American Industrial Hygiene Association Journal

ISSN: 0002-8894 (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/aiha20

Noise Exposure and Hearing Levels of Workers in the Sheet Metal Construction Trade

GARY D. KENNEY & HOWARD E. AYER

To cite this article: GARY D. KENNEY & HOWARD E. AYER (1975) Noise Exposure and Hearing Levels of Workers in the Sheet Metal Construction Trade, American Industrial Hygiene Association Journal, 36:8, 626-632, DOI: 10.1080/0002889758507302

To link to this article: https://doi.org/10.1080/0002889758507302

Noise Exposure and Hearing Levels of Workers in the Sheet Metal Construction Trade

GARY D. KENNEY and HOWARD E. AYER

University of Cincinnati, Department of Environmental Health, Kettering Laboratory, 3223 Eden Avenue, Cincinnati, Ohio 45267

Hearing and noise levels were measured at a jobsite involving sheet metal construction work and at a sheet metal fabrication shop. Noise levels up to 114 dBA (slow response) were measured when various powered hand tools were used. Noise levels exceeded 85 dBA between one-fourth and one-third of the time. Impact noise levels averaged about 120-125 dB peak SPL. Audiometric examinations showed that this group of construction workers had hearing losses, with the majority of the loss occurring in the 3 KHz to 6 KHz range. In addition the loss became more severe with increasing age. Temporary threshold shifts were observed both on the jobsite and in the shop after a single eight-hour exposure.

Introduction

RAMAZZINI NOTED IN HIS BOOK "De Morbis Artificum Diatriba," which was published in 1713, that copper workers became hard of hearing due to their hammering on the metal. In the late 1800's a high proportion of workers who fabricated steam boilers were found to have severe hearing loss. Since these early findings, loss of hearing acuity from prolonged exposures to high noise levels has been shown in many occupations within the textile industry, trucking, mining, agricultural, chemical and other industrial groups. However, in two studies[1,2] references were made to the noise exposures and hearing levels of sheet metal construction workers. Both of these studies were cross-sectional hearing level studies of various skilled and unskilled trades, and both came to the conclusion that sheet metal workers commonly exhibited hearing loss.

As a result, a group of sheet metal workers were selected for an in-depth noise and hearing level study.

Equipment and Procedures

General

The noise and hearing data reported here were collected at a field jobsite (the new University of Cincinnati Medical School building) where the primary task was the installation of a large duct, and at a sheet metal fabrication shop where the ductwork was being assembled. The size of the duct ranged from 6 in. diameter round to 24 in. x 36 in. rectangular.

Noise Measurements

The vast majority of noise measurements were performed using a type-2 sound level meter (General Radio type 1565-A). This instrument was calibrated each morning using an acoustical calibrator (General Radio type 1562-A). The calibration of the unit was then checked at noon and at the end of the workshift. The sound level measurements were taken by placing the meter as close to the worker's head as conditions would allow. In addition, where possible the microphone was positioned for grazing incidence to the noise source.

Octave band spectra of various noise sources were also taken. For these measurements, the octave band analyzer (General Radio type 1558-A) was usually positioned about 15 to 20 cm from the noise source itself. The microphone was positioned for grazing incidence. The unit was calibrated using the internal calibration of the analyzer.

Impact noises were measured using an impact noise analyzer (General Radio type

1556-B) that was connected to a sound level meter (General Radio type 1551-C). These noises were measured at the operator's hearing zone. The unit was calibrated using the internal calibration signal of the sound level meter. At least 50 separate readings were taken on each type of impact noise in order to estimate the spread of the peak pressure levels.

These workers are exposed to more than one noise level for varying lengths of time throughout a typical workday, so that systematic measurements were necessary to estimate their daily noise dose. The procedure used was the taking of A-weighted sound level measurements at one-minute intervals during various arbitrarily chosen hours. Because of the wide variation in noise exposures from hour to hour and day to day, it was felt that "sampling" a number of individuals to get an average exposure for each task performed would provide more information on which tasks involved hazardous exposures than would sampling one individual for a number of days. Therefore, after an individual had been "sampled" for an hour, all future measurements were made on different workers who were performing the same task. Also, additional sound level measurements were taken on a different day and over a different period of the day for each task.

