A Study of Hearing Loss

Among Alberta Construction Workers

Prepared for:

Construction Labour Relations – Alberta
10050 112 St. NW, Suite 904
Edmonton, Alberta T5K 2J1

Electrical Contractors Association of Alberta
(for unionized contractors and their employees that participate in the audiometric testing program)
17725 – 103 Avenue
Edmonton, Alberta T5S 1N8

Boilermaker Contractors' Association
4245 – 97 Street, Unit 100
Edmonton, Alberta T6E 5Y7

Prepared by:

Patrick A. Hessel, PhD
Epidemiologist
EpiLung Consulting, Inc.
#25, 26204 Township Road 512
Spruce Grove, Alberta T7Y 1C5

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Executive Summary

"Construction work" comprises a variety of occupations and work situations. Unlike many other industrial workers, construction workers often encounter unpredictable situations. Construction equipment is often noisy and construction workers frequently work in the proximity of other workers who are producing noise. Many of the noise exposures are difficult to control. The Construction Industry Audiometric Testing Program (CIATP) was initiated in 2006 by Construction Labour Relations – Alberta to monitor the hearing acuity of construction workers. Since its initiation, more than 17,000 audiometric tests have been performed. The present analysis is the first in-depth look at this valuable dataset.

The purposes of this analysis were:

1. To describe the level of hearing loss among construction workers overall, and by age and trade. This information can be of direct benefit to workers as well as employers and others involved in monitoring and improving worker health.
2. To compare the data from the CIATP to from a study of hearing loss conducted in the 1990s in several Edmonton-based construction trade unions.
3. To compare the assessment of hearing impairment based on the existing Alberta criteria to criteria used more commonly internationally.

Of the 17,476 audiograms comprising the CIATP, information on age and trade was available for 12,125 workers. More than 5,000 of the tested worker either had missing information for trade or they were not employed in a construction trade. Less than 600 had missing information for age. On the basis of the trade as stated by the workers at the time of testing and their union affiliation, the 12,125 workers were classified into one of 19 trades. For most of these trades there were adequate numbers of workers to provide reliable estimates of hearing loss with age.

Graphical presentation of the data showed patterns typical of noise-induced hearing loss, with greater losses in the higher frequencies. As expected, hearing loss increased with age. Using the Alberta criteria to assess hearing impairment, 2.1 percent of the workers had at least some impairment. Less than one percent of workers 45 years old or less were classified as having some impairment, while 14.4 percent of the workers over age 60 were similarly classified. Using the criteria more commonly used internationally, 12.3 percent of the workers were classified as having some hearing impairment. The percent with impairment increased with age from 2.3 percent of those aged 18 to 25, to 48.7 percent of those over age 60. Of those classified as having some impairment by the international criteria, more than half had less than five percent impairment and only 1.5 percent had 20+ percent impairment.

When the percentages of workers in the various trades with any impairment were calculated and ranked using the Alberta criteria and the international criteria, the structural ironworkers, millwrights, and carpenters appeared near the top of both lists (i.e., among the

trades with the highest percent of workers with at least some impairment). Plumbers and sheeters were near the bottom of both lists.

Substantial decreases in the percent of workers with hearing impairment were seen when the CIATP data were compared with the data from the study of construction trades workers that was conducted in the 1990s. In this analysis, workers in the CIATP data set were included so that their age distribution matched the earlier study. In the earlier study, 47.5 percent of the members of the boilermakers union had at least some impairment. In the present study 17.3 percent of the boilermakers and 18.4 percent of the welders had some impairment, using the international criteria (most of the members of the boilermakers unions in the CIATP data set were classified as either boilermakers or welders). This represents a decline of more than 50 percent over a period of 11 to 17 years. In the earlier study, 33.7 percent of the plumbers and pipefitters had some impairment, compared to 18.7 percent for the fitters and 11.0 percent for the plumbers in the present analysis: again, a decline of about 50 percent. For the electricians, the percent with some impairment declined from 20.0 percent in the earlier study to 14.0 percent in the present analysis. Reasons for this dramatic improvement in such a short time may relate to both occupational and non-occupational factors.

While the data demonstrate clearly that some of the hearing loss among these workers is related to occupational exposures, non-occupational factors such as shooting, snowmobiling, chain sawing and others may also play a role. Although the CIATP has collected data on these activities, the data have not been computerized and could not be explored in the present analysis.

The CIATP is one of the largest such databases in the world. It represents a unique approach to monitoring the health of a very diverse and geographically dispersed worker population. It is a valuable asset in the effort to maintain and improve the health of this very important occupational group. Although dramatic improvements in hearing acuity have been realized over the past decade and a half, continued exploration of this important data set should yield even greater improvements.

Introduction

The World Health Organization estimated that in 2004, 250 million people worldwide were suffering from hearing impairment of moderate or greater severity (Nelson et al, 2005). The leading causes of hearing loss among adults are noise, age, and ear infections (Ries, 1994). It is estimated that about 16 percent of hearing loss is the result of excessive noise in the workplace (Nelson et al, 2005).

Approximately 18 years ago, a study was undertaken to assess hearing loss in three groups of construction workers who were based out of Edmonton trade unions (Hessel, 2000). The study was funded by the Alberta and Northwest Territories Building and Construction Trades Council, the Alberta Workers' Compensation Board, and the Alberta Lung Association (a lung health component was also included). The workers came from the International Brotherhood of Electrical Workers (Local 424), the United Association of Journeymen and Apprentices of the Plumbing and Pipefitting Industry of the United States and Canada (Local 488), and the International Brotherhood of Boilermakers, Iron Shipbuilders, Blacksmiths, Forgers and Helpers (Local 146). These will be referred to as the electricians, the plumbers and pipefitters, and the boilermakers, respectively.

About 100 workers with at least 20 years of union membership were selected at random from each of these unions for audiometric testing. The results for each of the groups of construction workers were compared to the results for a group of workers from Edmonton Telephones. The average age was approximately 52, and they had spent, on average, 26 years in their trades.

Most of the construction workers stated that they were exposed to noise on the job, and most of them usually wore hearing protection. Using an available definition of "hearing loss," (i.e., sum of thresholds at 2000 Hz, 3000 Hz, and 4000 Hz > 105 dB in at least one ear), 19 percent of the electricians, 38 percent of the plumbers and pipefitters, and 50 percent of the boilermakers had hearing loss. As expected, hearing loss increased with age. A copy of the complete published report in included as Appendix A.

Given the nature of construction work, studies of hearing loss are difficult and few studies exist. The presence of a centralized testing program for construction trades workers in Alberta provided a unique opportunity to learn more about hearing loss in this important occupational group.

Construction Industry Audiometric Testing Program (CIATP)

The CIATP has been in operation since 2006. The CIATP was initiated by the Construction Labour Relations – Alberta on behalf of its participating employers to address the legislative requirements for the testing of noise-exposed workers in a multi-employer environment with a transient workforce. The stated goals are to:

1. Facilitate the ability for employers to be in compliance with legislation;
2. Provide a mechanism to fairly share in a cost-effective testing delivery service;
3. Maintain a central database to determine when testing is required; and
4. Monitor audiometric testing in a transient workforce.

Construction companies apply to participate in the CIATP. Their workers are then tested either at mobile testing facilities or at a permanent, central location (presently in Nisku, Alberta).

Goals and Objectives of the Present Analysis

The goals of the analysis are:

1. To describe the level of hearing loss among the construction workers who have been tested to date; and
2. To provide information that can be used to educate workers and better target hearing conservation efforts.

The objectives are:

1. To calculate average hearing thresholds for the workers overall, and by age and trade;
2. To determine the percent of workers with hearing impairment overall, and by age and trade;
3. To compare the results of the audiometric testing conducted by the CIATP with the results of the testing conducted in the 1990s (Hessel, 2000) and;
4. To compare the percentages of worker with hearing impairment using the Alberta criteria and criteria more commonly used internationally.

