision sound level meter (Type 2203) with octave filter (Type 1613) both before and after a survey. Audiometric frequency checks were performed periodically using a digital frequency counter. Typical calibration data are shown in Table 1. Listening tests were performed frequently to detect any miscellaneous audiometer malfunctions.

Test sounds were presented through TDH-39 earphones with MX-41/AR ear cushions enclosed in otocups to eliminate the possibility of masking by ambient noise, although ambient noise levels were within the limits specified in the ANSI S3.1-1960 (R 1971) standard for Background Noise in Audiometer Rooms with the air-conditioning and power generation systems in full operation. Typical results of an acoustical survey of ambient noise in the audiometric test chamber are shown in Table 2.

FIGURE 1

Audiometric Travel Lab.
6-Man Configuration

SCALE: APPROX. 1/4" = 10"

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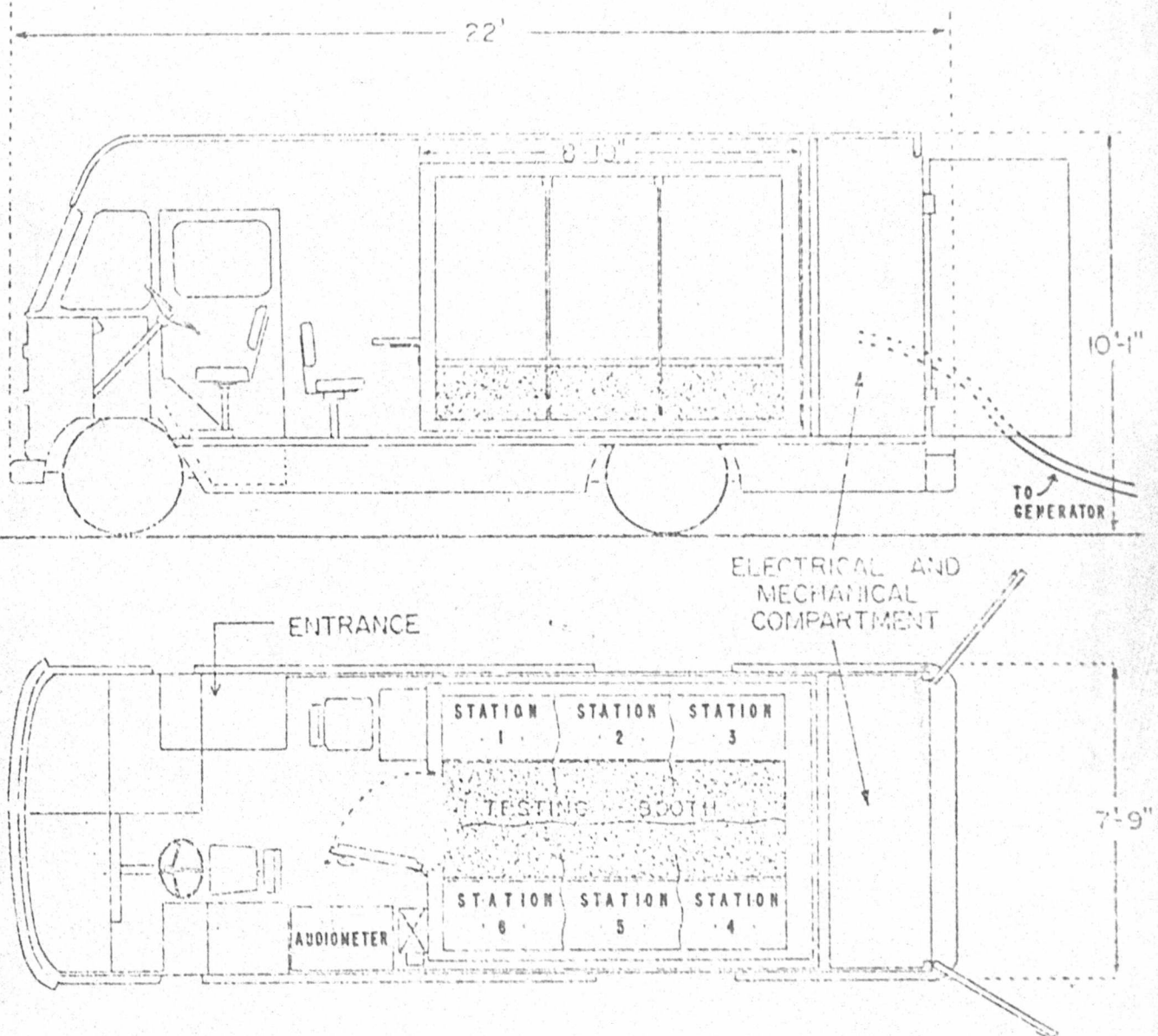
TABLE 1 TYPICAL POST-CALIBRATION DATA (1-31-69)

STATION	EAR	SOUND PRESSURE LEVELS* IN dB (re. 0.0002 dynes/cm^2) BY FREQUENCY IN HERTZ					
		500 (490)	1000 (1004)	2000 (2020)	3000 (3017)	4000 (4007)	6000** (5987)
1	L	11.9	6.9	9.1	10.3	9.3	5.5
1	R	11.4	7.0	9.1	10.2	9.4	5.8
2	L	11.6	7.1	9.1	9.8	9.3	5.6
2	R	11.6	7.1	9.0	9.9	9.5	5.5
3	L	11.3	6.6	8.5	9.6	9.0	5.5
3	R	11.1	6.6	8.8	9.3	9.0	5.0
4	L	11.3	6.6	8.6	9.5	9.1	5.4
4	R	11.2	6.7	8.6	9.4	9.0	5.4
5	L	11.7	7.0	9.1	10.0	9.3	5.7
5	R	11.6	7.0	8.9	10.0	9.8	5.4
6	L	11.3	6.6	8.6	9.6	9.1	5.4
6	R	11.3	6.8	8.8	9.4	9.1	5.1

Standard Audiometric Reference from ANSI S3.6-1969, Table F1

(11.5)	(7.0)	(9.0)	(10.0)	(9.5)	(5.5+10)	

*Pressure levels shown are equal to CSPL minus HL, where CSPL denotes
the Coupler Sound pressure level measured in an NBS Type 9A microphone
coupler (B & K type 4152), and HL denotes the hearing level as indicated
by the audiometer pen. All data shown here were taken with the
audiometer pens set to the 70 dB lines on the audiogram cards.

**At 6000 Hz in both ears, the audiometer was always calibrated 10dB low.
Appropriate corrections were made to audiometric threshold data.

TABLE 2   AMBIENT NOISE LEVELS IN AUDIOMETRIC TEST CHAMBER (1-22-71)

STATION	AIR BLOWER	SOUND PRESSURE LEVELS IN dB (re. 0.0002 dynes/cm^2) OCTAVE BAND CENTER FREQUENCY IN HERTZ				
		500	1000	2000	4000	8000
2	ON	32	31	30	30	30
4	ON	37	30	30	—	—
4	OFF	14	12	10	10	10

Maximum allowable SPL (re. ANSI S3.1)

		(40)	(40)	(47)	(57)	(67)

II-2. Hearing Test Procedure

The administration of a hearing test began with an instruction session
during which each subject was seated at one of the test stations and
familiarized with the audiometric procedure. The wording of the instructions
varied slightly during the series of surveys; however, the instruction
lecture shown below is typical of those used.

> "Take the earphones and black cord off the hook over
> your seat and hold them in your hands. Different sounds
> will be heard in the left phone and then in the right
> phone. Press the switch button (show the switch button)
> and keep it pressed until the sound fades away. At the
> instant it disappears, release the switch until you hear
> the sound again. When the sound reappears, no matter how
> faint, press the switch and keep it pressed so as to make
> it fade away again. Do this for all the sounds that you
> will hear. Are there any questions? (Pause. Ask those
> wearing glasses or earrings to remove them and those having
> long hair to pull their hair back behind their ears.)
> Place the earphones over your ears, being sure that the
> red earphone is on the right ear and the black one is on the
> left ear. (Check to make sure that the earphones are
> correctly placed over the ears). We will give you a
> little while to practice, and then if everything is working
> okay we will go right ahead with the test, which will take
> about seven minutes. Remember: Whenever you hear the
> sound press the switch and keep it pressed until the sound
> fades away. When it disappears, release the switch until
> you hear it again. When it comes back again, no matter
> how faint, press the switch and keep it pressed until
> it fades away."

It should be noted that the test instructor checked each subject's
earphones for proper placement and made sure that the ear cushions were
adequately sealed against the subject's head. Early during the course of
the occupational hearing survey series it was decided that a short practice
delay should also be given at the beginning of testing in the right ear.
The purpose of this delay was to allow time for the audiometer pen to move
from a large hearing loss at 6000 Hz in the left ear to a good threshold at

500 Hz in the right ear. This delay was achieved by manual activation of an override switch on the audiometer, and became a part of standard audiometric procedure.

Each noise-exposed subject was tested before the beginning of his workshift to avoid the possibility of temporary noise-induced hearing loss. Test scheduling usually required subjects to arrive for work 75 or 45 minutes early, depending upon the scheduling sequence for the audiometric test, otoscopic examinations, and individual data questionnaire. Non-noise exposed workers, such as office workers, were tested at any time during the work shift since their pre-test noise exposures were not considered significant enough to produce a temporary threshold shift.

III. EXCLUSION OF DATA FROM THE SCREENED SAMPLE

For a variety of reasons it was necessary to exclude some of the noise and hearing data from the analysis so that a valid statistical relationship could be developed relating hearing loss and occupational exposure to noise at known levels. The two basic criteria for data exclusion were: (a) uncertainty as to noise exposure history or validity of audiograms, and (b) evidence that hearing loss might have been caused by some factor other than occupational noise exposure. The term "exclusion" will be used to indicate deletion of a worker's test data from the analysis.

The questionnaire form presented in the appendix* was administered to each subject who was given a hearing test. The following text summarizes the evaluation procedure used to develop a "screened sample" for each of the occupational noise and hearing surveys.

1. Data was excluded from the screened sample if a subject's previous job history included two or more years of other work assignments in a noisy job.

2. A military history which included number of years in the service; number of years in combat; type of job performed; and weapon firing history, was obtained for each subject. Exclusions were based upon: (a) exposure to weapons-type noise for 100 days or more, (b) one or more years of actual combat experience, and (c) routine daily exposure to non-weapon type noise, e.g., noise from aircraft engines or armored vehicles for two years or more. However, those few workers who wore ear protection in such noise fields were not necessarily eliminated in the screening process.

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* The questionnaire form was revised during the course of the study. However the revised form was not substantially different.

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3. Consideration was given to non-occupational noise exposure, including the extent of civilian weapon use and the frequency and duration of participation in such activities as motorbike riding, mechanized farming, piloting an airplane, machine workshop activity, and sport car or drag racing. Firearm shooters exposed to 1000 rounds per year for one or more years, or 500 rounds per year for five or more years with no use of ear protectors were also exluded. Any subject who participated in a noisy off-job hobby besides shooting was excluded if this participation was at least three times per week for one year or more.

4. An exclusion from the screened sample was made if there was history of severe head trauma, chronic ear infection, of evidence of hereditary deafness in the family. Certain other conditions, e.g., Meniere's disease; use of ototoxic drugs; history of previous ear surgery; concurrent severe head colds; or tinnitus at the time of testing also meant exclusion.

5. An otoscopic examination of the aural canal and eardrum was made by a staff physician or trained audiologist to determine the presence of visible abnormalities. Any indication of congenital or acquired ear malformations, totally impacted cerumen, perforated or severely scarred tympanic membrane or an active ear involvement, e.g., otitis media, were grounds for exclusion of subject data from the screened sample.

6. If the subject had not been out of the working environment for 14 hours or more or if he had significant noise exposure prior to taking the audiometric test, he was excluded.

7. Exclusions based on audiometric irregularities included: (a) audiograms revealing as much or greater low frequency hearing loss as high frequency loss (suspected conductive loss) in one or both ears; (b) hearing losses in one ear were 40 dB greater than the other ear at two or more test frequencies; or (c) subject evidently responding to tinnitus rather than the tone presentation.

Whenever it was determined that one of the above criteria applied, the worker was assigned an appropriate exclusion code. No more than three exclusions were coded for any single worker. Table 3 lists exclusion categories used in coding, and also lists the number of workers who "failed" the criteria for each category, expressed as a percentage of the total number of subjects (3699). Also listed is the percentage of workers who failed at least one of the criteria (listed as "All categories").

The exclusion criteria discussed above were used to develop screened samples of data sufficient to estimate the impact of industrial noise exposures upon the occupational groups included in the individual noise and hearing surveys. However, for the composite occupational noise and hearing survey (ONHS) analysis, which sought to accurately determine the risk to hearing as a function of noise level, additional exclusion criteria were applied. In particular, hearing level data were excluded for workers for whom there was insufficient noise exposure data. Workers exposed to noise consisting of discrete impact sounds, or noise having highly variable and unpredictable levels, were not included in the

TABLE 3

EXCLUSION CATEGORIES

Category	FACTOR	WORKERS EXCLUDED
Exposure History	Previous Job History	11.9%
	Military Weapon Noise	8.6%
	Military History	4.4%
	Civilian Weapon Noise	3.6%
	Civilian History	1.5%
	Pre-test Noise Exposure	0.9%
Medical History	History of Trauma/Fracture	1.9%
	Recent Middle Ear Infection	2.0%
	Ear Surgery	2.7%
	Tinnitus/Labyrinthine Disorder	2.3%
	Family History	0.7%
Otological Examination	Severe Occlusion	1.4%
	Perforation	0.5%
	Scar Tissue	0.7%
	Calcerous Deposits	0.1%
	Inflamed Drum	0.1%
	Malformation/Growth	0.7%
	Other**	5.0%
All Categories		35.0% *

* The percentage listed here is <u>not</u> equal to the sum of the percentages
 listed for each individual category, because many of the workers
 failed more than one of the exclusion criteria.

** "Other" includes miscellaneous factors, e.g., mechanized farming,
 use of various forms of medication, audiometric irregularities, etc.

composite analysis. All maintenance workers were excluded because it
was impossible to quantify their noise exposures. Furthermore, only
male workers were used in the composite analysis. Current evidence
indicated statistical differences between the prevalence of hearing
loss found in male and female populations; thus, the relatively small
sample of female noise-exposed workers (N = 110) was segregated, but was
not large enough to permit valid analysis.

Population totals used in the composite occupational noise and
hearing survey (ONHS) study are presented in Table 4. The individual
survey totals, however, do not include those individuals who were
rejected from the sample because of an incomplete questionnaire; an
apparent misunderstanding of the procedure of the hearing test; or
mechanical failure of the audiometer. From the total of 3699 subjects,
65% were included in the screened samples; and 23% (or 49% of the screened
sample) were included in the composite ONHS analysis.