From these data, the average time that the level fell into different 5 dBA classes starting at 85 dBA was computed. The data were then used to determine the 8-hour daily noise dose using the equation

$$\frac{C_1}{T_1} + \frac{C_2}{T_2} + \ldots + \frac{C_n}{T_n} = \text{fraction of permissible noise dose.}$$

where C_n = exposure time for a certain 5 dBA class

T_n = allowable exposure time based either on the 85 dBA-8 hour or 90 dBA-8 hour baselines

The midpoint of each class, e.g., 87.5 for the 85-89.5 class, was used to obtain allowable exposure times for calculation of the dose.

Audiometric Measurements

To determine whether there was occupationally associated hearing loss, 33 sheet metal workers were tested using pure tone audiometry. A Maico Ma-2B audiometer calibrated to the ANSI-1969[3] threshold levels was used in conjunction with TDH-39 earphones that were mounted in a pair of circumaural earmuffs. The calibration of the unit was checked both before and after the study.

Since the field jobsite was close to the laboratory, the individuals who were working at the jobsite were tested in the laboratory's IAC audiometric booth. Background noise levels in this booth were well below the ANSI[4] standards for background levels in an audiometric test room. The hearing tests performed on the workers at the shop were done in a closed room of a house trailer that was physically separated from the shop. Due to sensitivity limitations of the octave band analyzer used, sound levels in this room could not be measured below 44 dB. However, with sound levels below 44 dB per octave band and with the added attenuation of the circumaural earmuffs in which the earphones were mounted, it was felt that the background noise levels were suitable for the screening audiograms taken.

Inasmuch as the services of a licensed physician were unavailable for this study, otoscopic examinations were not performed on the individuals tested. Therefore, some discrepancies may result in comparing the hearing levels of these workers to those of a population having otologically normal ears.

The technique used in performing the audiometric examinations was that published by Sataloff.[5] Each ear was tested at the frequencies of 500, 1000, 2000, 3000, 4000, 6000 and 8000 Hz.

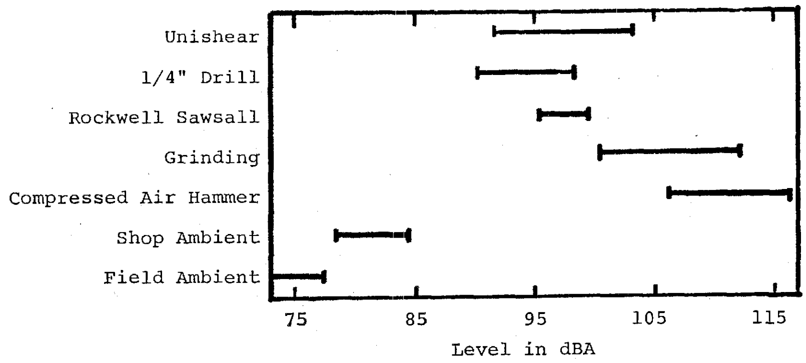

Figure 1. Range of noise levels for some commonly used tools and the background levels.

Thresholds were tested in the morning (rested ear) before the workday began, and again in the afternoon, five minutes after the cessation of a workday.

At the end of the morning examination, a questionnaire was filled out by each worker. The questionnaire inquired about avocational noise exposure, past otological problems and previous occupational and military noise exposures. A positive response to certain key questions precluded the use of the audiogram in this study.

Survey Results

Figure 1 presents the range of noise levels for some of the tools used by these workers. Background levels at the field jobsite and at the shop are also presented. In general, the background noise levels were below 85 dBA. Noise levels of about 95 dBA were found when various powered hand tools (e.g., drills, sawsalls, unishears) were used in the field. Levels as high as 110 dBA were found when certain tools (e.g., grinders and compressed-air hammers) were used in the shop.

These workers are not exposed to a single noise level for an entire workday, so that it was necessary to estimate their daily noise dose by measuring exposure times to the various noise levels. Table I presents the daily noise doses (D) as a fraction of the "permissible" noise dose for several of the commonly performed tasks. Two values of the dose are given for each task. The first value was computed using 90 dBA for 8 hours of exposure time as a permissible baseline while the second was computed using 85 dBA for 8 hours as the permissible baseline. Only one of the five tasks reported has a daily noise dose above unity when the 90 dBA-8 hour baseline is used

TABLE I
Fraction of "Permissible" Daily Noise Dose Estimated for Workers at Several Tasks

Task Description	Noise Dose Using 90 dBA-8 hr. Baseline	Noise Dose Using 85 dBA-8 hr. Baseline
FIELD TASKS		
Hanging duct	0.4	1.1
Grill work	0.3	0.7
SHOP TASKS		
Duct assembly	2.2	4.7
Welding	0.4	1.1
Bench layout	0.1	0.6