Methods

Since the inception of the CIATP, more than 17,000 audiometric tests have been conducted. Information on the individuals being tested, including date of testing, age, company, trade, union, site name and city, and the measured hearing thresholds has been computerized for all of these tests. Many of these tests are classified as "baseline" (i.e., the first test for that individual) and others are classified as "periodic" (i.e., follow-up tests conducted on a set schedule following the baseline tests). For the present analysis, the most recent audiogram was used.

In addition to the computerized information listed above, each of the workers being tested has completed a form describing their health/medical history, non-occupational noise exposures (e.g., loud music, firearms, snowmobiling), and an estimate of how recently they were exposed to loud noise. These forms were available; however, they have not been computerized and are not part of the present study.

The tests were performed by certified audiometric technicians. The testing facilities, whether stationary or mobile, met the Alberta requirements for background noise levels (i.e., 0.5 kHz – 22 dB; 1 kHz – 30 dB; 2 kHz – 35 dB; 4 kHz – 42 dB; 8 kHz – 45 dB). The audiometers included the Tremetrics RA650, RA300, and RA 500. They measured hearing acuity in 5 dB increments at 0.5, 1, 2, 3, 4, 6 and 8 kHz. All audiometers were calibrated at least annually.

There were 17,476 audiograms available for analysis. As noted above, the trade of the worker being tested was typically recorded. The frequency distribution of the trades recorded in the database appears in Appendix B. Several observations can be made. The first entry in the table in Appendix B is blank. This indicates that there were 4,847 of the tested workers who had no trade listed. Among the entries that follow in Appendix B, there are some that are non-construction trades workers (e.g., accountant, administrative assistant). The construction workers with similar trades are recorded in a variety of ways (e.g., pipefitter, pipefitter helper, PF JM, PFSUPT, pipefitter/welder). Appendix B was reviewed by a group with a long history in the Alberta construction industry. The descriptors that reflected construction trades were summarized into 19 categories.

In addition to trade, the union affiliation was also listed for the workers. The frequency distribution of the listed unions appears in Appendix C. Again, the first entry in the table is blank, indicating that for 5,725 of the tested workers, no union affiliation was listed. The listing in Appendix C was also reviewed by the group familiar with the Alberta construction industry. For some of the unions, they felt that it was possible to determine the trade of the worker to a reasonable probability, based on the union affiliation.

To categorize the workers into one of the 19 categories (trades), any workers whose trade could be classified based on their union affiliation were classified first in that way. After that, the workers were classified according to the trade that was listed. In this way, anyone whose union affiliation suggested a specific trade but who listed their trade differently would be reclassified according to the trade they listed. The trades and the numbers of workers in each trade that were tested appear in Table 1. For most categories, substantial numbers of workers were tested. There were relatively few reinforcing ironworkers, sheeters, and mechanics. Nearly 30 percent either had no trade listed or had a trade that was not a construction trade.

In studies involving health information it is standard practice that the study protocol is reviewed to ensure that it conforms to accepted norms for research on human subjects. The study protocol was reviewed and ethics approval was obtained from the Alberta Research Ethics Community Consensus Initiative.

Table 1: Number and percent of workers tested by trade

Trade	Number tested	Percent
Boilermaker	1041	6.0
Welder	1025	5.9
Electrician	2595	14.8
Fitter	2406	13.8
Instrument Technician	199	1.1
Plumber	249	1.4
Structural Ironworker	581	3.3
Reinforcing Ironworker	13	0.1
Carpenter	455	2.6
Scaffolder	1489	8.5
Millwright	122	0.7
Insulator	645	3.7
Sheet Metal Worker	229	1.3
Sheeter	45	0.3
Labourer	766	4.4
Crane Operator	121	0.7
Piling/Heavy Equipment	244	1.4
Mechanic	59	0.3
Other or no trade listed	5192	29.7
Total	17476	100

Results

The age distribution of the workers who were tested appears in Table 2. There were substantial numbers of workers in all of the age categories. There were larger numbers of workers in the younger age groups and then a fairly even distribution from age 31 to age 55.

Table 2: Number and percent of workers tested by age category

Age category	**Number tested**	**Percent**
18-25	2457	14.1
26-30	2234	12.8
31-35	2085	11.9
36-40	1922	11.0
41-45	1909	10.9
46-50	2084	11.9
51-55	1948	11.1
56-60	1382	7.9
61-80	877	5.0
No age listed	578	3.3
Total	17476	100

Table 3 lists the tested workers in each of the trades by age category. In all, 12,125 workers could be classified by trade and age. A bias toward younger workers can be seen among the boilermakers, plumbers, and reinforcing ironworkers. A bias toward older workers can be seen among the millwrights, crane operators, and piling/heavy equipment workers. The differences in the age distributions may have some effect on the overall comparisons that follow (e.g., percent of workers by trade with hearing impairment) because hearing acuity typically declines with age, even in the absence of occupational noise exposure. The graphs of hearing acuity for each trade (to follow) were not affected by differences in the age distributions of the various trades because they showed average hearing thresholds by age category.

Figures 1-36 summarize the average hearing thresholds by age overall (Figures 1 and 2) and for each of the trades (Figures 3-36). A hearing threshold is the intensity of the sound (of that frequency) that is just audible to the worker. There were too few reinforcing ironworkers to graph, so these were not included in the figures. The vertical axes in these figures represent the average hearing threshold. The horizontal axes signify the sound frequency, ranging from 0.5 kHz to 8 kHz.

Several observations are warranted.

Because Figures 1 and 2 contain the largest numbers of workers, the data are most stable. In these figures, the fairly consistent decline in hearing acuity with age can be seen. Part of this is the result of normal aging. Some may be attributable to occupational noise exposure and some to non-occupational noise. Some hearing loss may also be related to hereditary conditions, infections, certain drugs or other factors.

All of the graphs have the same basic patterns. In addition to the consistent decline in hearing acuity with age across all frequencies, greater losses can be seen in the frequencies from 4 kHz to 8 kHz. Most speech is heard in the lower frequencies (0.5 kHz to 3 kHz). This “notch” in the higher frequencies is indicative of noise induced hearing loss. The fact that the effects of noise are greater in the higher frequencies relates to a variety of factors, possibly including greater sensitivity of the ear to higher frequency sounds and the geometry of the cochlea (the part of the ear that senses sound).

It can also be seen (more clearly in Figures 1 and 2) that hearing loss is slightly greater in the left ear than in the right ear. This again, is a common finding. This may result from right-handed rifle shooting (which exposes the left ear to more noise) and driving vehicles with windows open. Hearing loss associated with occupational noise exposure is more often bilateral (relatively equal in both ears).

It is difficult to compare the trades with one another from the graphs. As expected, there appears to be more variability in the graphs for sheeters and mechanics, where the numbers of workers were smaller.