Table 5 contains summary abstracts of the individual noise and
hearing surveys conducted during the years 1968-1972. This table includes
a tabluation of numbers of tested subjects, classified by job or department,
and also lists the numbers of subjects utilized in the composite ONHS
study. The numbers listed under the heading, "Number in Screened Group"
indicate those workers surviving the screening criteria. Also included
are the median dBA levels for the various job groups used in the composite
data analysis. Typical octave band spectra are shown in Figures 2 and 3.

Survey	Company	Subjects Tested	Subjects in Screened Sample	Subjects in Composite ONHS Study Non-Noise Exposed Males	Females	Noise Exposed Males
I	Steel Fabricating & Processing	605	471	110	19	122
II	Paper-Bag Making	194	158	6	10	17
III	Printing	154	133	31	20	63
IV	Aluminum Fabricating & Processing	138	95	10	13	64
V	Quarry	96	63	3	10	42
VI	Woodworking	308	177	20	11	113
VII	Hydro-Electric Power	340	204	7	3	0
VIII	Steel Fabricating	368	266	32	5	8
IX	Tunnel Patrol	173	121	16	22	48
X	Printing and Engraving	185	100	41	23	29
XI	Printing	800	403	104	70	203
XII	Tunnel Patrol	306	201	--	--	63
XIII	Trucking	32	20	--	--	20
	Totals	3699	2412	380	206	792

TABLE 4 MAKEUP OF COMPOSITE ONHS STUDY

TABLE 5

INDIVIDUAL SURVEY DATA

Survey I: Steel Fabricating and Processing

Notes: Some of the hearing test subjects worked in areas for which no noise surveys could be performed, and thus were not included in the composite ONHS study. Typical octave band spectra are shown in Figure 2 .

Job (Department)	Number of Subjects Tested	Number in Screened Group	Composite ONHS Study	
			Number of Subjects	Median Sound Level (dBA)
Office	180	151	110	<80
Maintenance	86	65		
Open Hearth	30	24	16	82
T & L	9	7		
Shipping	16	11		
Processing	42	37	7	92
			2	93
			6	94
			3	95
Hot Strip Mill	94	75		
Zinc Grip	26	22	1	83
			2	86
			14	88
			3	89
Strip Pickler & Cold Reduction	17	14	4	89
			4	95
Galvanizing	9	7		
Blast Furnace	49	39	38	92
			12	94
Power	19	14	4	88
			1	91
Round House	12	9		
Basic Oxygen	10	9	5	80
Totals	605	490	232	

TABLE 5

Continuation (2)

Job (Department)	Number of Subjects Tested	Number in Screened Group	Composite ONHS Study	
			Number of Subjects	Median Sound Level (dBA)
Survey II: Paper-Bag Making Company				
Office	18	16	6	<80
Bag & Handle Making	36	27	5	95
Square Bag	19	11	5	92
Handle Insertion	68	58	2	90
			2	80
Shipping & Pkg.	28	24		
Preprinting & Twisting	25	22		
Totals	194	158	23	
Survey III: Printing Company				
Office	49	42	23	< 80
Press	38	35	35	94
Bailing	2	2	2	93
Bindery No. 1	21	19	6	85
Bindery No. 2	8	7	7	86
Maintenance	8	6		
Mailing	17	13	13	81
Composing; Warehouse	11	9	8	< 80
Totals	154	133	94	

Survey II: Paper-Bag Making Company

Notes: Workers in bag making are generally exposed to noise from repeated impacts of many cutting knives which produce a steady-state background noise. Typical octave band spectra are shown in Figure 2.

Survey III: Printing Company

Notes: The configuration of the presses and other noise sources was known to have remained unchanged over a period of many years, thus prividing well-controlled, long-term exposures to steady state noise. Typical octave band spectra are shown in Figure 2.

TABLE 5
Continuation (3)

Job (Department)	Number of Subjects Tested	Number in Screened Group	Composite ONHS Study Number of Subjects	Median Sound Level (dBA)
Survey IV: Aluminum Fabricating and Processing Plant				
Office	33	23	10	< 80
Press Operators	14	9	9	93
Asst. Press-men	16	10	10	94
Stretchers; Sawyers	35	23	23	93
Dummy Block Men	15	14	14	9'
Tailstock	11	8	8	88
Crane Operators & Misc.	14	8		
Totals	138	95	74	
Survey V: Quarry				
Office	21	13	3	< 80
Burner Op's.	5	3		
Ledgermen	21	13	13	102
Quarry Workers	7	5	5	96
Wire Saw Op's.	11	7	7	81
Saw Shed Workers	14	10	10	98
Shed Workers	10	7	7	94
Maintenance	7	5		
Totals	96	63	45	

Survey IV: Aluminum Fabricating and Processing Plant

Notes: All workers at this location were given audiometric tests. There was very little variation in dBA level and noise spectrum. Typical octave band spectra are shown in Figure 2 .

Survey V: Quarry

Notes: Noise levels remained rather constant during the 8-hour day. Typical octave band spectra are shown in Figure 2 .

TABLE 5

Continuation (4)

	Job (Department)	Number of Subjects Tested	Number in Screened Group	Composite ONHS Study	
				Number of Subjects	Median Sound Level (dBA)
Survey VI: Woodworking Company	Office	37	24	13	< 80
	Warehouse, Yard, & Kiln Workers	38	23	7	77
Notes: Although dBA-slow sound level measurements varied in some areas, statistical analysis indicated high repeatability or median levels. Typical octave band spectra are shown in Figure 2 .	Door, Ladder, & Lamination Section	94	49	39	88
	Rough & Finish Mill	139	31	74	94
	Totals	308	177	148	
Survey VII: Hydroelectric Power Plant	Office	60	43	7	< 80
	Shift & Ass't. Shift Engineers	16	13		
Notes: Unfortunately, because of the highly intermittent nature of the noise and changing locations of the workers, the noise-exposed workers could not be included in the Composite ONHS Study.	Unit & Ass't. Unit Op's	36	28		
	Auxiliary Operators	11	9		
	Laborers	43	15		
	Coal Foremen, Conveyor & Heavy Equip't. Operator	20	9		
	Electricians	19	6		
	Machinist & Instrument Mech's.	40	32		
	Boilermakers & Boiler Welders	29	15		
	Steam Filters	34	18		
	Switchboard Op's.	6	5		
	Janitors, Painters, Misc.	26	11		
	Totals	340	204	7	

TABLE 5
Continuation (5)

Job (Department)	Number of Subjects Tested	Number in Screened Group	Composite ONHS Study	
			Number of Subjects	Median Sound Level (dBA)
Survey VIII: Steel Fabricating Company				
Office	48	37	32	< 80
Shear Operators	51	39		
Asst. Shear Op's.	31	21		
Bender Operators	51	32		
Asst. Bender Op's.	48	35		
Hookers, Loaders, Checkers	43	34		
Welders	9	8	8	88
Supervisors	44	30		
Crane Op's.	43	30		
Totals	368	371	40	

Notes: A very substantial amount of noise survey data was gathered, including many tape recordings. Third-octave band spectrum analyses and dBA-level probability distribution analyses were performed. Additionally, 78 steelworkers were given post exposure audiometric exams to determine the presence of temporary threshold shift. Of all noise-exposed workers t. ted, only the welders could be included in the composite ONHS study because of the highly intermittent nature of the other noise. Typical octave band spectra for the welders are shown in Figure 3 .

Job (Department)	Number of Subjects Tested	Number in Screened Group	Number of Subjects	Median Sound Level (dBA)
Survey IX: Tunnel Patrol				
Office	50	37	16	< 80
Tunnel Patrol	61	48	48	86
Toll Collectors	58	34		
Maintenance	4	2		
Totals	173	121	64	

Notes: Patrolmen typically spent 6-7 hours per day in protective booths at various locations inside the tunnel. Typical octave band spectra are shown in Figure 3 .

TABLE 5
Continuation (6)

	Job (Department)	Number of Subjects Tested	Number in Screened Group	Composite ONHS Study	
				Number of Subjects	Median Sound Level (dBA)
Survey X: Printing and Engraving Company	Computer Services	20	12	11	<80
Notes: Most operators of high noise level machinery used this machinery only for short periods during the day, and were not included in the composite ONHS study. Typical octave band spectra are shown in Figure 3 .	Negative Engravers	33	23	8	<80
	Photographers	31	17	12	<80
	Compositors	13	4	3	<80
	Relief Map Makers	18	7	7	<80
	Pressmen	42	25	25	90
	Shredder Operators	4	3		
	Carpenters	8	4		
	Relief Model Reproducers	7	1	1	92
	Bindery Workers	9	4	3	81
	Totals	185	100	70	
Survey XI: Printing Company	Office	281	174	104	<80
Notes: Noise survey data gathered from many different locations indicated a very constant, steady-state environment in the press rooms. Typical octave band spectra are shown in Figure 3 .	Bindery Workers	133	50	37	86
	Offset Pressmen	115	39	39	87
	Main Press	195	86	86	87
	Postal Card Section	4	0		
	Carpentry	18	13		
	Monocasting	54	41	41	91
	Totals	800	403	307	

TABLE 5
Continuation (7)

	Job (Department)	Number of Subjects Tested	Number in Screened Group	Composite ONHS Study	
				Number of Subjects	Median Sound Level (dBA)
Survey XII: Tunnel Patrol	Tunnel Patrol	87	63	63	86
Notes: Similar to Survey IX. A large quanity of dBA level probability distribution data was obtained. Typical octave band spectra are shown in Figure ~ .	Tunnel Patrol & Service Garage Work	38	25		
	Office Workers (& mixed jobs)	40	32		
	Electricians	1	0		
	Toll Collectors	117	64		
	Maintenance	23	17		
	Totals	286	201	63	
Survey XIII: Trucking Company	Drivers	32	20	20	89

Notes: Drivers indicated that they usually traveled 7-9 hours per day. Spaced-sample measurements of in-cab noise levels were made to obtain probability distribution of dBA levels. Typical octave band spectra are shown in Figure 3 .

Figure 2

TYPICAL OCTAVE BAND SPECTRA
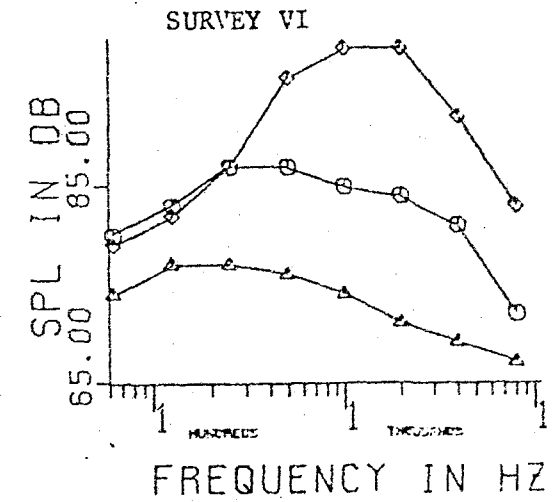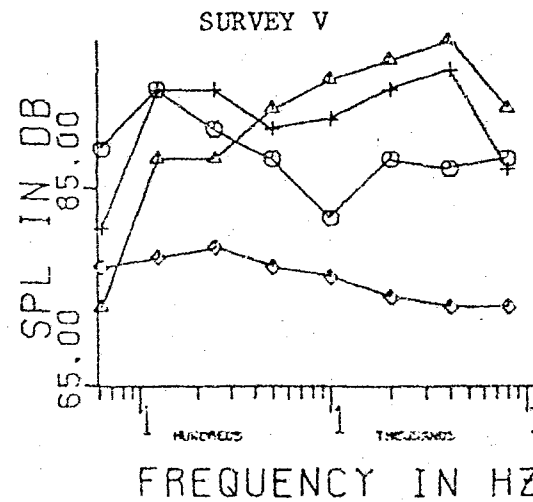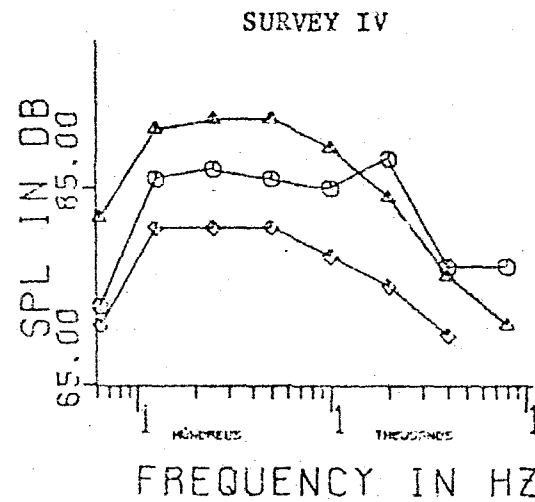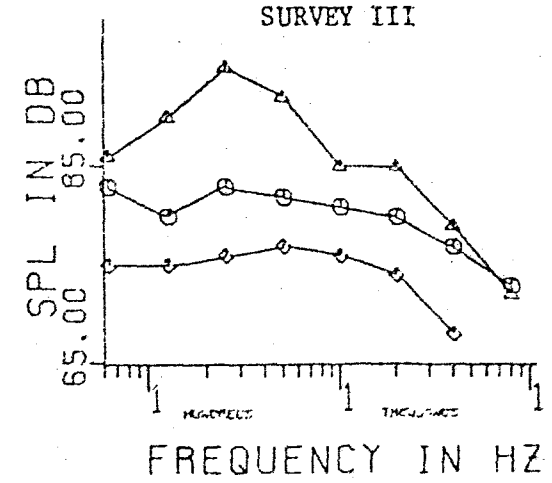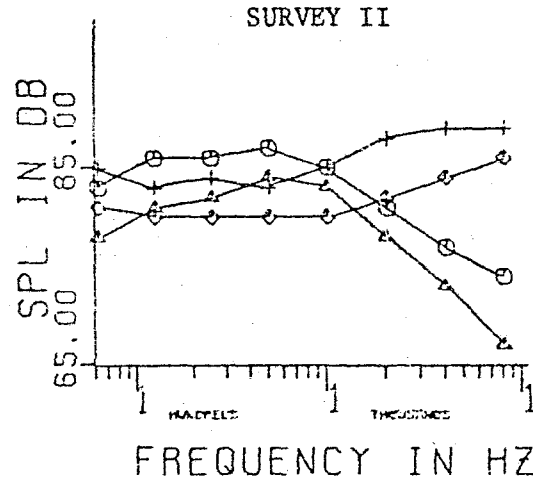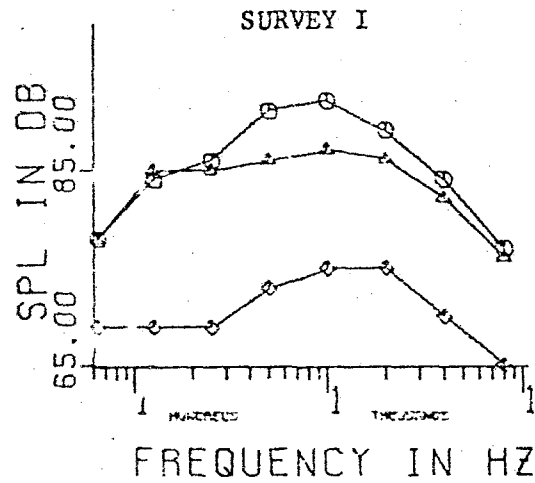
Figure 3