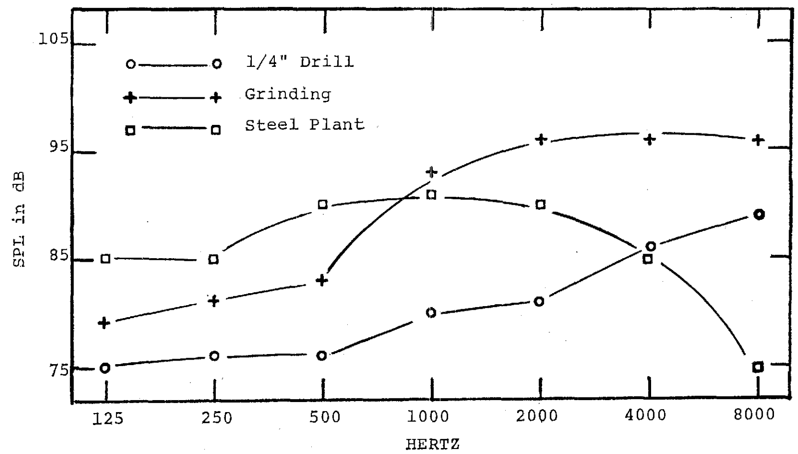

Figure 2. Octave band spectra of two commonly used powered hand tools and a steel fabricating plant taken from the National Noise Study.[6]

to compute the dose. However, when the dose is computed using the 85 dBA-8 hour baseline, three of the five tasks reported have values in excess of unity.

Of all the impact noise measures, none exceeded 140 dB peak sound pressure level. Most of the impact noises averaged about 120-125 dB peak sound pressure level.

Figure 2 presents the octave band spectra of two powered hand tools commonly used by these workers. Octave band levels for a metal products plant are also presented.[6] Note that the sound pressure levels increase at the higher frequencies which is uncommon for industrial noises.

Hearing Levels

Using the customary convention, each ear is treated as a separate unit in the computation of the median hearing thresholds in this study. Therefore, the sample sizes (N) reflect the number of ears tested rather than the number of persons tested.

The reproducibility of the audiometric data was checked by testing three men twice. At only one frequency for one subject was the difference between the two tests as much as 15 dB, while in five such cases, the difference varied by 10 dB. The group median differences were all equal to zero except for the median difference at 2 KHz which equaled 2.5 dB. This value was not found to be significant ($p < 0.05$) when analyzed using a Walsh test.[7]

Figure 3 presents the median hearing levels of the workers classified by age. The dip in the 4000-6000 Hz range, common to noise-induced permanent threshold shift, is seen in all of these curves. In addition, as the age increases, this loss also increases. Except for the crossover at 6 KHz, the hearing levels are seen to progress regularly

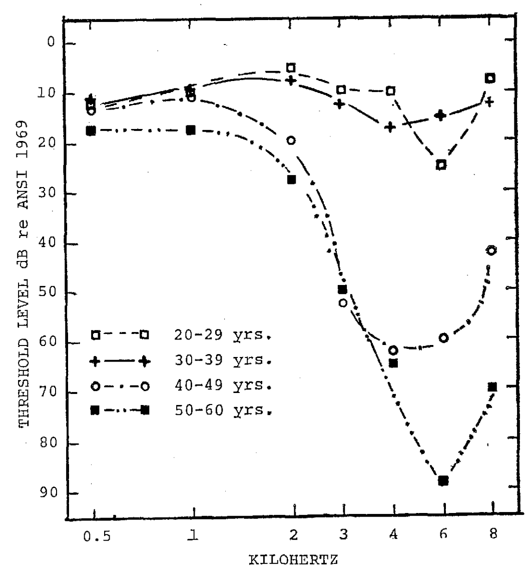

Figure. 3 Median hearing levels of a group of sheet metal workers classified by age.

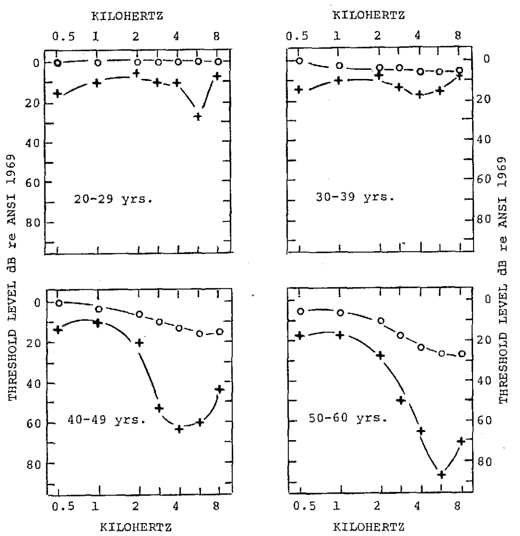

Figure 4. Median hearing levels of a group of sheet metal workers and of a population of otologically normal ears having no noise exposures. The median levels of the sheet metal workers are represented by a "+" and the normal ears are represented by a "0."

between age groups.