Table 3: Number and percent of workers tested in each trade by age*

Trade	18-25	26-30	31-35	36-40	41-45	46-50	51-55	56-60	61-80	Total
Boilermaker	335 (33)	192 (19)	130 (13)	121 (12)	61 (6)	68 (7)	60 (6)	35 (3)	15 (2)	1017 (100)
Welder	109 (11)	140 (14)	169 (17)	148 (15)	98 (10)	98 (10)	99 (10)	82 (8)	56 (6)	999 (100)
Electrician	274 (11)	316 (12)	301 (12)	374 (15)	350 (14)	319 (12)	305 (12)	205 (8)	126 (5)	2570 (100)
Fitter	262 (11)	273 (12)	297 (13)	263 (11)	264 (11)	300 (13)	299 (13)	233 (10)	168 (7)	2359 (100)
Instrument Technician	18 (9)	23 (12)	20 (10)	18 (9)	24 (12)	29 (15)	34 (17)	13 (7)	16 (8)	195 (100)
Plumber	60 (24)	49 (20)	47 (19)	28 (11)	22 (9)	18 (7)	9 (4)	9 (4)	6 (2)	248 (100)
Structural Ironworker	81 (14)	75 (13)	99 (17)	69 (12)	63 (11)	49 (8)	62 (11)	46 (8)	35 (6)	579 (100)
Reinforcing Ironworker	4 (31)	4 (31)	2 (15)	0 (-)	1 (8)	1 (8)	1 (8)	0 (-)	0 (-)	13 (100)
Carpenter	56 (12)	47 (10)	45 (10)	35 (8)	50 (11)	77 (17)	65 (14)	52 (12)	23 (5)	450 (100)
Scaffolder	236 (16)	203 (14)	169 (11)	155 (10)	171 (12)	190 (13)	185 (12)	130 (9)	48 (3)	1487 (100)
Millwright	9 (7)	10 (8)	18 (15)	13 (11)	12 (10)	13 (11)	12 (10)	21 (17)	13 (11)	121 (100)
Insulator	94 (15)	66 (10)	63 (10)	47 (7)	68 (11)	89 (14)	111 (17)	59 (9)	45 (7)	642 (100)
Sheet Metal Worker	37 (16)	28 (12)	26 (11)	26 (11)	24 (10)	34 (15)	31 (14)	13 (6)	9 (4)	228 (100)
Sheeter	6 (14)	6 (14)	3 (7)	4 (9)	4 (9)	11 (25)	9 (20)	0 (-)	1 (2.3)	44 (100)
Labourer	120 (16)	69 (9)	55 (7)	51 (7)	90 (12)	137 (18)	116 (15)	75 (10)	44 (6)	757 (100)
Crane Operator	14 (12)	11 (10)	14 (12)	6 (5)	7 (6)	20 (17)	13 (11)	14 (12)	17 (15)	116 (100)
Piling/Heavy Equipment	21 (9)	38 (16)	26 (11)	29 (12)	18 (8)	22 (9)	31 (13)	26 (11)	30 (12)	241 (100)
Mechanic	6 (10)	10 (17)	7 (12)	9 (15)	7 (12)	6 (10)	7 (12)	6 (10)	1 (2)	59 (100)
Total	1742 (14)	1560 (13)	1491 (12)	1396 (12)	1334 (11)	1481 (12)	1449 (12)	1019 (8)	653 (5)	12125 (100)

*Numbers in parentheses are row percents.

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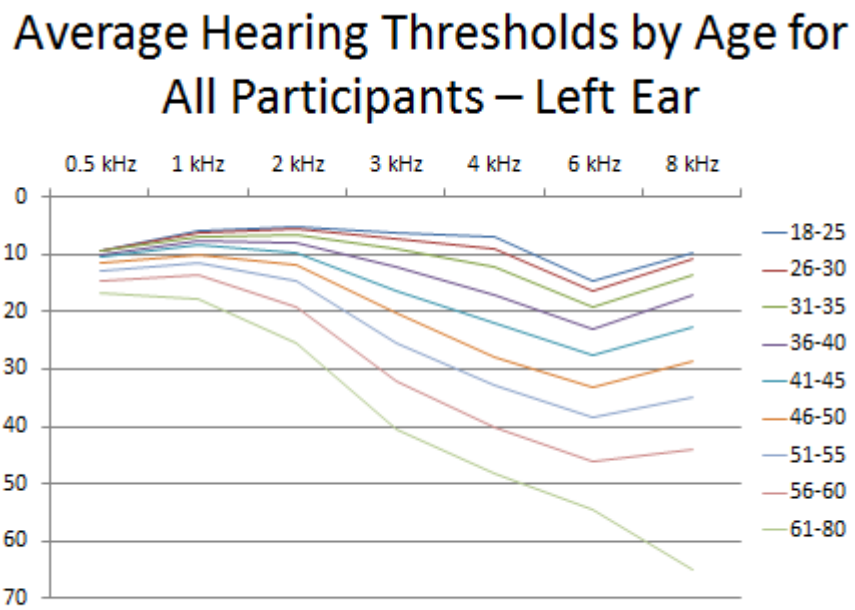

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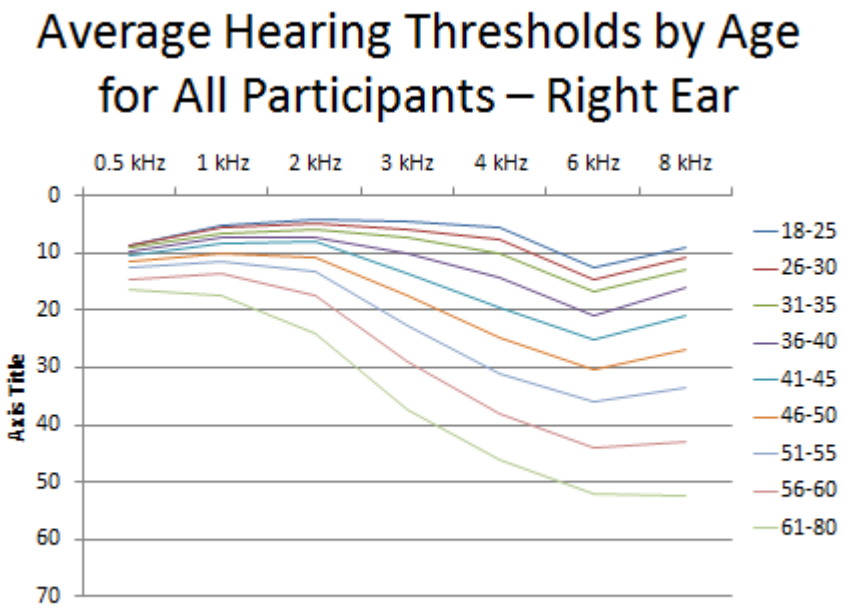

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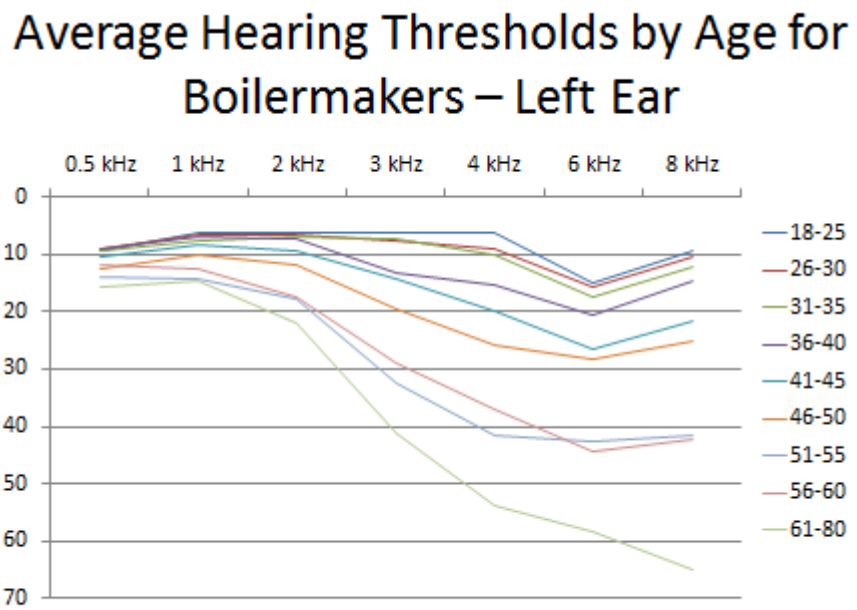