TYPICAL OCTAVE BAND SPECTRA

28
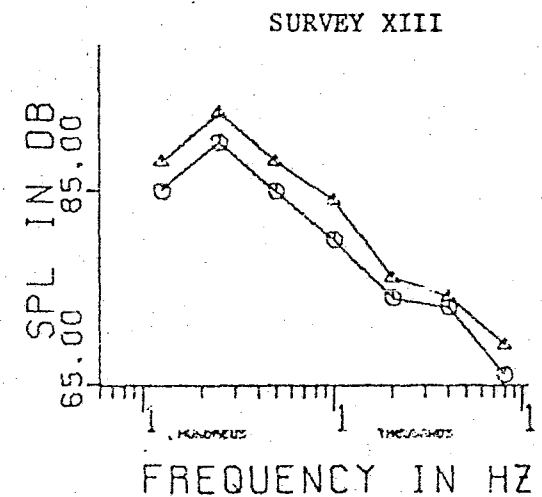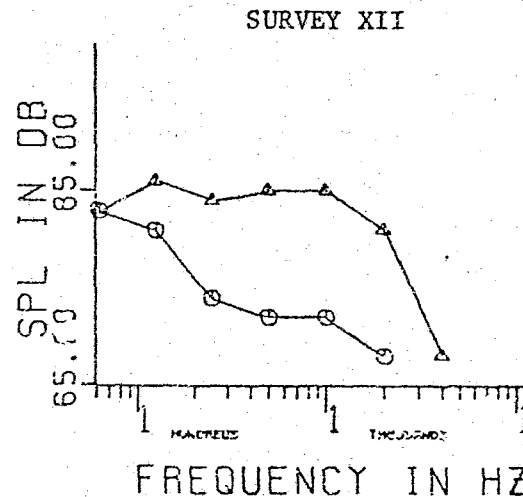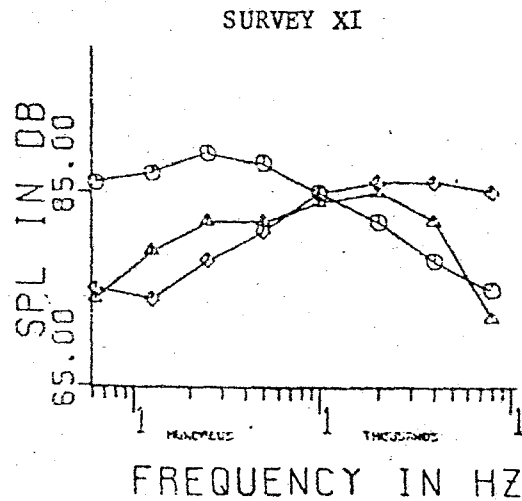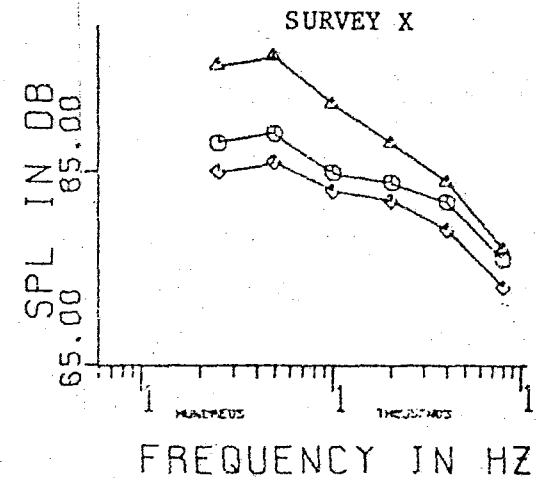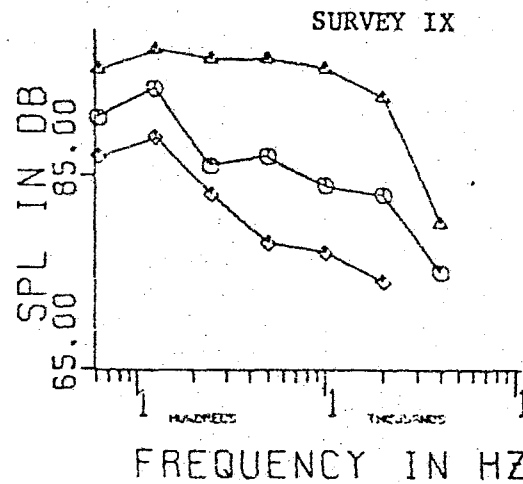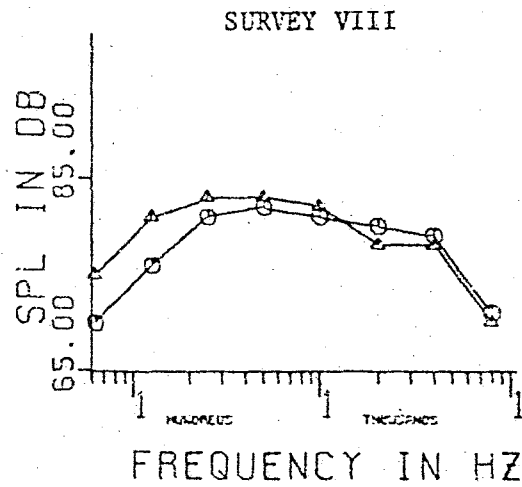
V. HEARING LEVELS OF NON-NOISE EXPOSED PERSONS

In order to use the hearing level statistics of the non-noise exposed

persons as normal or baseline statistics for comparison with the noise

exposed populations, a mathematical model was developed to generate hearing

level statistics for a population of non-noise exposed persons having any

specified distribution of ages. The model was based on the presence of

a Gaussian distribution of the logarithm of [hearing level + K], with age

as a parameter, where K is a constant which depends upon frequency, i.e.,

K = K(f) where f is the audiometer test frequency in Hertz. In fact

linear regression of log [hearing level + K] on age proved to accurately

fit the hearing level data of non-noise exposed workers (i.e., those

working in noise levels <80 dBA). For each of the six audiometer fre-

quencies, K was selected to provide homogeneity of the variance of hearing

level data about the regression line. Hearing levels were averaged over

left and right ears.

Figures 4 - 8   illustrate centile distributions of the male,

non-noise exposed, raw hearing level data split into five age groups.

(Each age group contains the same number of workers.) These figures also

show centile distributions generated by the mathematical model, utilizing

the actual distributions of ages within each age group, by a method which

will be described below. The data generated by the model are termed

"Smoothed Data" in the figures.