Since age is known to cause a loss in hearing acuity, it is common to compare the hearing loss of noise exposed persons with groups of similar age that have had no significant noise exposure.

Figure 4 presents the median hearing levels of the sheet metal workers tested (classified by age) and the median levels of a similarly age-classified group without significant noise exposures.[8] The hearing levels for the sheet metal workers are consistently poorer than the hearing levels for the non-noise exposed groups.

The differences between the median hearing levels of the sheet metal workers and the non-noise-exposed workers are shown in Table II.

For each age group, the maximum difference occurs at 6 KHz except for the 30-39 age group where the maximum difference occurs at 4 KHz. The difference at 6 KHz increases with increasing age except for the 30-39 year age group. Using a Walsh test, all but three of the differences were found to be significant at the 0.01 confidence level in the sense that the differences of magnitude shown could be expected to occur by chance no more than once in a hundred times. The three differences that were not significant at 0.01 were significant at the 0.05 confidence level.

Temporary Threshold Shift

In addition to causing a permanent change in hearing acuity, exposures to noise will also produce a temporary shift in an exposed worker's hearing level (TTS).

The temporary threshold levels of these workers were calculated by subtracting the morning hearing levels from those levels taken five minutes after the end of a workday (TTS_5). These TTS_5 values were then back corrected to TTS_2 levels using correction values of Kryter.[9]

Table III presents the median calculated TTS_2 levels by task. The greatest shift generally occurred in the 3 to 6 KHz range. However, some shift is also seen in the

TABLE II
Differences between Median Hearing Levels of Sheet Metal Workers and Non-noise-exposed Workers by Age Groups and Frequencies Tested

Age Group	Frequency in Hz 500	1K	2K	3K	4K	6K	8K
20-29	15.0*	10.0*	7.5*	10.0*	10.0*	17.5*	7.5**
30-39	11.5*	9.0*	5.4*	8.2*	11.8*	7.9*	3.8**
40-49	7.2*	7.2*	14.3*	45.5*	43.4*	43.7*	26.9*
50-60	11.8*	11.8*	16.3*	32.6*	42.1*	60.4*	55.8*

*significant at the 0.01 level
**significant at the 0.05 level

TABLE III
Median Calculated TTS_2 Levels Classified by Task

Tasks	500	1K	2K	3K	4K	6K	8K
	Frequency in Hz						
Field Tasks:							
Hanging Duct	6.0*	3.5*	6.0*	12.5*	12.5*	12.5*	6.0*
Grill Work	1.0	1.0*	1.0	3.5*	6.0*	1.0	1.0
Shop Tasks:							
Duct Assembly	3.5	9.5*	6.0*	12.5*	19.5*	6.0*	6.0*
Welding	3.5	9.3*	6.0*	9.3*	9.3*	6.0*	3.5

*significant at 0.05 level

lower frequencies. In general, the TTS_2 shifts in the 3 to 6 KHz range were found to be statistically significant by the Walsh test. Shifts at the frequencies of 0.5, 1, 2 and 8 KHz often were not significant.

In 1966, CHABA Working Group 46 adopted the following TTS_2 values as being acceptable daily amounts of TTS: 10 dB at 1 KHz and below, 15 dB at 2 KHz, and 20 dB at 3 KHz and above.[10] None of the tasks measured involve noise exposures which could be classified as hazardous using these criteria. However, the values proposed by Kryter of 0 dB at and below 2 KHz and 10 dB above 2 KHz for acceptable TTS_2 levels[11] are exceeded for the tasks of hanging duct and shop duct assembly. By these latter criteria, the task of welding represent a marginal noise exposure hazard.

Hearing Loss Index

One method proposed to determine when a hearing loss constitutes a hearing impairment is to average the threshold levels at the frequencies of 1, 2 and 3 KHz for both ears.[12] This value is referred to as the Hearing Loss Index (HLI). An HLI in excess of 25 dB is considered to be a hearing impairment. Table IV presents the results of these calculations. None of the workers in the 20-29 and 30-39 year ago group had an HLI in excess of 25 dB. However, three of the four workers in the 40-49 year ago group and all four of the workers in the 50-60 year ago group did have an average loss in excess of 25 dB at the frequencies of 1, 2 and 3 KHz.