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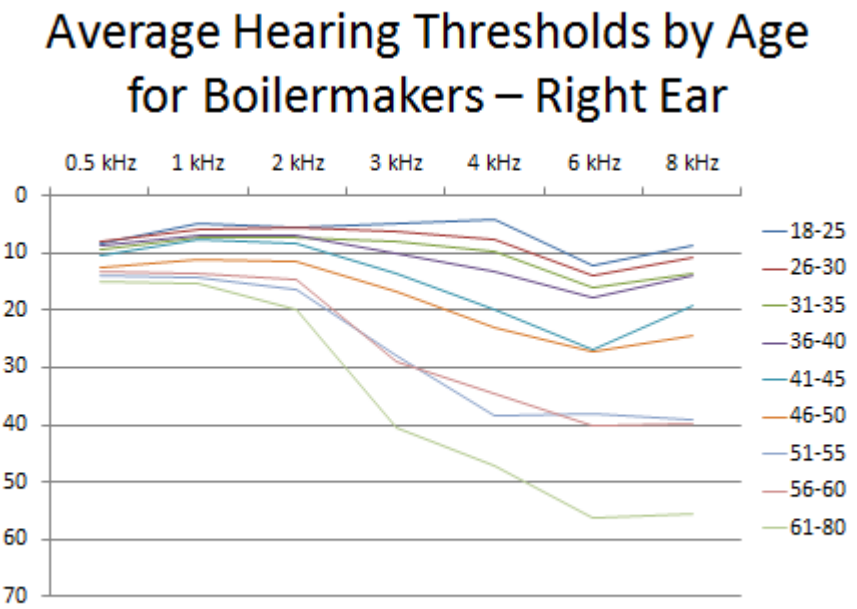

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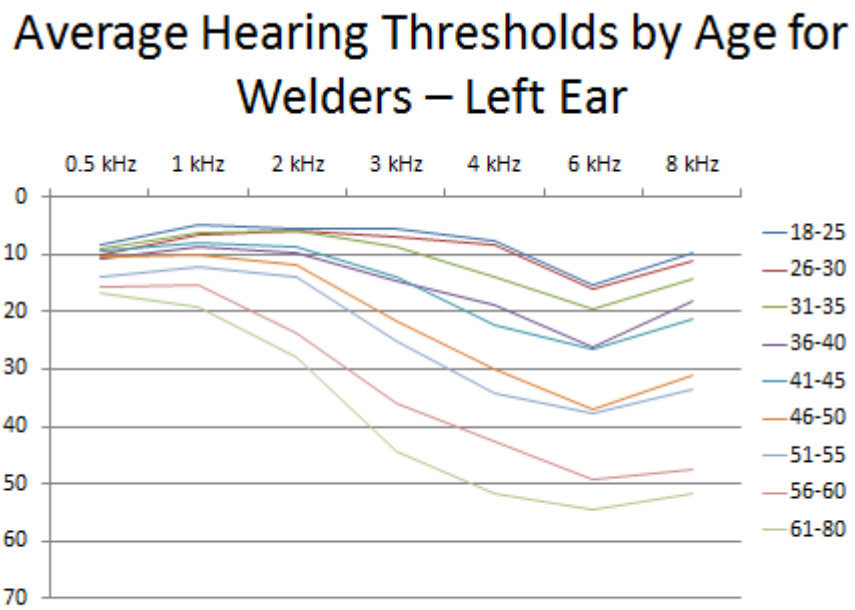

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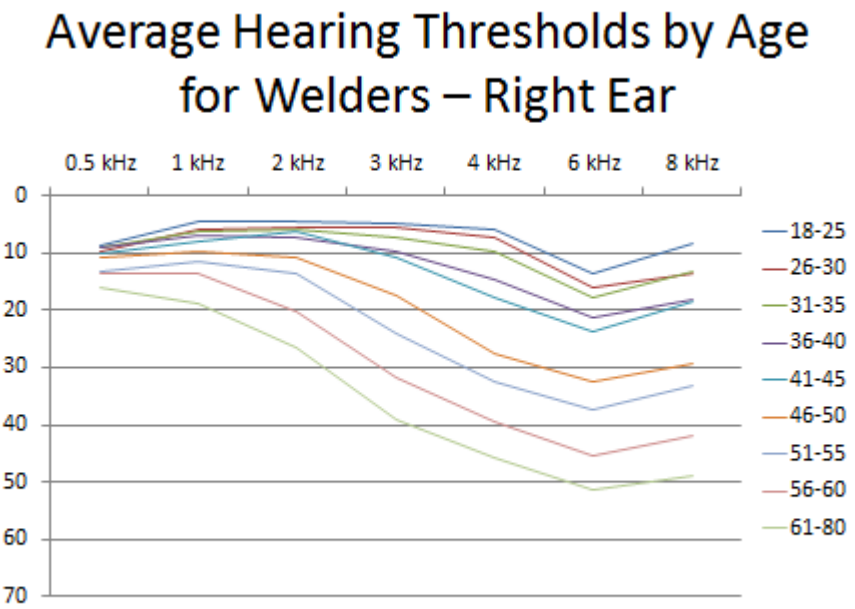

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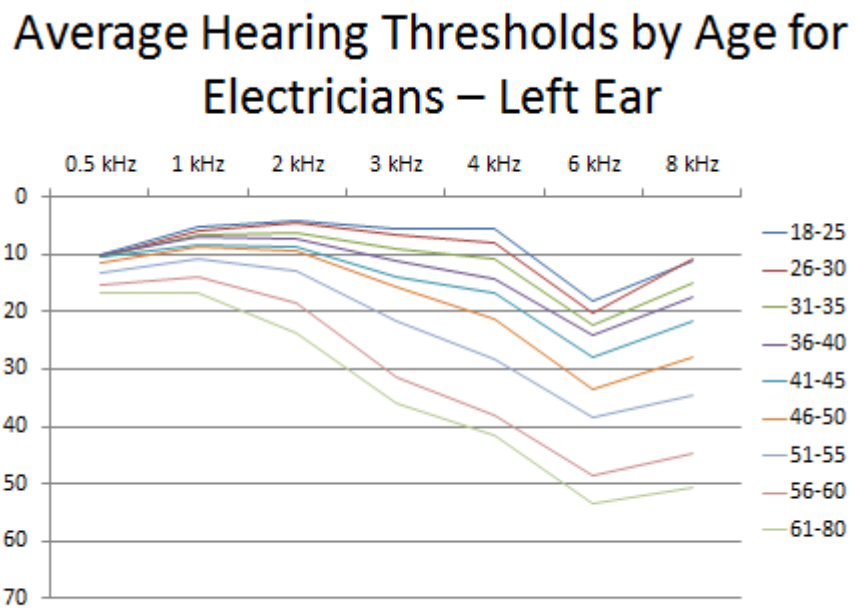

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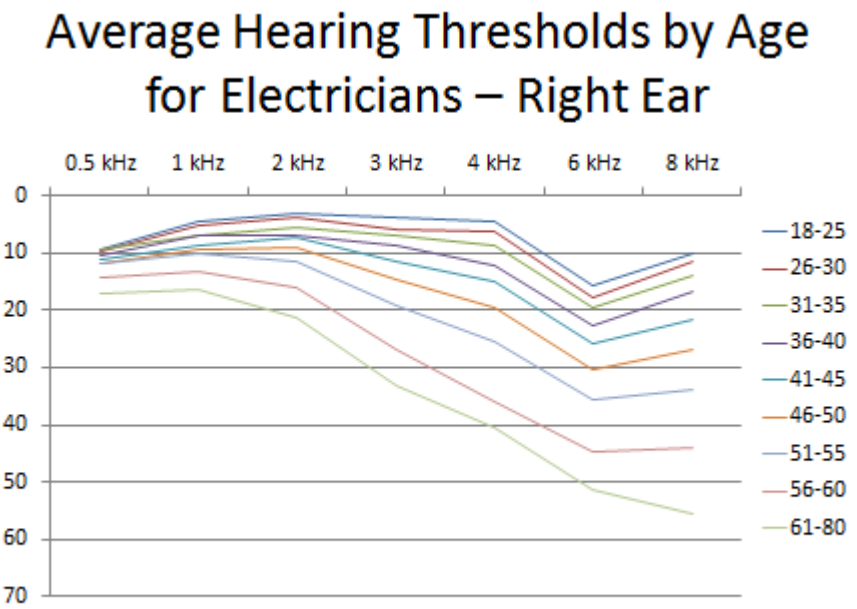