At the 10%, 25%, and 50% (or median) levels, comparisons of model

versus raw data indicate agreement to within 3 dB; at the 75% and 90%

FIGURE 4

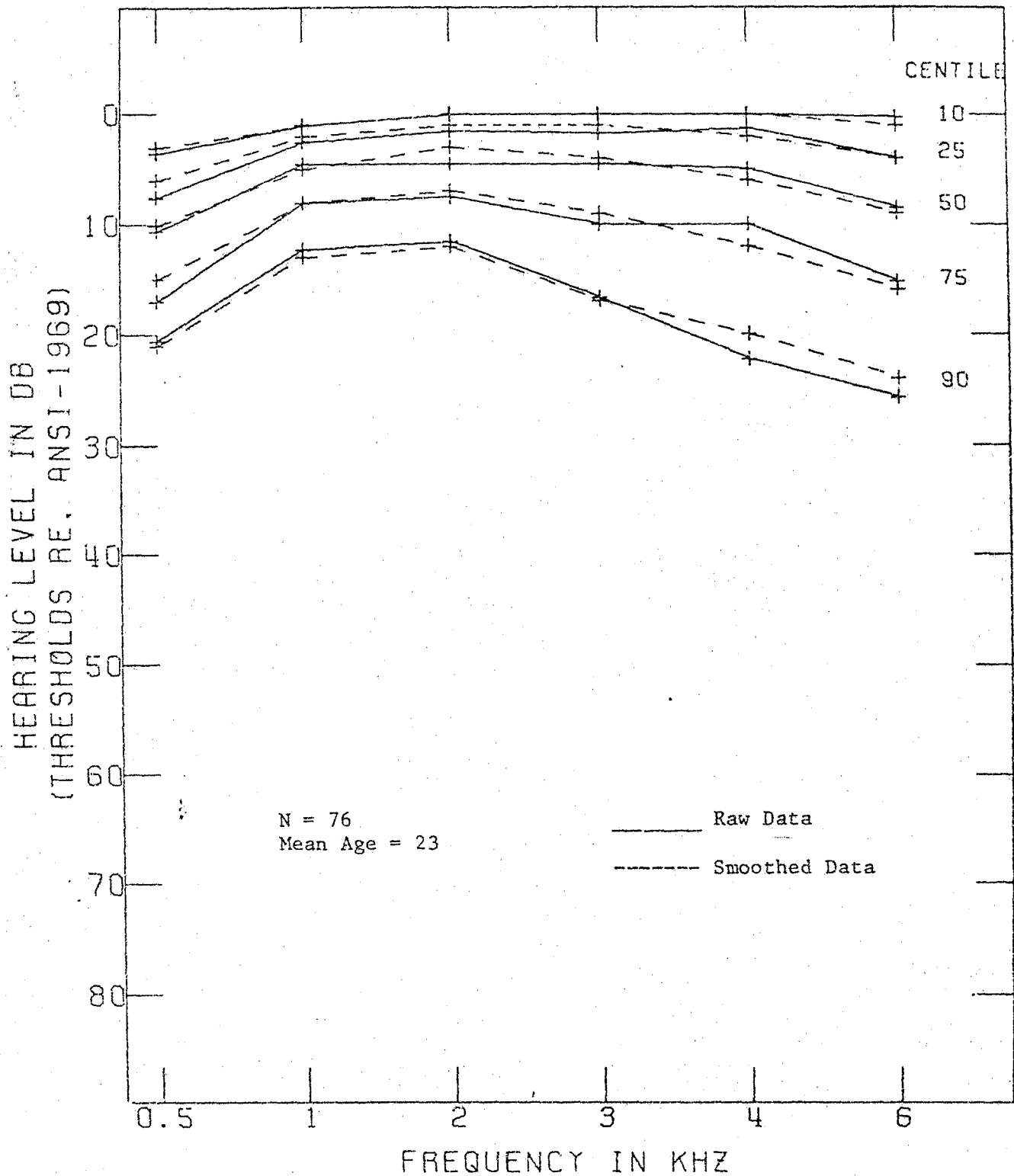ONHS: MALE NON-NOISE EXPOSED WORKERS AGES 17 TO 26 YEARS

N = 76
Mean Age = 23

_____ Raw Data
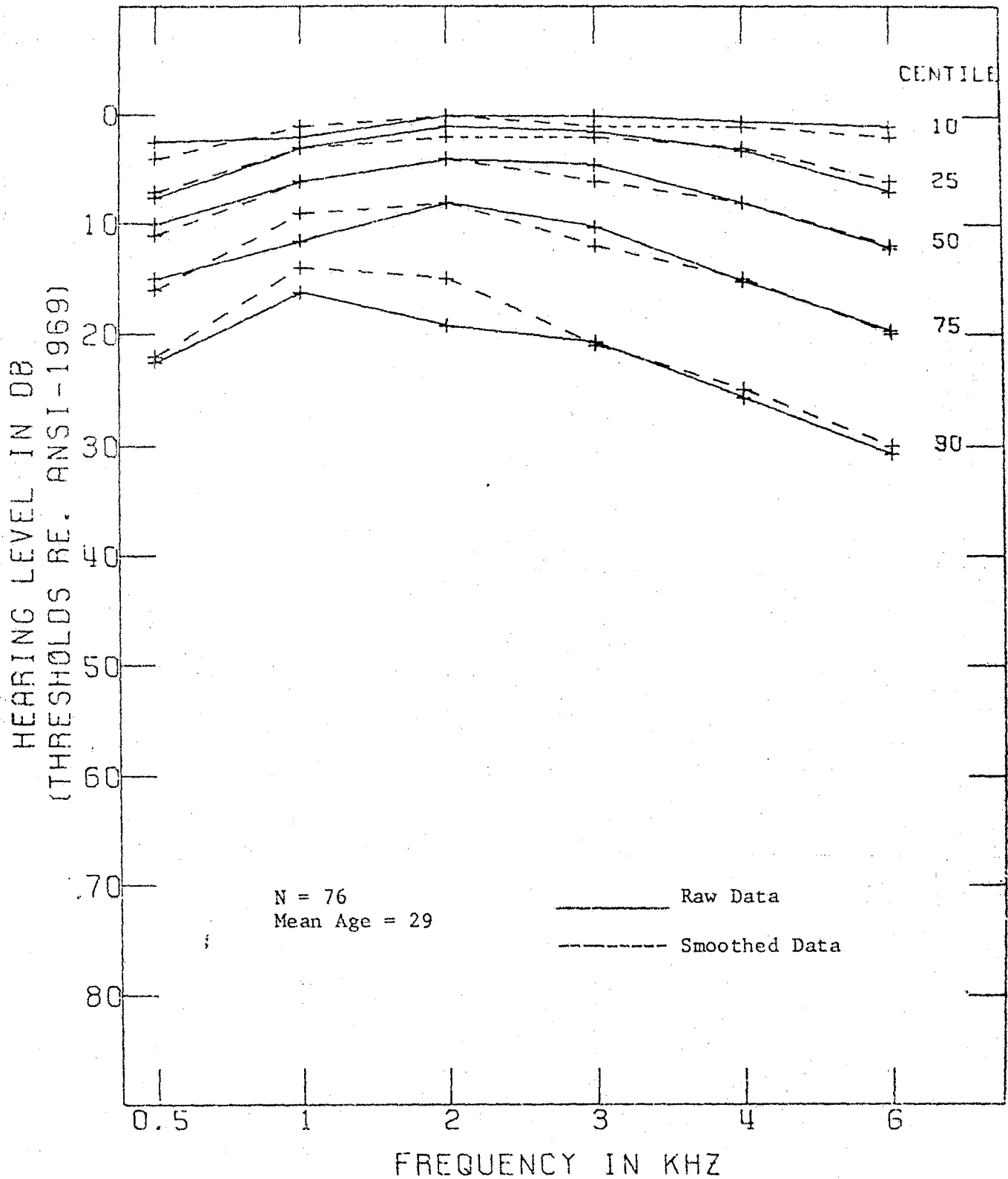
--------- Smoothed Data

FIGURE 5

ONHS: MALE NON-NOISE EXPOSED WORKERS AGES 26 TO 32 YEARS

FIGURE 6

ONHS: MALE NON-NOISE EXPOSED WORKERS AGES 32 TO 38 YEARS

N = 76
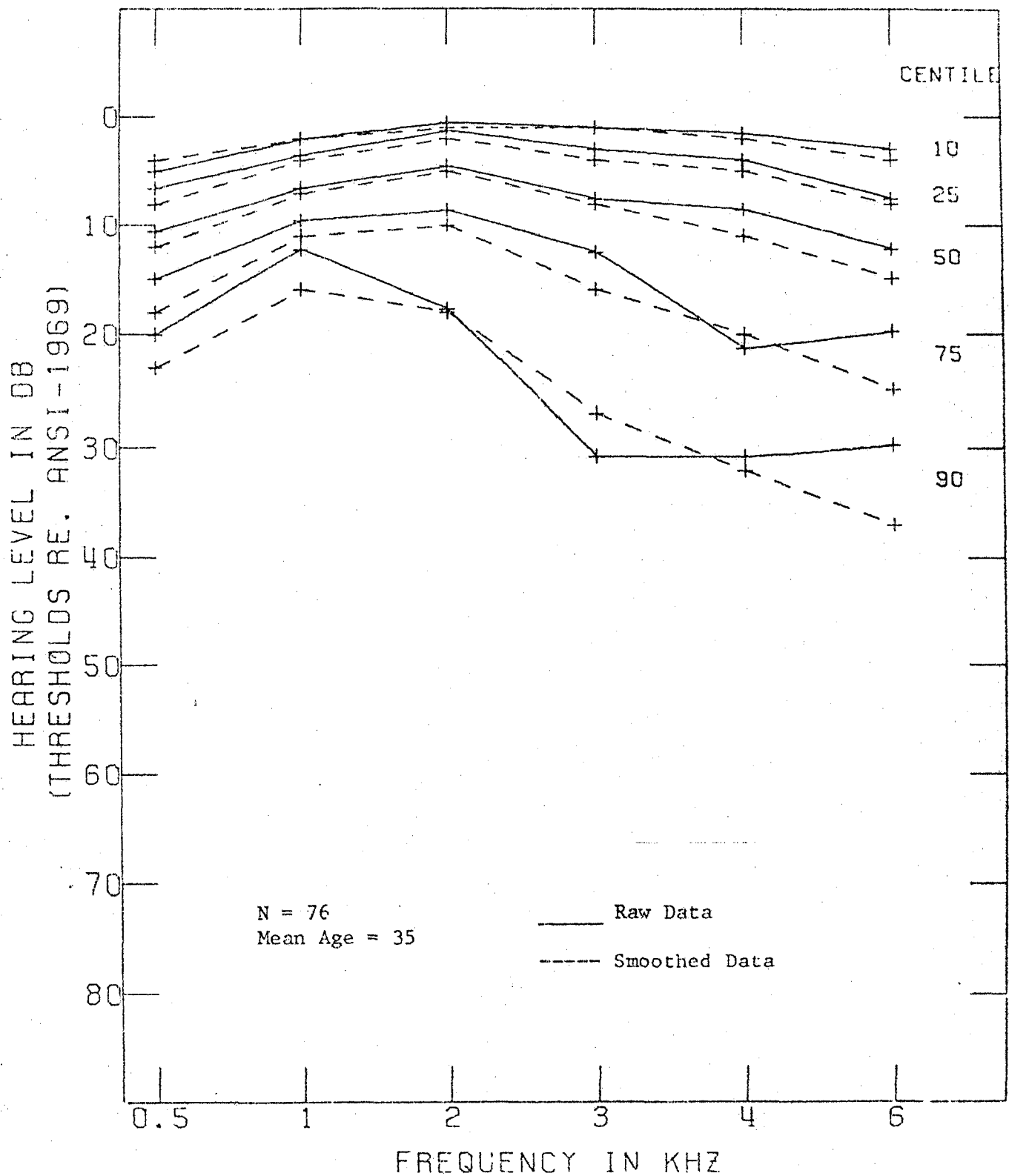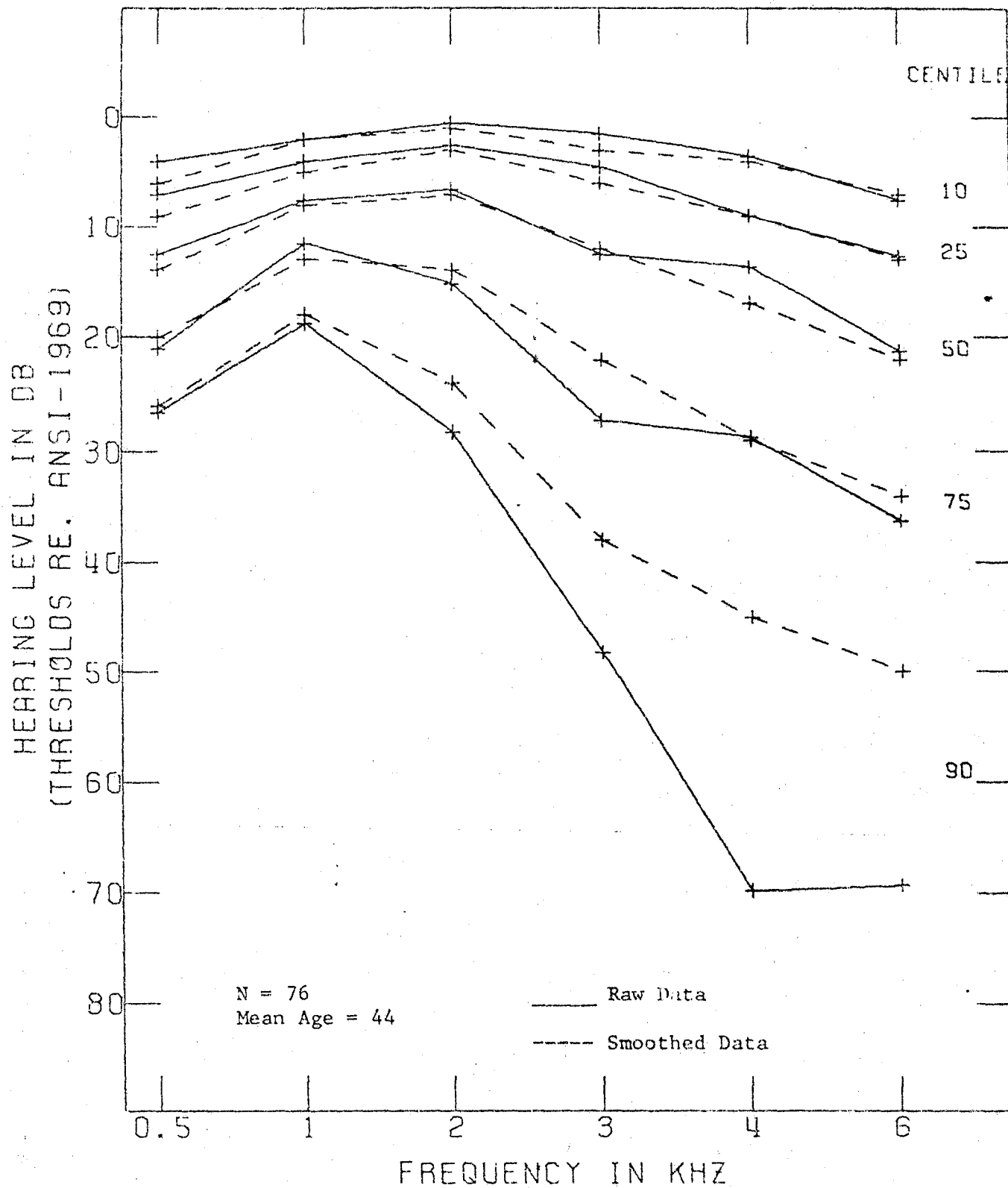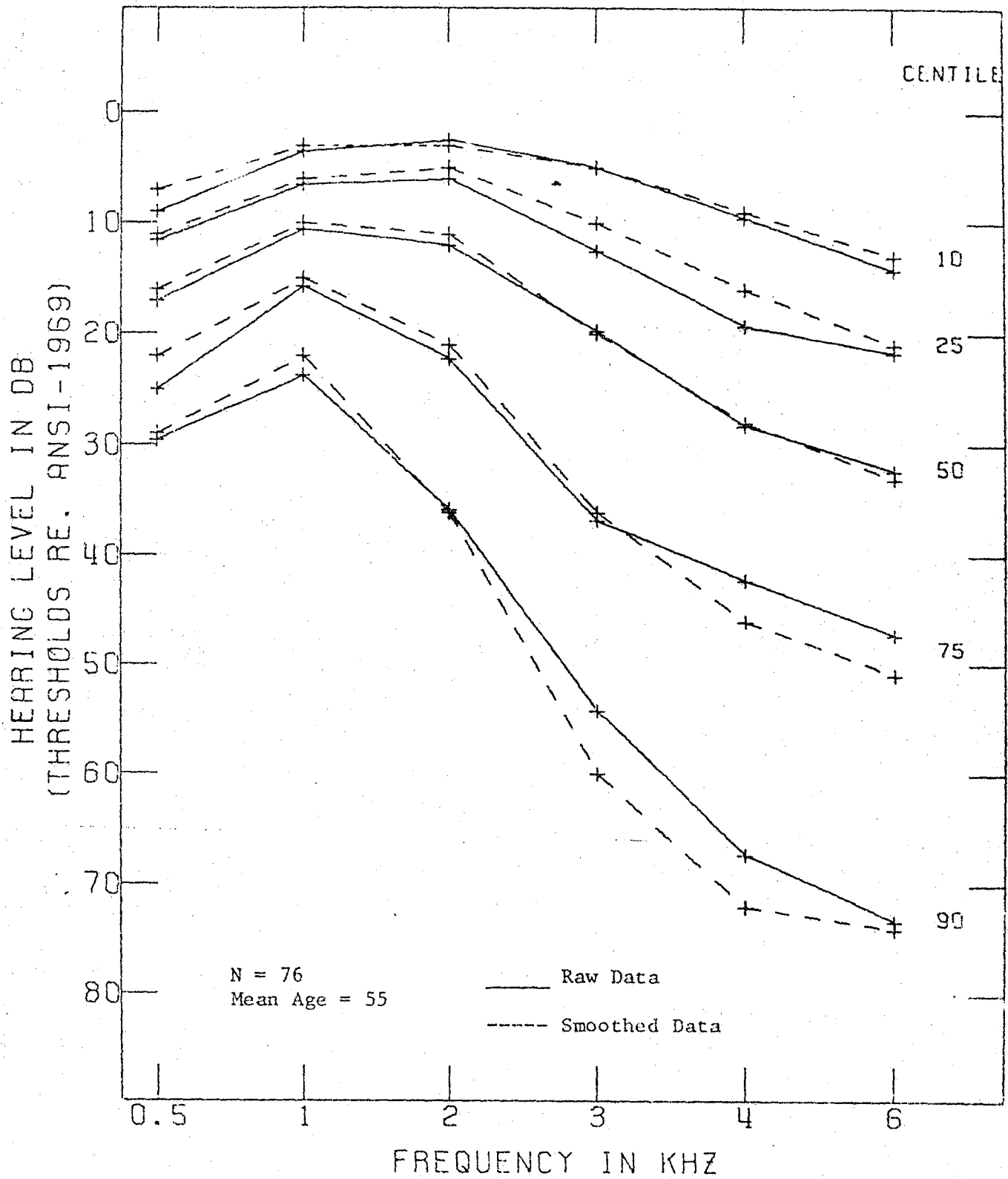Mean Age = 35

_____ Raw Data

- - - - - Smoothed Data

32

FIGURE 7

ONHS: MALE NON-NOISE EXPOSED WORKERS AGES 38 TO 48 YEARS

N = 76
Mean Age = 44

Raw Data
- - - - - - Smoothed Data

FIGURE 8

ONHS: MALE NON-NOISE EXPOSED WORKERS AGES 48 TO 65 YEARS

N = 76
Mean Age = 55

———— Raw Data

----- Smoothed Data

levels, agreement is to within 5 dB, except at the 90% level for the 38 to 48 years age group. A complete presentation of non-noise exposed male and female population statistics will be presented in a subsequent report.

The method by which the mathematical model generates "non-noise" hearing level statistics for any sample population of workers is as follows: For each member of the sample population the log-Gaussian probability distribution of hearing level is generated. This distribution, of course, depends upon his age and sex, as well as audiometric frequency, and is derived using the regression line. These distributions are then super-imposed to form a single, "mixture distribution" for the entire group. Using this mixture distribution it is possible to derive non-noise statistics of any type, e.g., centile distributions.

All non-noise data presented in this report have been generated by the technique just described.

VI. ONHS COMPOSITE ANALYSIS: HEARING LEVEL STATISTICS

VI-1 Hearing Level Distribution Grouped by Age and dBA

Hearing level distributions for all noise exposed workers included
in the occupational noise and hearing survey (ONHS) composite analysis
are displayed in Figure 9. Data have been grouped into five age groups
and three noise exposure categories classified as 85 dBA (80 to 87 dBA),
90 dBA (88 to 92 dBA), and 95 dBA (93 to 102 dBA). Although it may
appear that the 85 dBA and 95 dBA groups include excessively broad ranges
of noise levels, in reality only 15% of the 85 dBA group had noise levels
of 83 dBA or below, and only 10% of the 95 dBA group had noise levels at
97 dBA or above. The boundaries for the five age groups were selected
so as to separate the entire sample of noise-exposed workers into equal
blocks. In the figure the solid lines depict median audiograms for the
noise-exposed workers. The dashed lines depict median audiograms for
comparable non-noise exposed populations. The split "rolling pins"
which also appear on the graph are used to indicate the tenth, twenty-
fifth, seventy-fifth and ninetieth percentile points; those on the left
side of the data points represent noise-exposed subject data, while those
on the right represent non-noise exposed subject data. The mean age,
mean exposure (in years), and number of workers are listed for each
group. All audiometric data shown are averages of individual right and
left ear data. The figure very clearly demonstrates the effect of noise
upon hearing, particularly at frequencies of 2000 to 6000 Hz.