TABLE IV
Percent of Workers Classified by Age
Having an HLI >25 dB

Age Group	Number of Individuals	% Having an HLI >25 dB
20-29	15	0
30-39	6	0
40-49	4	75
50-60	4	100

Questionnaire Results

Due to past noise exposures, it was necessary to exclude the audiograms of three workers from the results of this study. In addition, a fourth worker was excluded due to a past skull fracture.

During this period of questioning, many of the workers spontaneously complained of hearing problems such as understanding TV sound or discerning what a person was saying in the presence of background noise. However, when each worker was asked if he felt he had normal hearing, all of them responded positively.

Discussion

The results of this study suggest that some presently used damage risk criteria and standards for hazardous exposures to noise are inadequate. Although noise levels in excess of 90 dBA were found when various powered hand tools were used, daily noise doses calculated using the 90 dBA-8 hour baseline were, in general, below unity. In addition, the TTS_2 levels were below the 10, 15 and 20 dB acceptability levels pro-

10, 15 and 20 dB acceptability levels pro-

posed by CHABA. However, examination of the rested ear hearing levels of these workers appears to demonstrate a permanent threshold shift.

This inconsistency may possibly be the result of the limited number of persons studied, or it may be the result of variables not covered in this brief study. However, the possibility that some presently used damage risk criteria and standards are under-protective when persons are exposed to combined steady state/impact noises should not be dismissed. Recent research by Hamernick, et al. on exposing chinchillas to combined continuous/impact noise noted that the effects on hearing were more than additive.[13]

Until further studies can be performed on this type of exposure either to confirm or negate the present results, it would appear preferable to use the 85 dBA-8 hour baseline to compute the daily noise dose.

Establishment of a hearing conservation program for these workers is recommended.

References

1. Chadwick, D. L.: Occupational Hearing Loss and the Otologist, in Robinson, D. W., ed.: *Occupational Hearing Loss.* Academic Press, 1971.
2. Piesse, R. A., J. A. Rose, and N. E. Murray: *Hearing Conservation in Industrial Noise.* Australian Department of Labor, 1962.
3. American National Standards Institute. *Specifications for Audiometers* S 3.6 ANSI, 1969.
4. American National Standards Institute. *Criteria for Background Noise in Audiometer Rooms.* S 3.1 ANSI, 1960.
5. Sataloff, J.: *Industrial Deafness.* McGraw-Hill, New York, 1957.
6. U.S.D.H.E.W., NIOSH. *Occupational Noise and Hearing.* 1968-1972. NIOSH, 1973.
7. Siegel, S.: *Nonparametric Statistics.* McGraw-Hill, 1956.
8. ISO, Technical Committee 431 sc: *Proposal for Hearing Levels of Non-Noise Exposed People at Various Ages.* ISO, TC 431 sc, 1970.
9. Kryter, K. D.: Exposure to Steady State Noise and Impairment of Hearing. *J. Acous. Soc. of Am. 35:*1515 (1963).
10. Kryter, K. D., W. D. Ward, J. D. Miller and D. H. Eldridge: Hazardous Exposure to Intermittent and Steady State Noise. *J. Acous. Soc. of Am. 39:*451 (1966).
12. U.S.D.H.E.W., NIOSH: *Criteria for a Recommended Standard, Occupational Exposure to Noise.* NIOSH, 1972.
13. Hamernik, R. P., D. Henderson, J. J. Crossley and R. J. Salvi: Interaction of Continuous and Impulse Noise: Audiometric and Histological Effects. *J. Acous. Soc. of Am. 55:*117 (1974).

This study was supported in part by National Institute for Occupational Safety and Health Training Grant No. 5 T01 OH-00028.

Delaware Valley Section Schedules Tour

The Delaware Valley Section is sponsoring a tour to England September 11-19, 1975. This includes a visit to London and attendance at the XVIII International Congress on Occupational Health in Brighton. Special workshops have been arranged by the Section for the exchange of information regarding training, research methodology and regulatory procedures in the practice of industrial hygiene. Tax deductible. For further information, contact Dr. Samuel Elkin, President, Delaware Valley Section, Temple University, School of Pharmacy, 3307 N. Broad St., Philadelphia, Pennsylvania 19140, phone (215) 221-4915.