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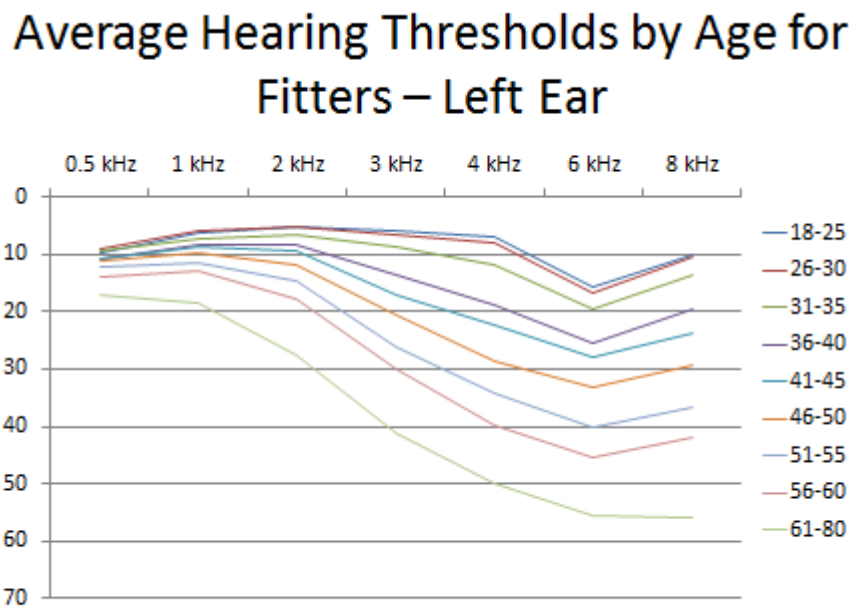

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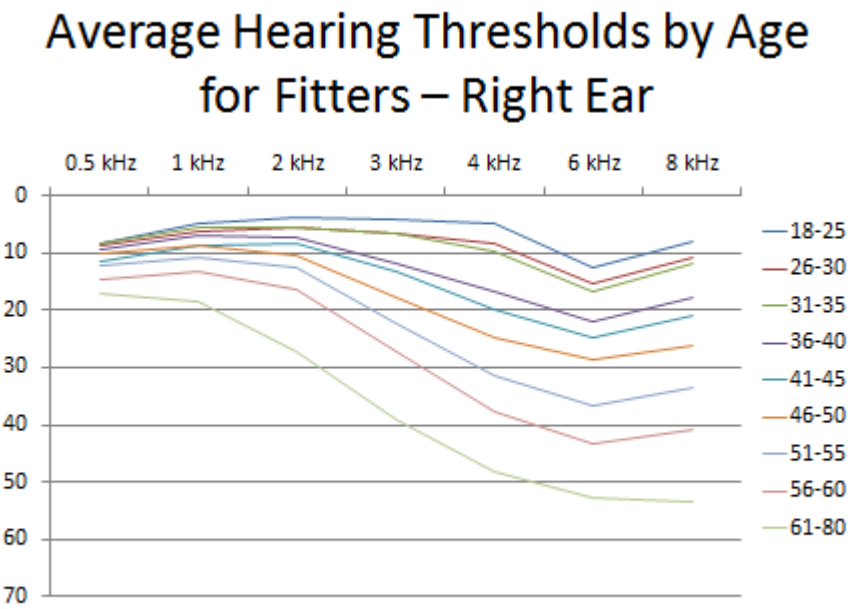

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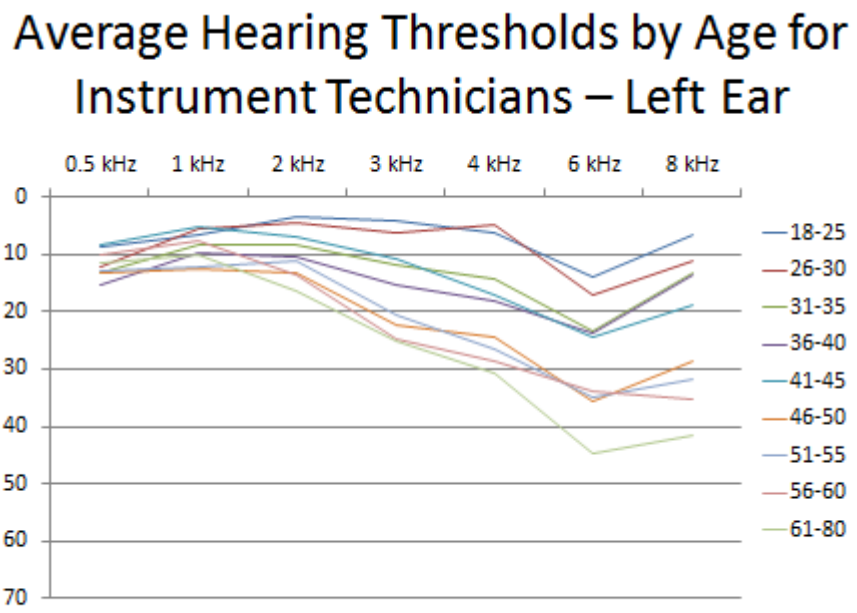

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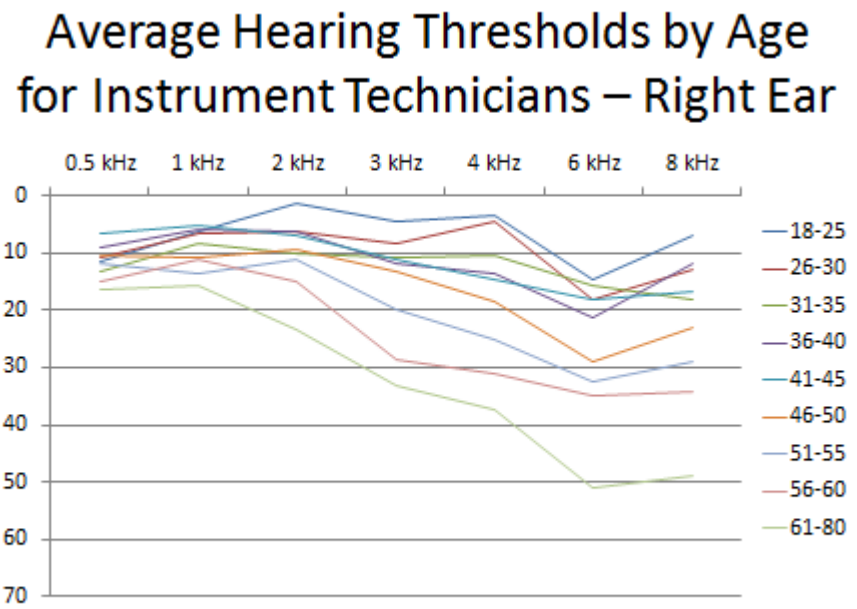

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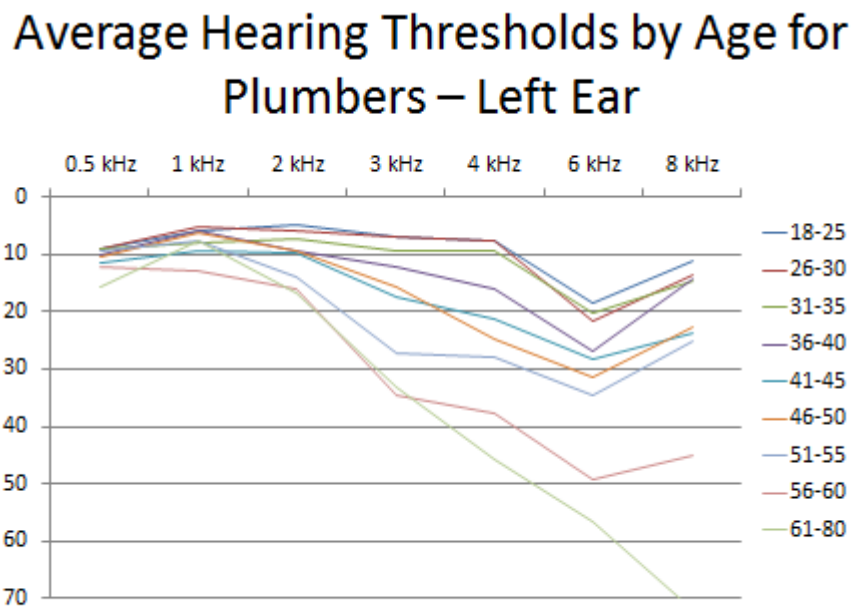