FIGURE 9

ONHS HEARING LEVEL DISTRIBUTIONS
GROUPED BY AGE AND dBA

FREQUENCY IN KHZ

37

85 dBA

90 dBA

95 dBA
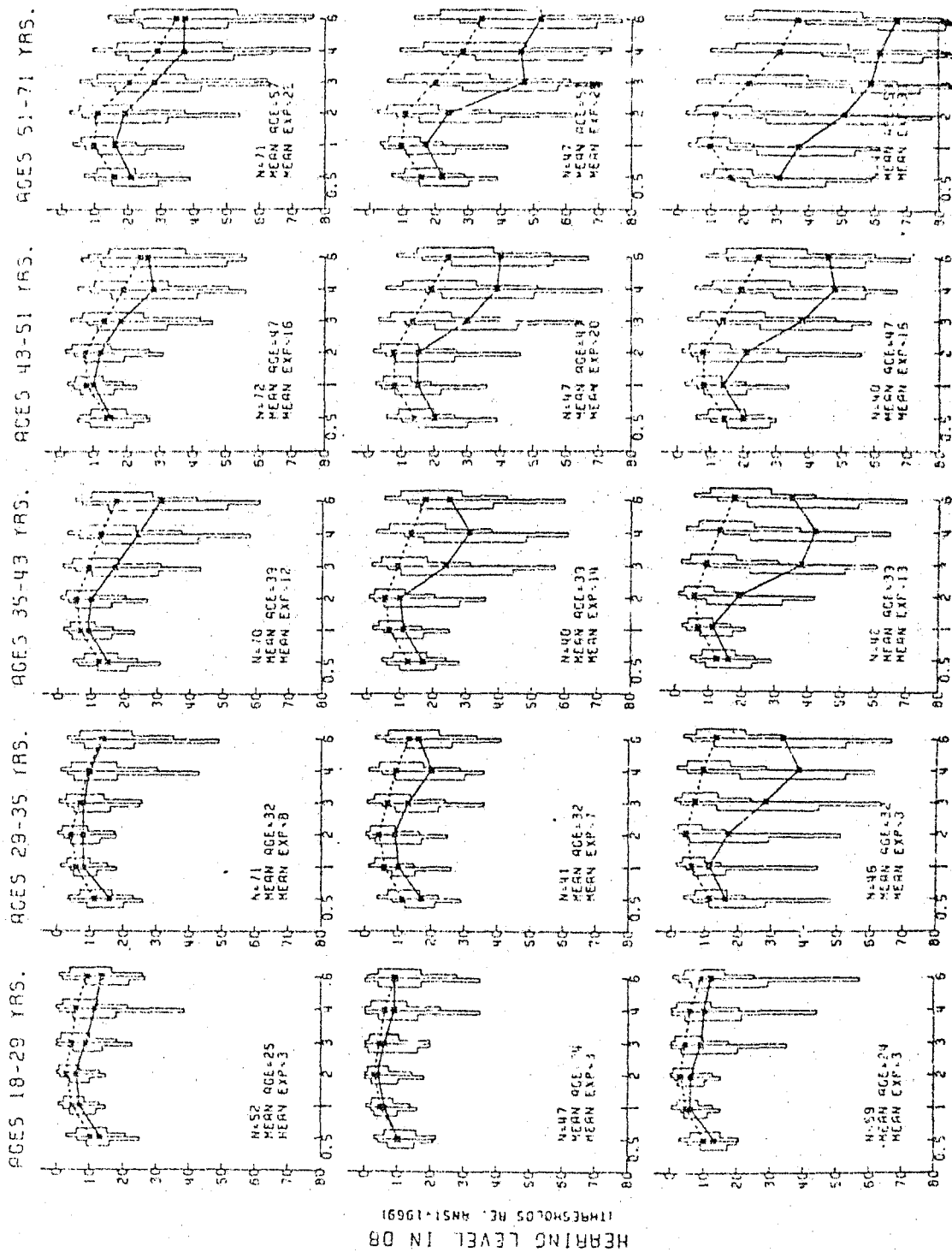
VI-2, Comparison of NIOSH Baseline Data with Other Recent Data

Hearing threshold levels of young, non-noise exposed persons may
be regarded as baseline data by which different hearing studies may be
compared. Figure 10 illustrates median audiograms obtained during the
past few years by several investigators for comparison with non-noise
exposed subject data from the NIOSH composite ONHS analysis. The
National Physical Laboratory (NPL) data (N = 168; ages 18-25) are reported
by Dr. D. W. Robinson in his book, Hearing and Noise in Industry," 1970.
Data from the Eastman Kodak Company (E. K. Co.; N ≈ 6151 for ages 15-24
years) and the National Health Survey (NHS) are discussed in Section III
of the NIOSH noise criteria document. The data depicted by Glorig are
taken from his report, "Hearing Loss as a Function of Age," 1962.
Glorig's screened sample of 74 professional men (mean age = 24.5 years)
is presented. Hearing levels at 500 Hz were not given in his article.

The NIOSH data are quite comparable to all the other studies except
the NPL study, but even in that single case the curves have the same
shape.

It should be noted that the age and dBA level groupings described
in this section were not employed in generating the hearing impairment
and risk statistics that were used to support the NIOSH recommended
standard for occupational noise exposure.

VI-3, Consequences of a 90 dBA Standard

Hearing level distributions of "workers exposed to 90 dBA" are
presented in Figures 11 to 15. The workers in the ONHS composite study
whose daily noise exposure level was in the range 88-92 dBA (N = 222)

FIGURE 10

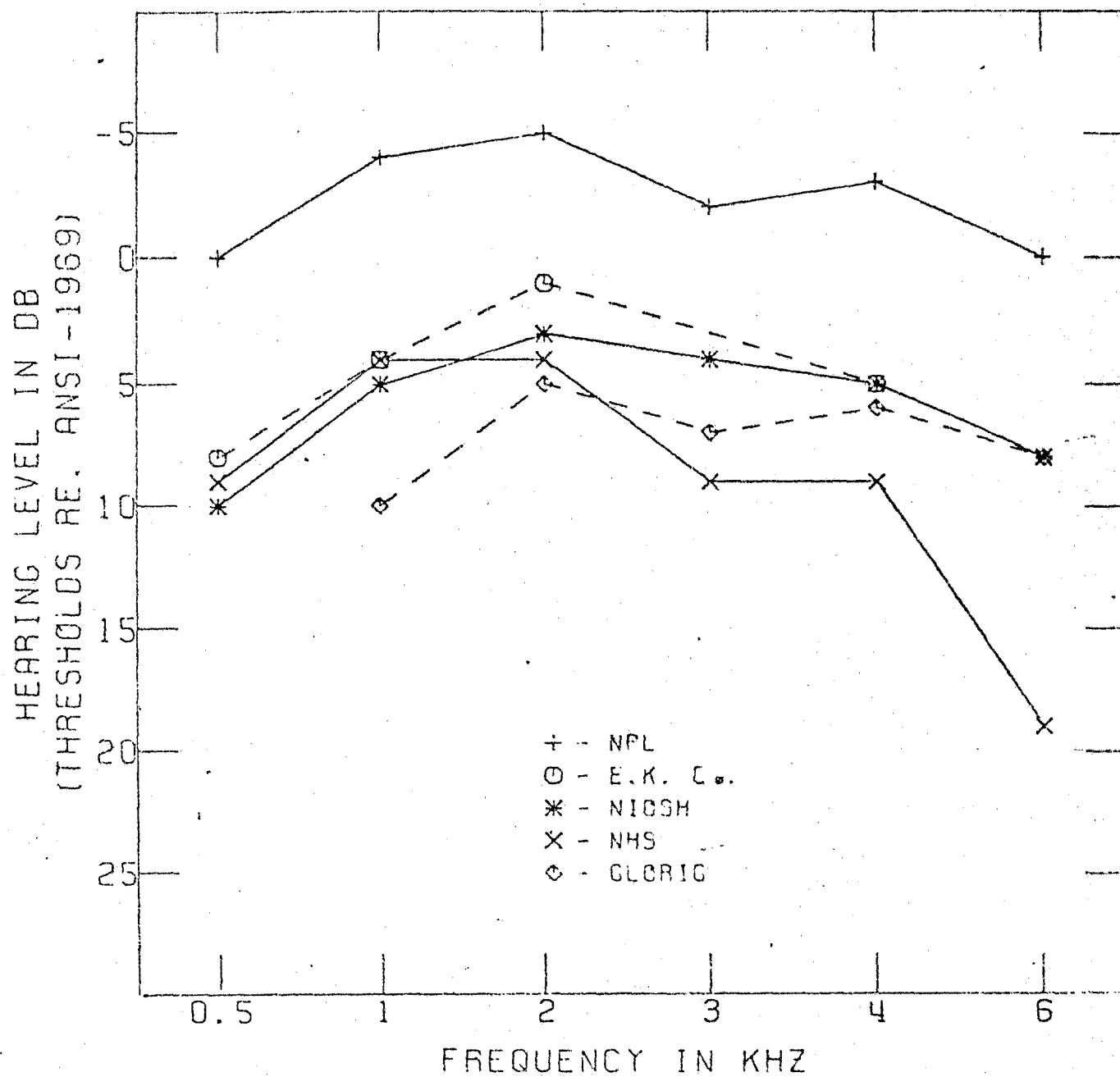MEDIAN HEARING LEVELS OF BASELINE POPULATIONS
AGES 15-24 YEARS

39

FIGURE 11

OHNS SUMMARY DATA:
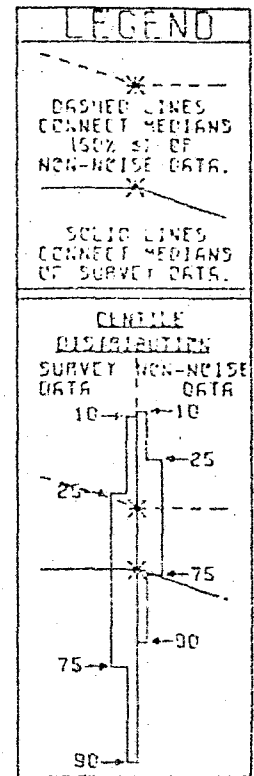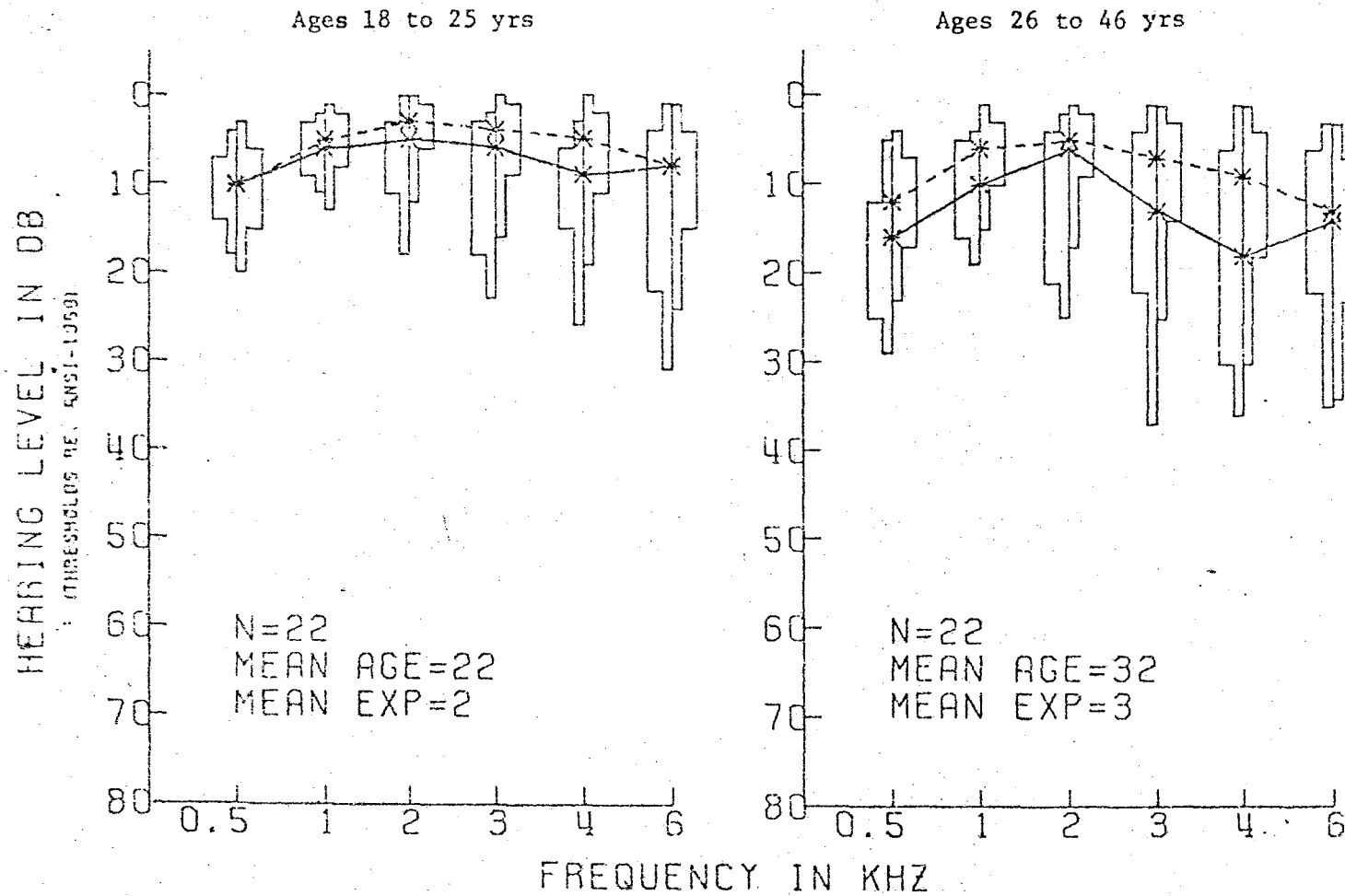Workers Exposed to 90 dBA
for 0 to 4 years

Ages 18 to 25 yrs

N=22
MEAN AGE=22
MEAN EXP=2

Ages 26 to 46 yrs

N=22
MEAN AGE=32
MEAN EXP=3

HEARING LEVEL IN DB
(THRESHOLDS RE. ANSI-1969)

FREQUENCY IN KHZ

LEGEND

DASHED LINES
CONNECT MEDIANS
(90% SI OF
NON-NOISE DATA.

SOLID LINES
CONNECT MEDIANS
OF SURVEY DATA.