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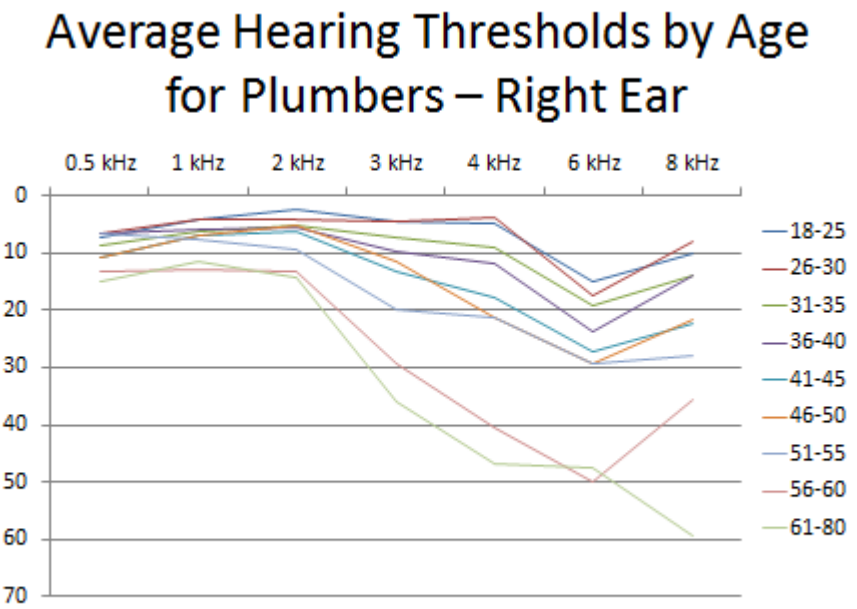

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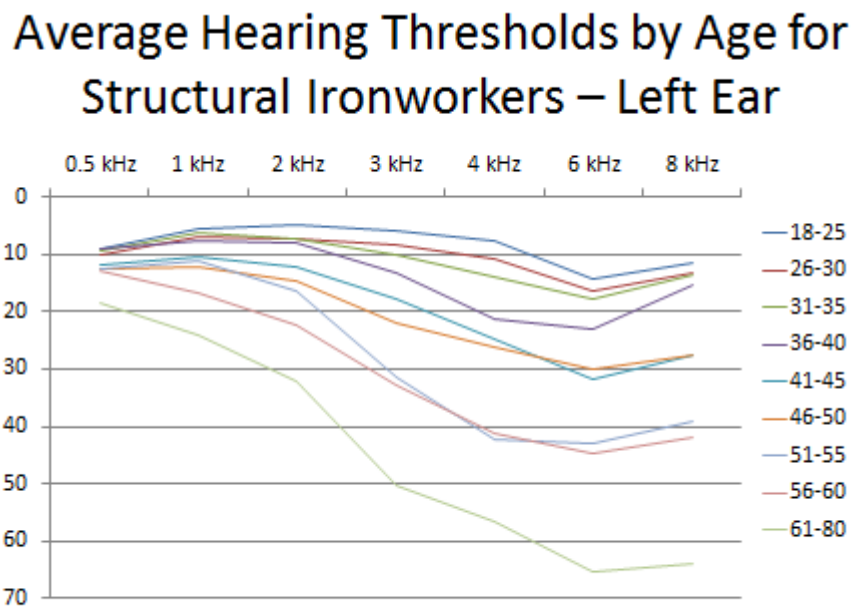

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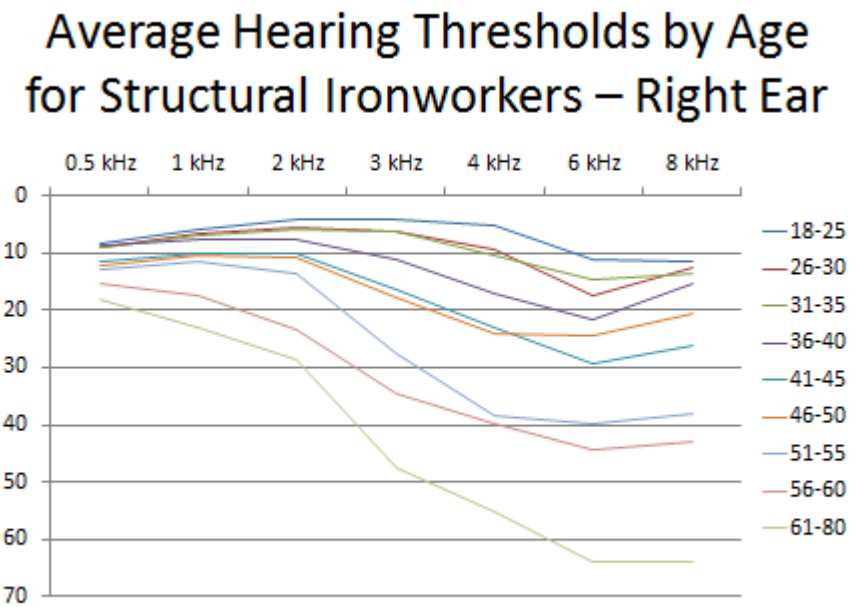

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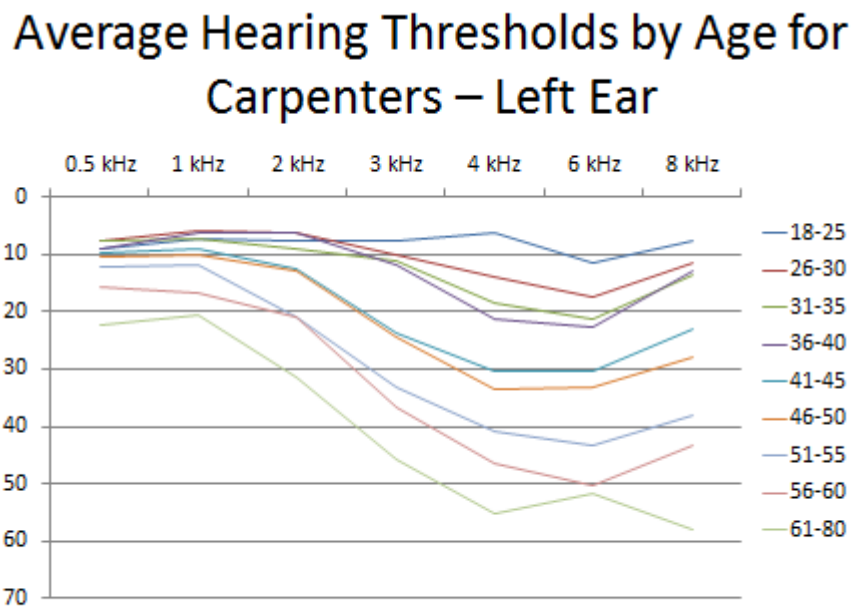

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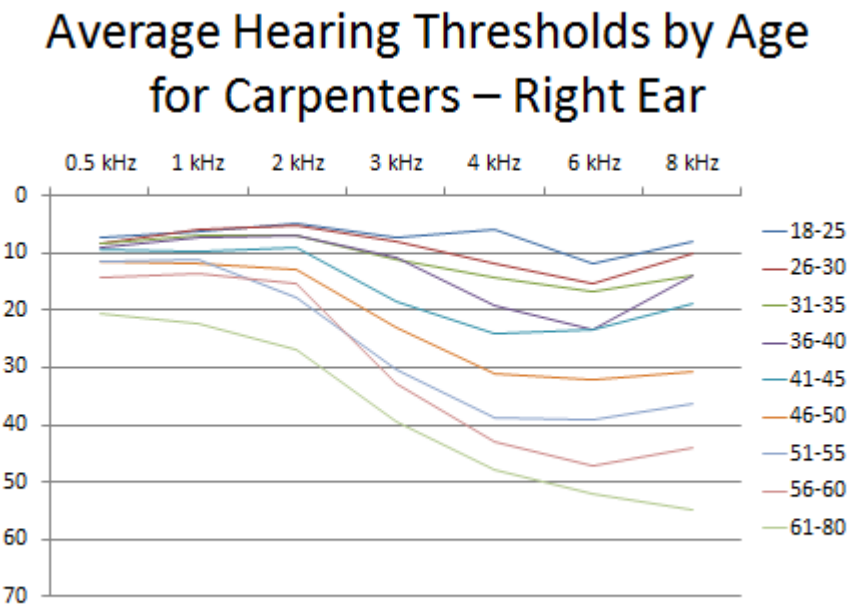