CENTILE
DISTRIBUTION

SURVEY   NON-NOISE
DATA   DATA

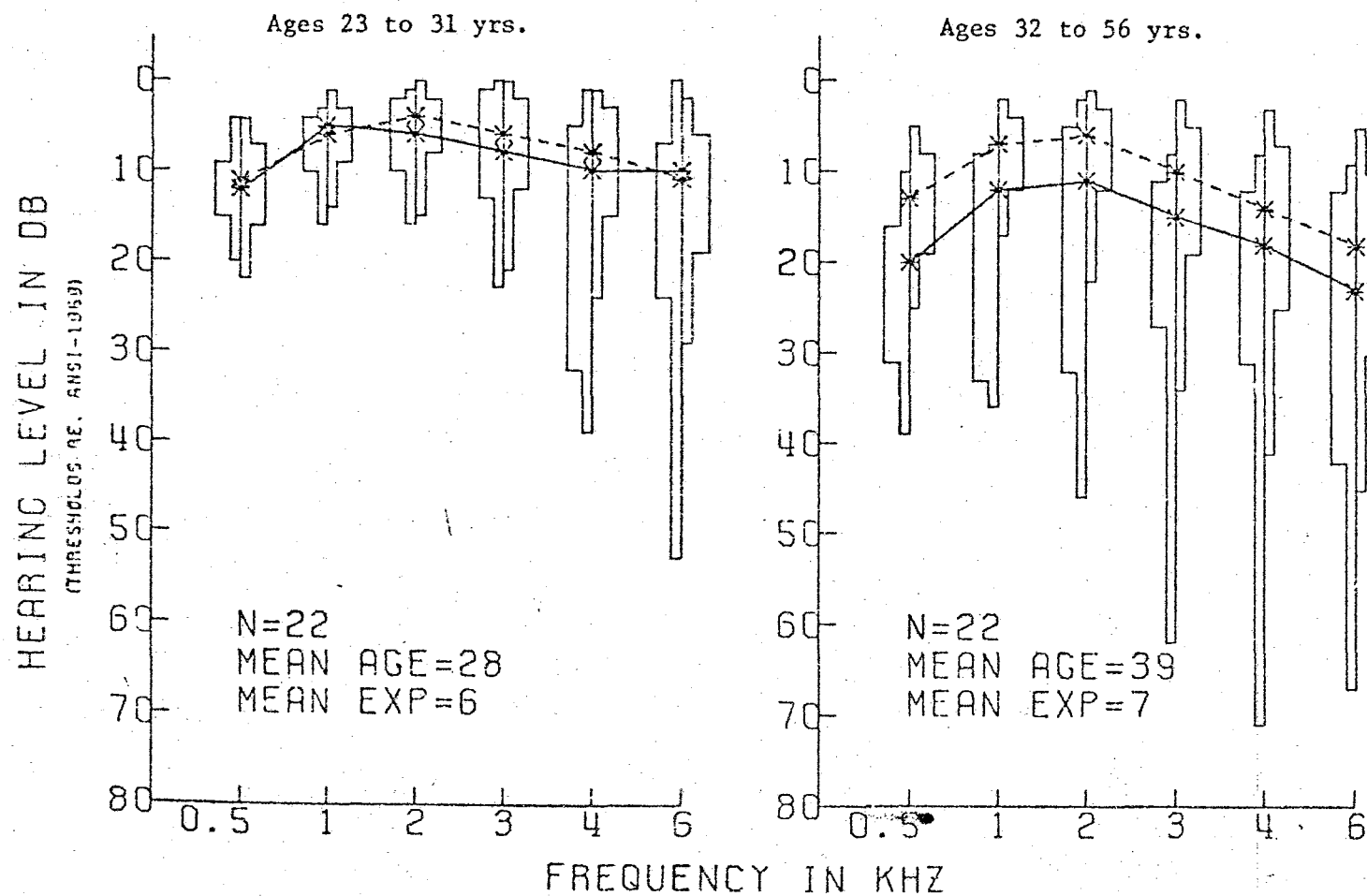10 → 10
25
25
75
75 →
90
90

FIGURE 12

ONHS SUMMARY DATA:
Workers Exposed to
90 dBA for 4 to 9 yrs

41
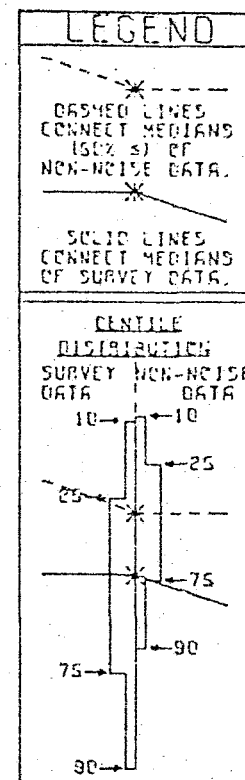
FIGURE 13

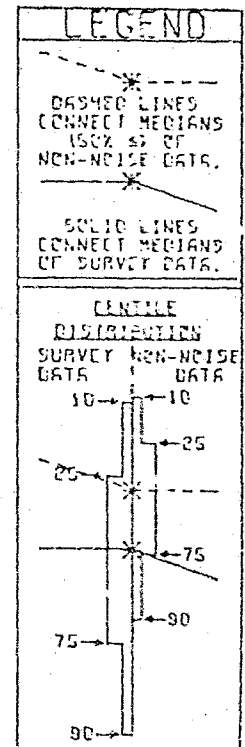ONHS SUMMARY DATA:
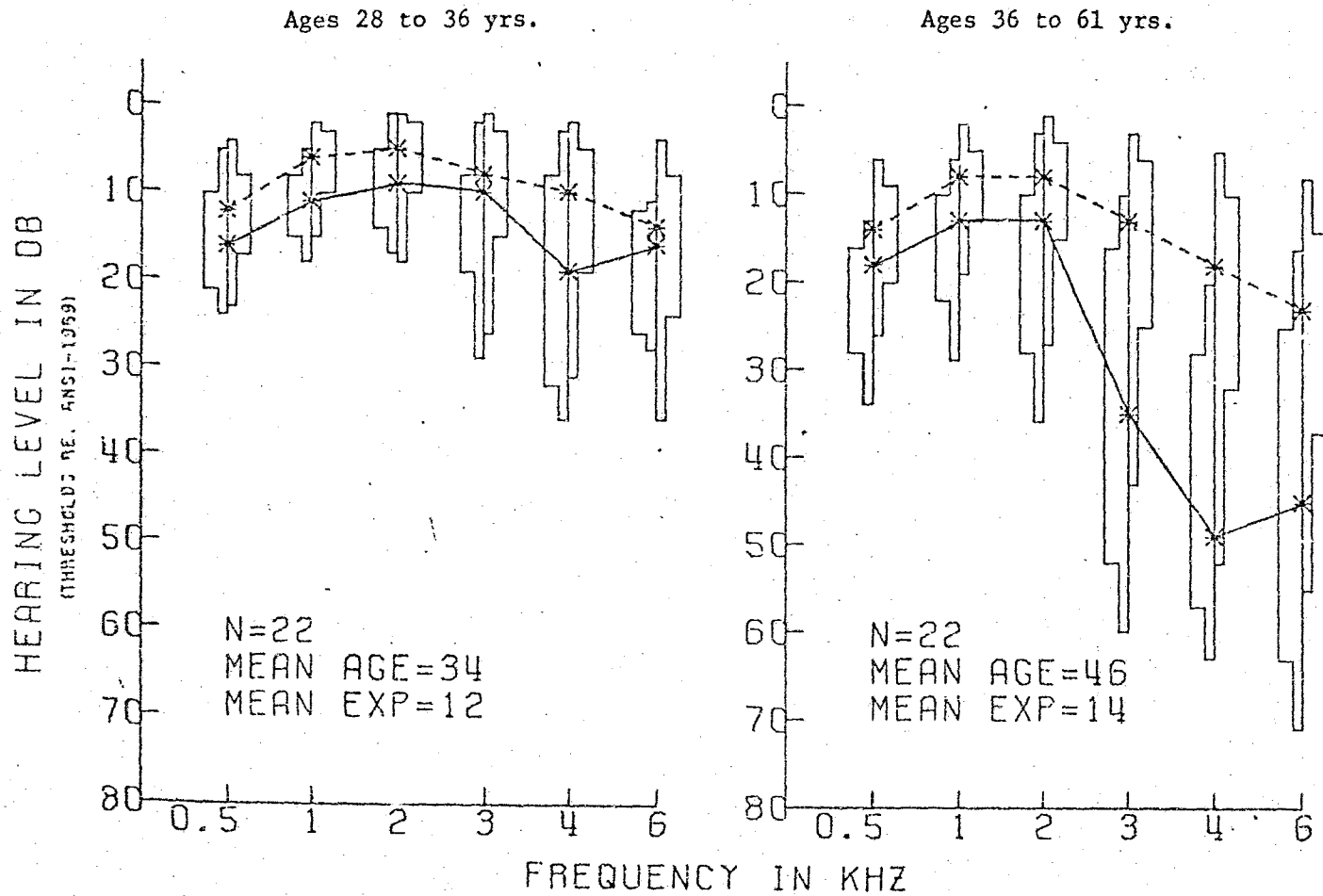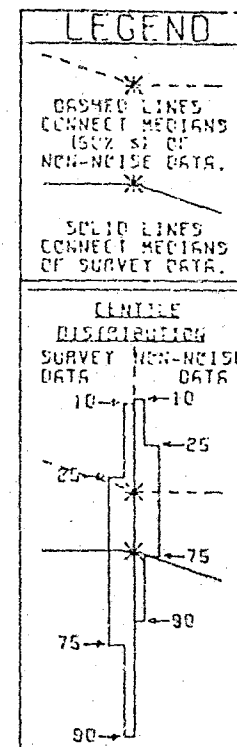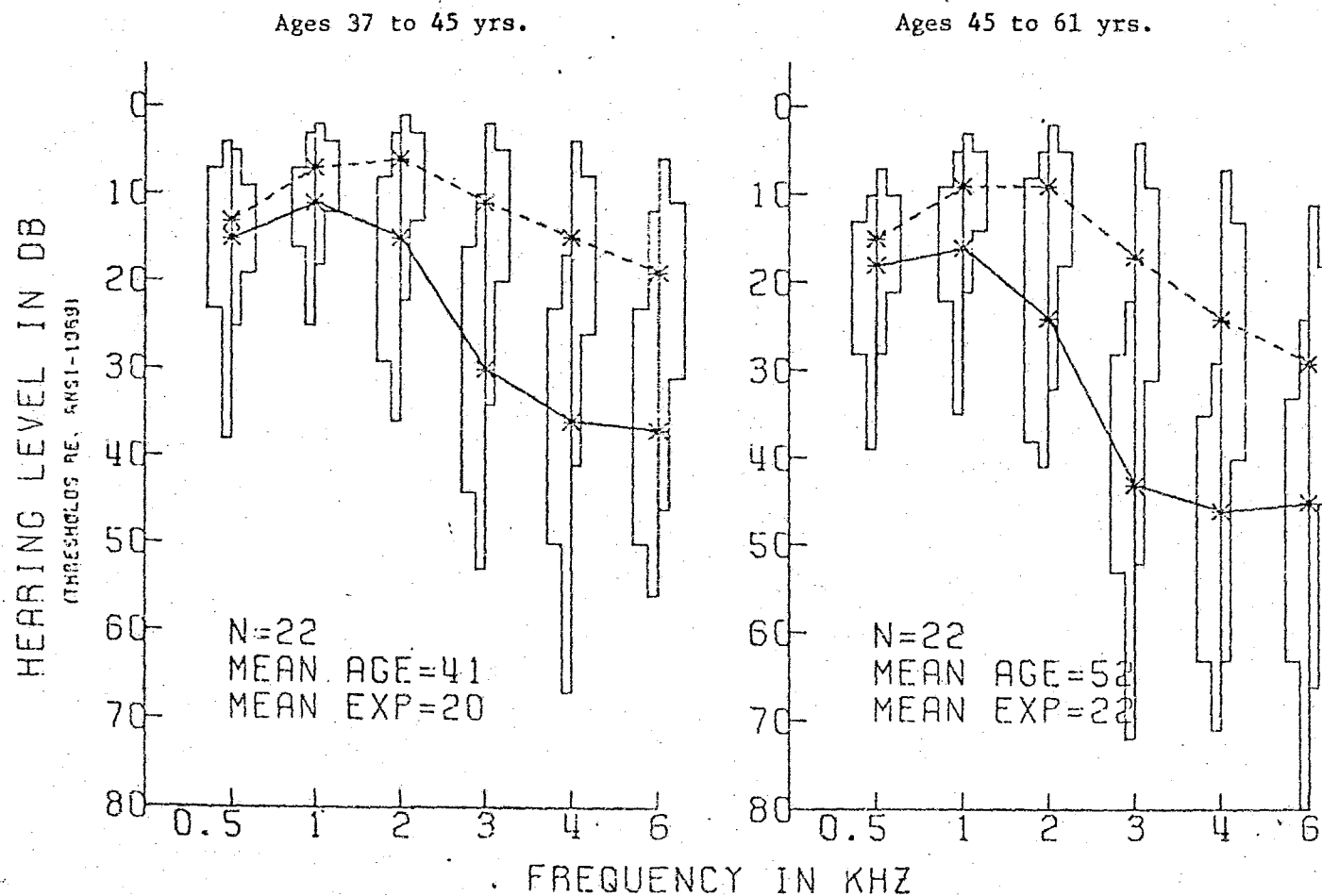Workers Exposed to
90 dBA for 9 to 17 yrs.

Ages 28 to 36 yrs.

Ages 36 to 61 yrs.

HEARING LEVEL IN DB
(THRESHOLD RE. ANSI-1969)

N=22
MEAN AGE=34
MEAN EXP=12

N=22
MEAN AGE=46
MEAN EXP=14

LEGEND

DASHED LINES
CONNECT MEDIANS
(90% of
NON-NOISE DATA.

SOLID LINES
CONNECT MEDIANS
OF SURVEY DATA.

CENTILE
DISTRIBUTION
SURVEY NON-NOISE
DATA   DATA
10→   ←10
          ←25
25→
          ←75
75→   ←90

90→

FREQUENCY IN KHZ

42

FIGURE 14

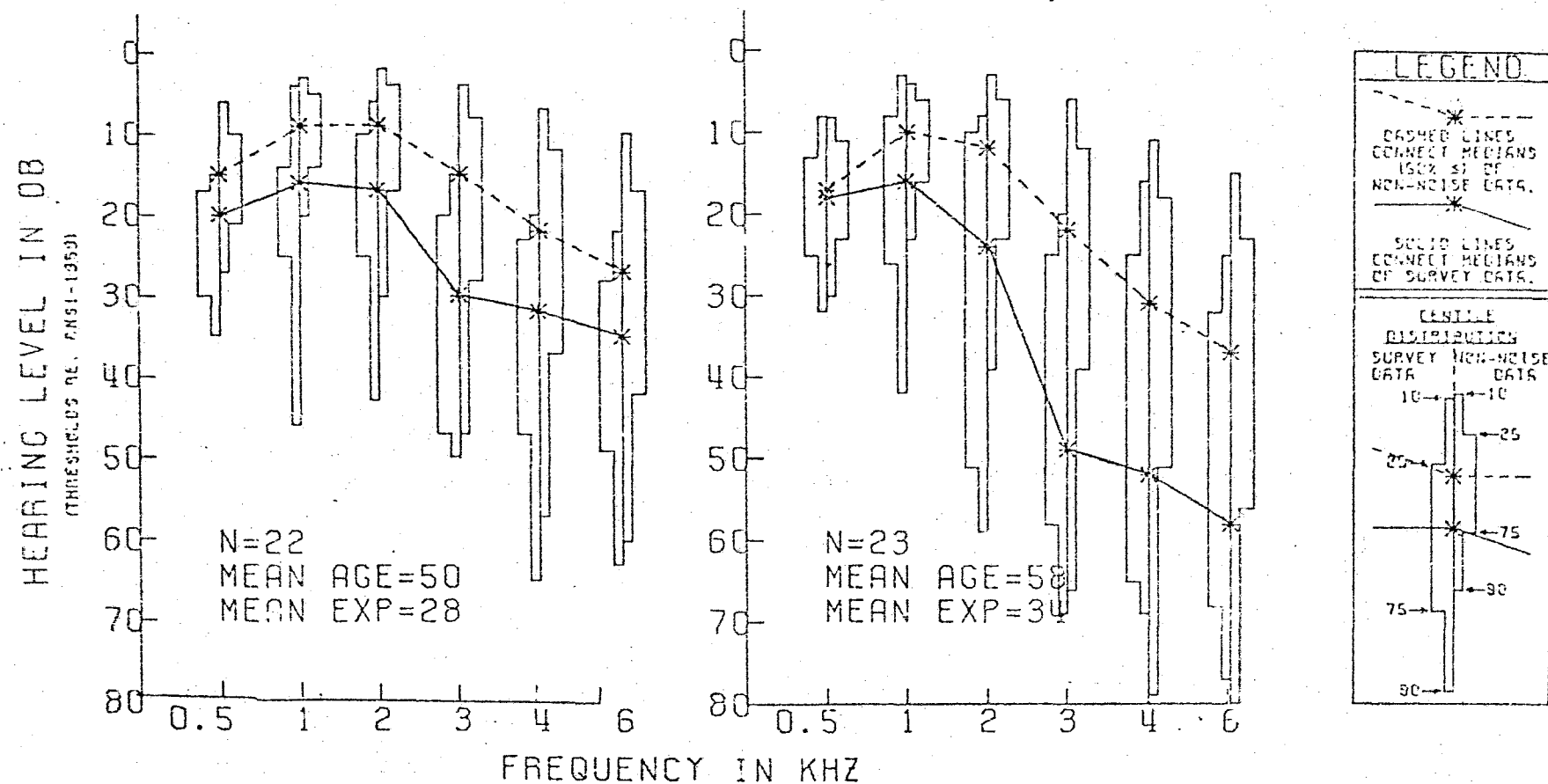ONHS SUMMARY DATA:
Workers Exposed to
90 dBA for 17 to 25 yrs.

Ages 37 to 45 yrs.

Ages 45 to 61 yrs.

N=22
MEAN AGE=41
MEAN EXP=20

N=22
MEAN AGE=52
MEAN EXP=22

HEARING LEVEL IN DB
(THRESHOLDS RE. ANSI-1969)

FREQUENCY IN KHZ

FIGURE 15

ONHS SUMMARY DATA:
Workers Exposed to
90 dBA for 26 to 44 yrs.

were separated into five experience categories. The division into experience categories was accomplished as follows: (1) the individual data were placed in ascending order by number of years of job experience, workers with identical numbers of years of experience being additionally sorted into ascending order by age; (2) the resulting set of data was then separated into five contiguous experience groups of equal size; (3) within each of the five groups the data were then placed in ascending order by age, workers with identical ages being additionally sorted into ascending order by experience; (4) each of the five groups was then bisected (at the median age). Thus, ten groups were derived from the original sample. The separation of the worker population into sub-groups in this manner was found to be the most efficient method through which the population could be studied in detail without using elaborate smoothing techniques.

Centile distributions of the averaged (left-right) hearing levels of each such group are shown, plotted against hearing level distributions for non-noise exposed workers (generated using the procedure described in section IV). Inspection of these graphs indicates that the onset of hearing loss resulting from daily exposure to 90 dBA is present after just 2 or 3 years of experience, with noise-induced losses occurring especially at the audiometric frequencies 3000, 4000, and 6000 Hz, increasing with age and experience. These predominantly high frequency noise-induced losses appear to increase until about age 40 and 15-20 years of job experience, at which point additional high frequency

losses seem to depend only upon age. However, it is also evident that once the noise-induced components of high frequency loss approach their maximum, significant losses continue to develop at 500, 1000, and 2000 Hz, with losses progressing from the higher to the lower of these frequencies. The curves indicate that one should expect a 15-30 dB noise-induced hearing loss at the higher frequencies (3000, 4000 and 6000 Hz) and 5-15 dB noise-induced hearing loss at the lower frequencies following 15 years of daily exposure to 90 dBA. Within each experience category it is apparent that the hearing level differences between non-noise exposed and noise exposed populations are larger for the older of the two age groups. Remarkably, the "quantity" of noise exposure (i.e., job experience) does not alone determine noise-induced hearing loss; i.e., the effects of noise and presbycusis are apparently not directly additive.

VII. COMPOSITE ONHS ANALYSIS: HEARING IMPAIRMENT

VII-1. The 1972 NIOSH Recommendations for A Noise Standard

In July 1972 the document, "Criteria for A Recommended Standard. . . Occupational Exposure to Noise" was published by NIOSH. In it the recommendation was made that the daily, eight-hour workplace noise limit be reduced to 85 dBA as soon as the Secretary of Labor, in consultation with the Secretary of Health, Education, and Welfare, determines that it is economically feasible to do so.

The NIOSH recommendations for a noise standard were based upon analysis of available literature, consultation with leading authorities on noise exposure control and the effects of noise on hearing, and NIOSH laboratory and field studies. The NIOSH occupational noise and hearing survey (ONHS) data described in this report were considered particularly appropriate in the development of a recommended noise standard for the following several reasons:

1. The ONHS survey data represented a variety of types of occupational noise exposures, requisite to the development of a single comprehensive Federal standard.

2. All ONHS audiometric tests of noise exposed workers were performed prior to the workshift, thus eliminating contamination by temporary threshold shift.

3. The ONHS data were screened to eliminate irrelevant factors, and to select only those workers whose occupational noise levels were well known.

4. Noise levels in the ONHS study were concentrated in the crucial range, namely 85-95 dBA.

5. The ONHS study included a large control sample of non-noise exposed workers who were tested concurrently with noise exposed workers, thus ensuring that the effects of occupational noise could be isolated from possible influences of audiometric test procedure, geographic or cultural differences, and audiometer idiosyncrasies.

6. Raw audiometric data from the ONHS study were available for exhaustive statistical analysis.

VII-2. Hearing Impairment

The criterion that essentially all workers be protected from a significant impairment of their ability to hear and understand speech sounds formed the basis for the protection goal set forth by the NIOSH recommended standard.

Two hearing level indices were utilized as determinants of hearing impairment. The first, termed HLI $(\overline{1,2,3})$, was the average of left and right ear audiometric thresholds at 1000, 2000, and 3000 Hz. The second, HLI $(\overline{.5,1,2})$, was defined as the average of thresholds at 500, 1000, and 2000 Hz. It was presumed that noise-induced hearing losses were binaural, and that averages taken over both ears would reduce the random error in the analysis without biasing the data. HLI $(\overline{.5,1,2})$ utilizes the audiometric frequencies adopted by the American Academy of Ophthalmology and Otolaryngology (AAOO) in 1959 to measure one's ability to hear conversational speech. The other index, HLI $(\overline{1,2,3})$, was adopted by

NIOSH as the index most highly correlated with ability to discriminate and understand speech, based on investigations currently available in technical journals. In the ONHS composite analysis the first criterion used for existence of a hearing impairment was that HLI $(\overline{1,2,3})$ be greater than 25 dB. In order to permit a comparison with other data in the literature a second criterion for hearing impairment was also employed; namely, that HLI $(\overline{.5,1,2})$ be greater than 25 dB. It should be noted that the criteria just described define a beginning impairment in hearing ability, and do not necessarily imply the presence of extreme impairment in ability to hear speech. A thorough discussion of the basis for these choices of hearing impairment criteria is presented in Section VI of the NIOSH criteria document.

Figures 16 through 19 plot the percentage of workers classified as having hearing impairment, as a function of age, for four noise exposure categories and for both of the hearing impairment criteria just described. The starred data points represent raw data, i.e., they indicate the actual percentages of ONHS workers having hearing impairment. The line graphs and cross-hatched plots represent the hearing impairment statistics presented in Table XII and XIII of the NIOSH criteria document. Since the NIOSH tables provided a further breakdown of the data into experience groups, it was necessary to use cross-hatched regions here in order to show the range spanned by the tabulated hearing impairment statistics. The hearing impairment statistics tabulated in the NIOSH criteria document were obtained by a statistical smoothing technique which is described on pages VI-26 through VI-28 of that document.

FIGURE 16

PERCENTAGE OF WORKERS HAVING HEARING IMPAIRMENT
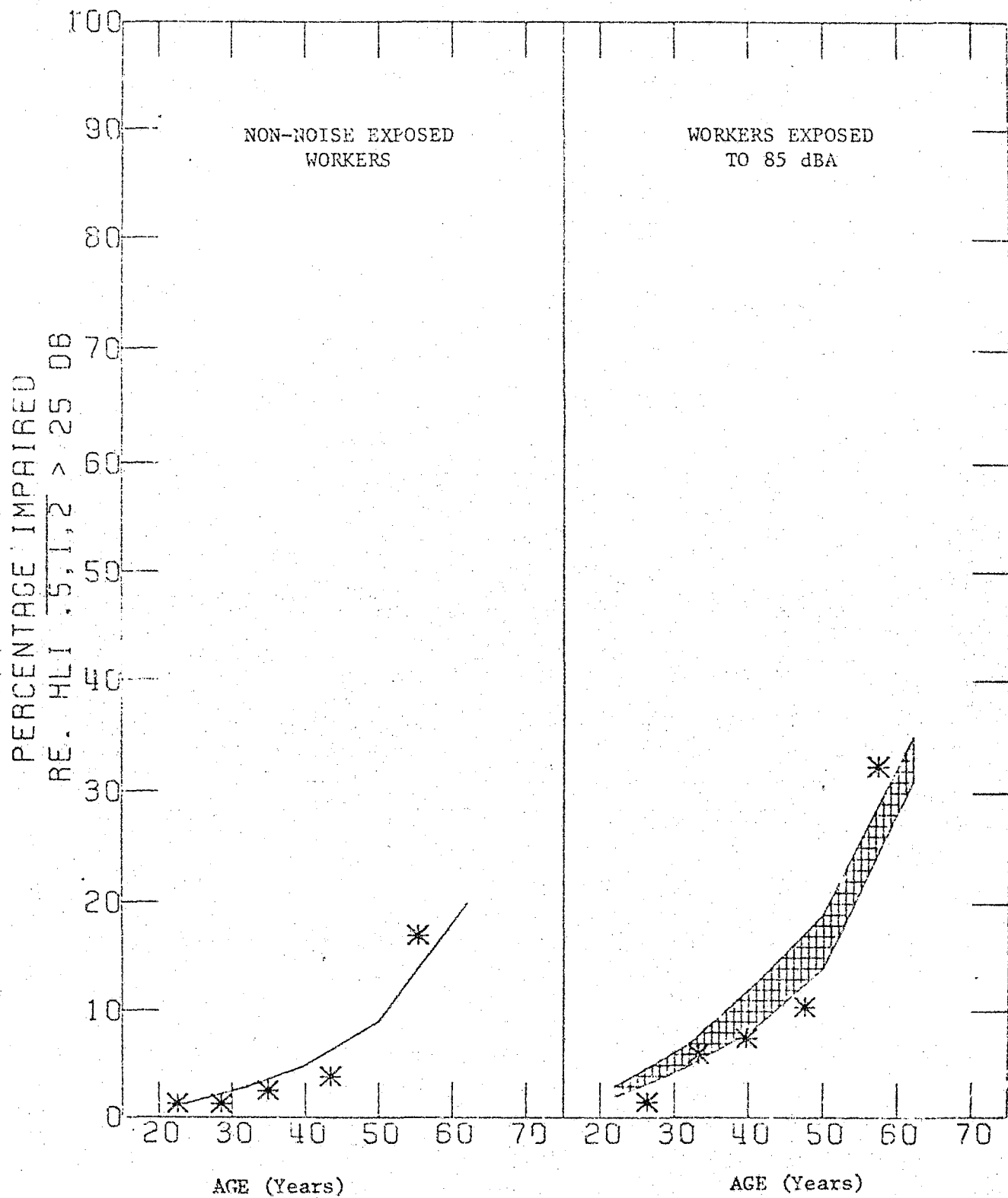USING THE CRITERION HLI $(.5,1,2) > 25$ dB