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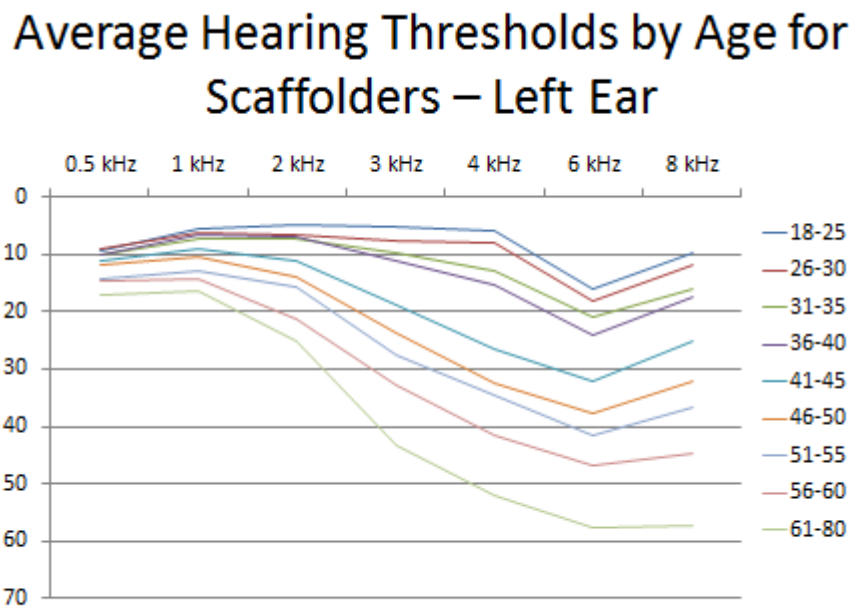

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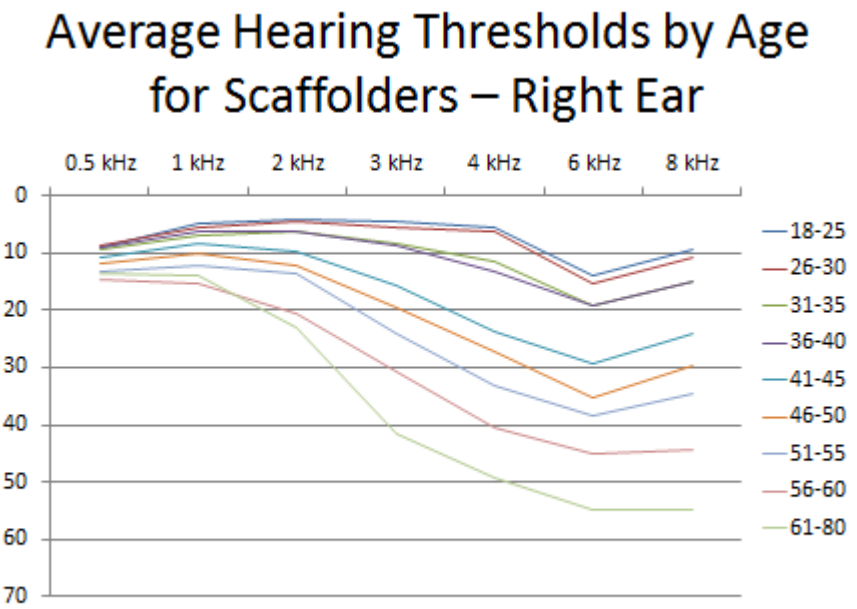

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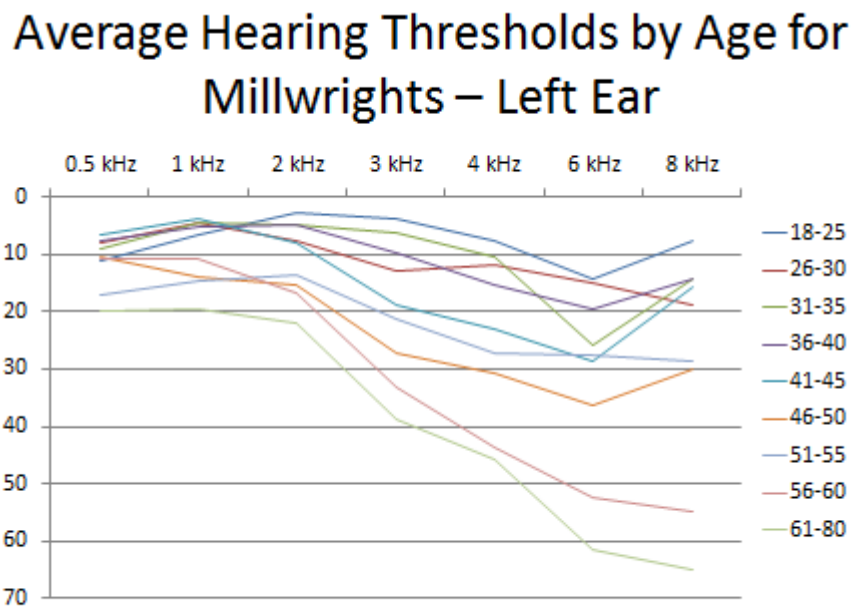

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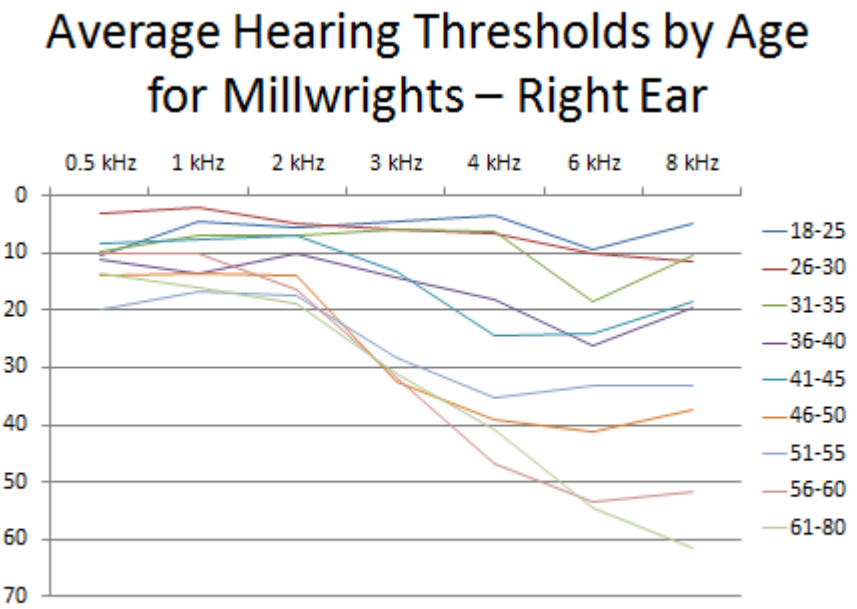