FIGURE 17

PERCENTAGE OF WORKERS HAVING HEARING IMPAIRMENT
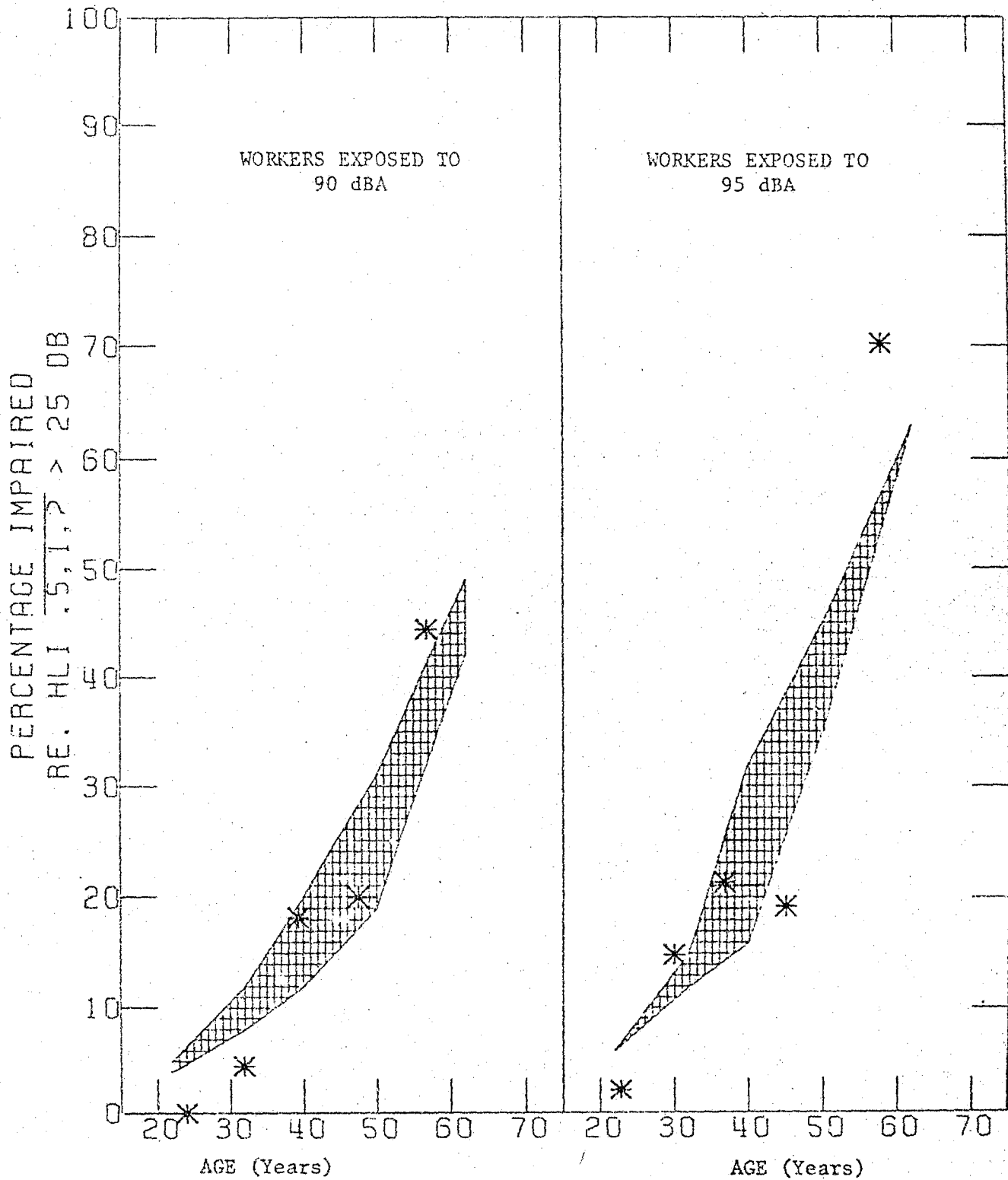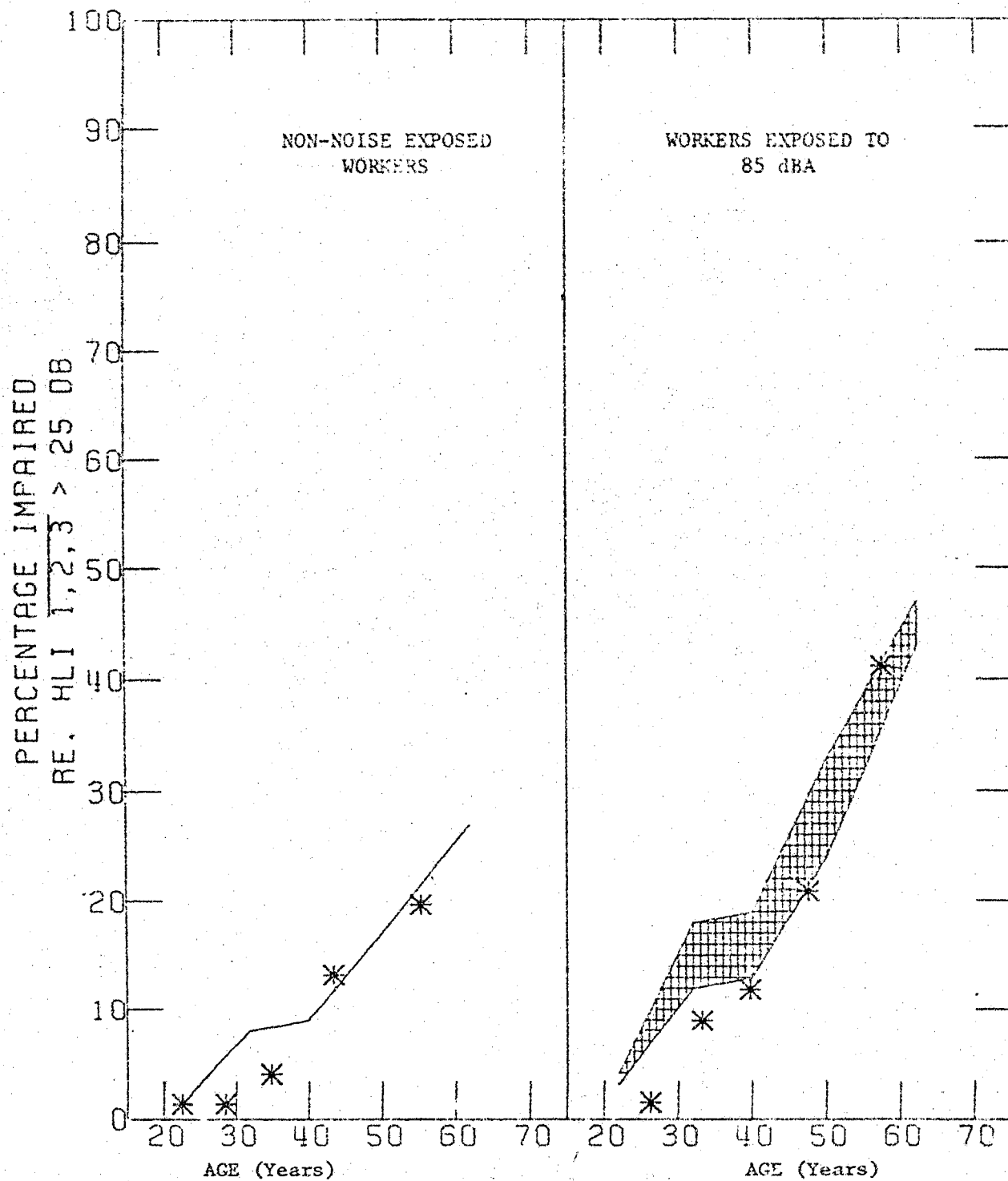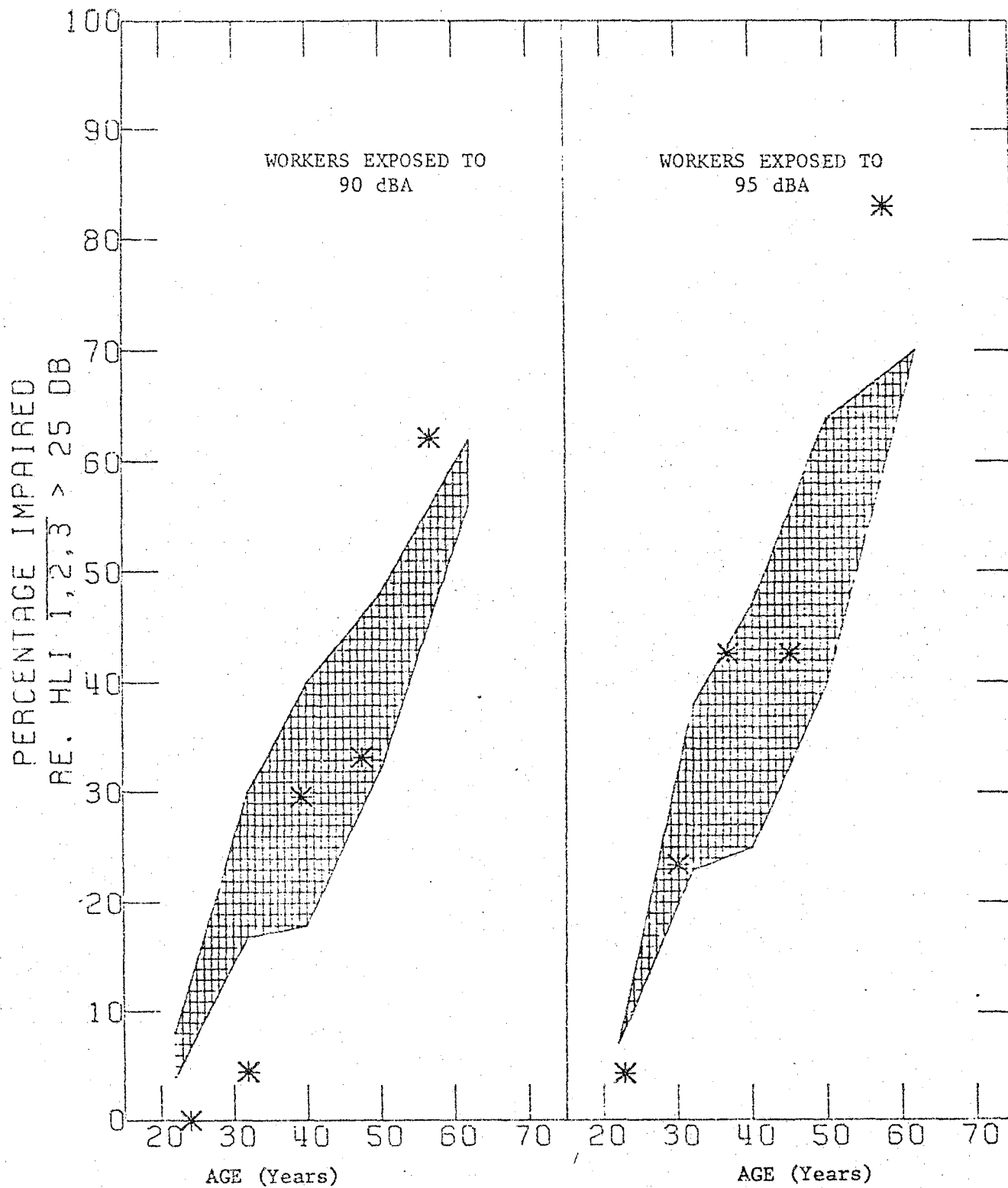USING THE CRITERION HLI $(\overline{.5,1,2}) > 25$ dB

51

FIGURE 18

PERCENTAGE OF WORKERS HAVING HEARING IMPAIRMENT
USING THE CRITERION HLI ($\overline{1,2,3}$) > 25 dB

PERCENTAGE OF WORKERS HAVING HEARING IMPAIRMENT
USING THE CRITERION HLI (1,2,3) > 25 dB

The raw data percentages (starred data points) were obtained in the following manner: the ONHS workers were divided into three dBA level groups as has been previously in section VI of this report. The non-noise exposed workers were used as a fourth group. Each of these four groups was then segmented into five age groups of equal size, and the percentages of workers having hearing impairment were calculated. Slight inconsistencies in the results of this analysis are evident; however, the basic findings are well in line with the more rigorous analysis presented in the NIOSH criteria document. In fact, the ability of rather sophisticated statistical tools to enhance the basic aspects of data analyses is thus illustrated.

VIII. CONCLUSIONS

The relationship between hearing-loss-risk and noise level has been roughly defined for employees who work 8 hours a day in relatively simple, or "ordinary" noise environments. The results of the analysis of NIOSH data included in this report and in the NIOSH criteria document substantiate the results of other similar investigations. However, the effects of fluctuating levels, "quiet" rest periods, shortened exposures at higher levels, administrative controls, ear protectors, impact or impulsive noise, lengthened exposures, seasonal exposures, high frequency noise, and infrasonic noise cannot be quantified until further research and evaluation are performed. Additional work is also needed to enhance the effectiveness of audiometric monitoring and noise measurement techniques, and to develop better indicators and criteria for hearing loss.

APPENDIX

DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
PUBLIC HEALTH SERVICE
National Center for Urban and Industrial Health
Occupational Health Program
Cincinnati, Ohio 45202

OCCUPATIONAL NOISE AND HEARING STUDY

ASSURANCE OF CONFIDENTIALITY

The U. S. Public Health Service hereby gives its assurance that your
identity and your relationship to any information obtained by reason of
your participation in the Occupational Noise and Hearing Study will be
kept confidential in accordance with PHS regulations (42 CFR 1.103(a))
and will not otherwise be disclosed except as specifically authorized
below. A copy of this regulation will be made available to you upon
request.

Director, National Center for
Urban and Industrial Health,
BDPEC: USPHS

CONSENT

I hereby voluntarily agree to participate in the Occupational Noise and
Hearing Study which will be conducted by the U. S. Public Health Service.
It has been explained to me that in addition to my answering a question-
naire, there will be a routine medical examination of my ears and a
standard hearing test. I have been advised that I may withdraw from
this study at any time if I so desire.

_____   _____
Signature   Date

AUTHORIZATION TO RELEASE MEDICAL INFORMATION

I hereby request the U. S. Public Health Service to inform my personal
physician should there be any evidence from this study of an active ear
disorder.

Dr. _____

Street _____

City _____ State _____ Zip Code ____

Telephone _____

_____   _____
Signature   Date

Plant Name_____
Worker Number_____

(Note: Questions 1-7 below are to be completed by staff interviewer anytime before hearing exam).

(1) Name:_____

(2) Address:_____

(3) Age:_____ (4) Sex:_____

Job History	Location in Plant	Occupation: Describe kind of work	Dates (Mo.Yr.) From------To	Average Number wks per yr on job	hrs work per week
a. Present Job			Present		
b. Last Job	_____				
c. Previous Job	_____				

(6) Military Service:
  (a) Were you in military service? Yes_____ No_____
  (b) What was your unit assignment? (e.g., infantry, armored)_____
  (c) Did you fire weapons? Yes_____ No_____
  (d) If so, what kinds?_____
  (e) For how long?_____
  (f) Were you exposed to weapon noise even if you did not fire them? Yes_____ No_____
  (g) If so, for how long?_____
  (h) Were you exposed frequently to noise from aircraft, armored vehicles or large engines? Yes_____ No_____
  (i) If so, for how long?_____

(7) Non-Occupational Noise Exposure:
  (a) Have you used firearms as a civilian? Yes_____ No_____
  (b) If so, what kind(s) of weapons?_____
  (c) When (e.g., childhood, 10 years ago, currently)?_____
  (d) For how many years have you used such weapons?_____
  (e) How frequently?_____
  (f) How many rounds per year?_____
  (g) Do you routinely wear ear protectors when you fire weapons? Yes_____ No_____
  (h) Do you participate in hobbies or other off-job activities that are typically noisy or have loud sounds (e.g., motorbike racing, rock-roll music playing, machine work, etc.)? Yes_____ No_____
  (i) If so, specify?_____
  (j) For how many years have you taken part in this hobby or activity?_____
  (k) How frequently? (daily, weekly, monthly)_____

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Plant Name_____

Worker Number_____

(Note: Questions 8 and 9 below will be completed by staff medical doctor 2-3 days before scheduled hearing test).

(8) Relevant Medical History:
Have you had any of the following:

	Yes	No			Yes	No
(a) Head noises	( )	( )	(e) Running ears		( )	( )
(b) Deafness in family	( )	( )	(f) Earaches		( )	( )
(c) Hearing test	( )	( )	(g) Hearing aid		( )	( )
(d) Treatment by MD for ear trouble	( )	( )	Elaborative Comments_____			

(h) Do you think you have normal hearing? Yes_____ No_____

(9) Otologic Check: Normal ( )   Abnormal ( )

	R(ight)	L(eft)	Elaborative Comments: _____
(a) Perforation of drum head	R(ight)	L(eft)	_____
(b) Drainage from ear	R	L	_____
(c) Malformation or growth in ear	R	L	_____
(d) Ear occlusion	R	L	_____
(e) Ear disease	R	L	_____
(f) Other (specify)	R	L	_____

(Note: Question 10 below will be completed by audiometrist just before worker takes hearing exam).

(10) Time and Duration of Last Notable Exposure:
(a) What was your most recent exposure to loud noise (specify, e.g., horn, airplane, work place, gunshot, etc.)? _____
(b) How long ago did this exposure take place?_____(in days)
(c) How long did the exposure last?_____(minutes or hours)

(11) Hearing Level Data:

Pure Tone I

Date:	Tester:	
Time:	Station:	
Freq	R	L
250		
500		
1000		
1500		
2000		
3000		
4000		
6000		
8000		

Pure Tone II (optional)

Date:	Tester:	
Time:	Station:	
Freq.	R	L
250		
500		
1000		
1500		
2000		
3000		
4000		
6000		
8000		

Speech Reception (Optional)

Date:	Tester:
Time:	Station:
Type of Test:	
Score =	

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