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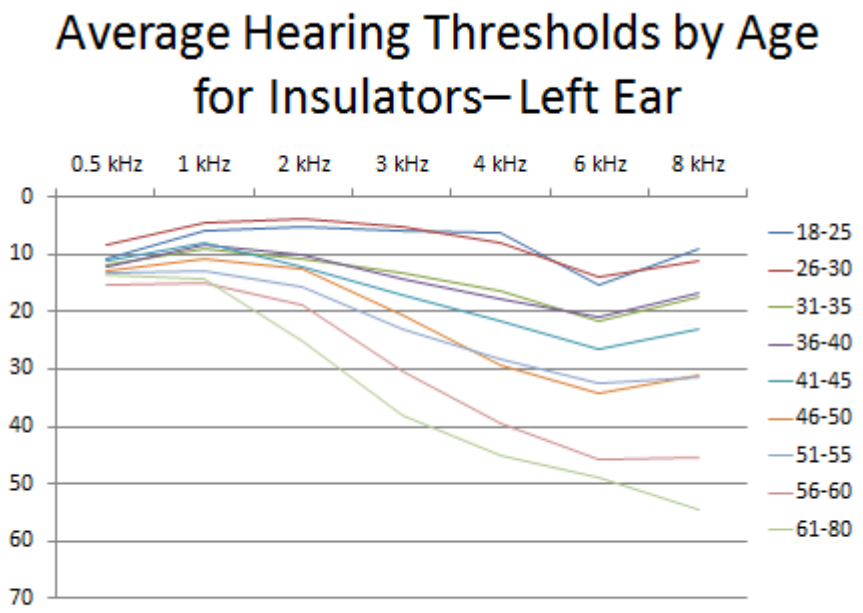

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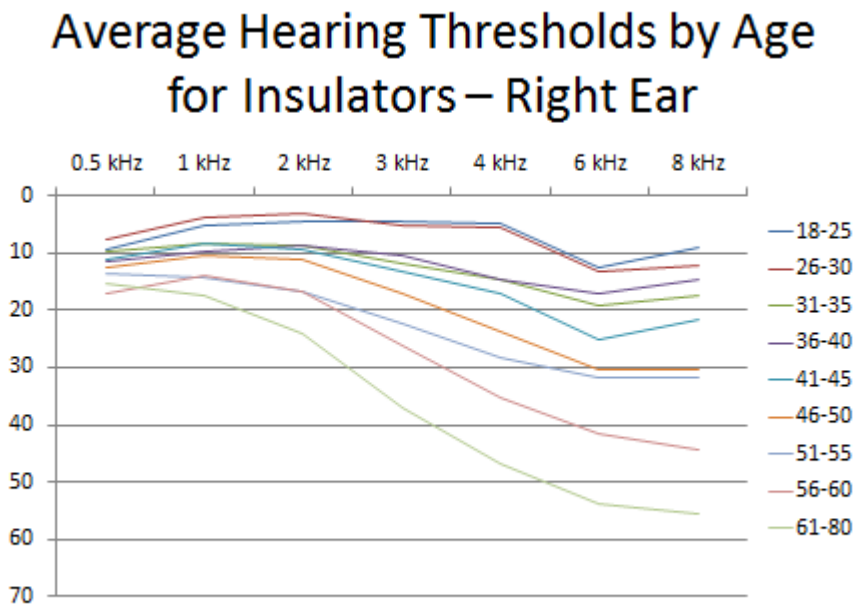

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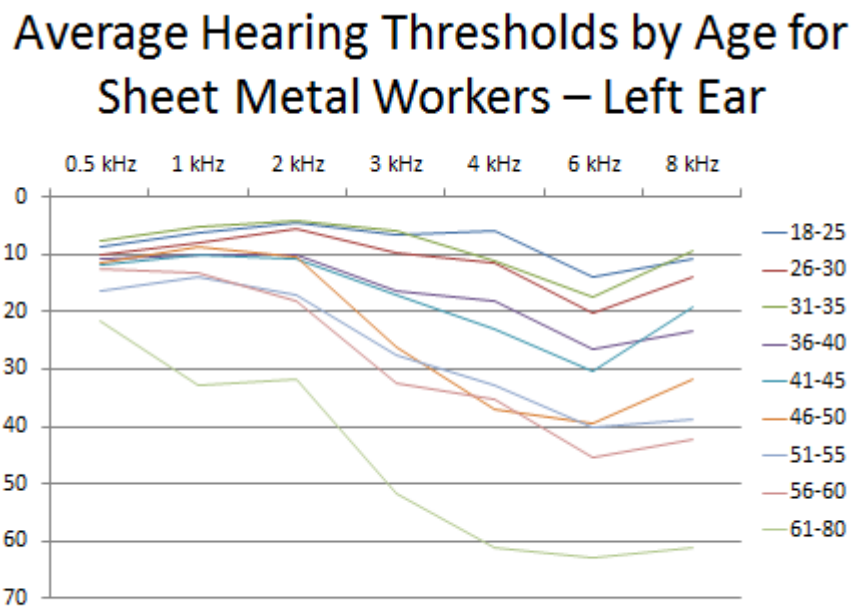

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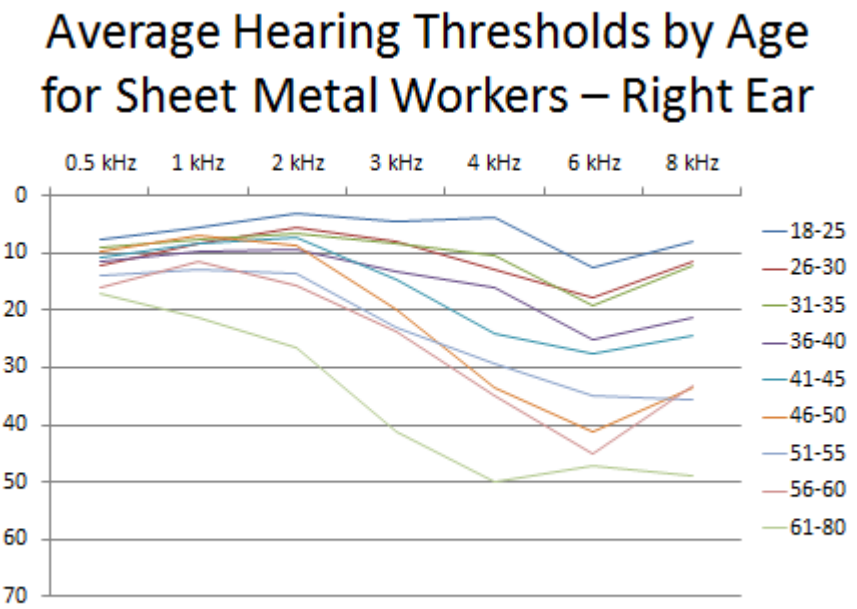

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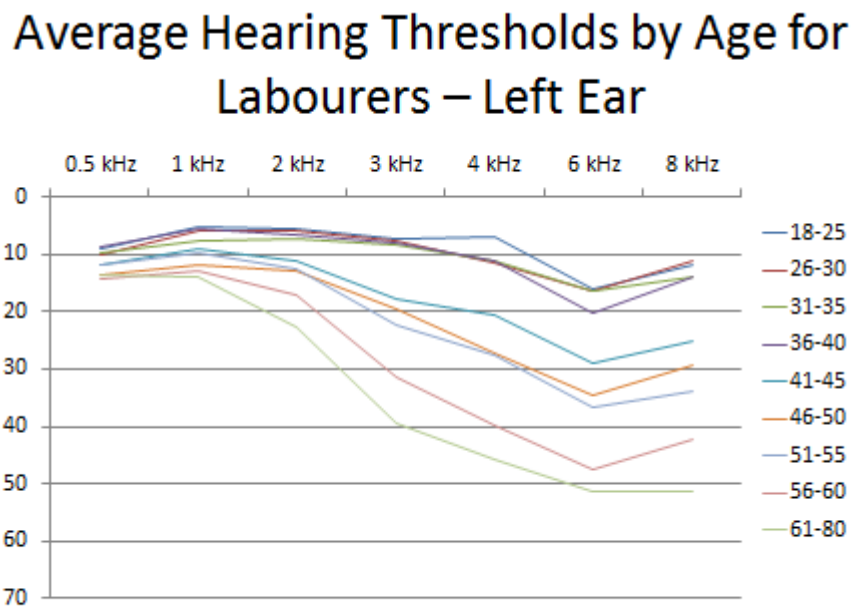

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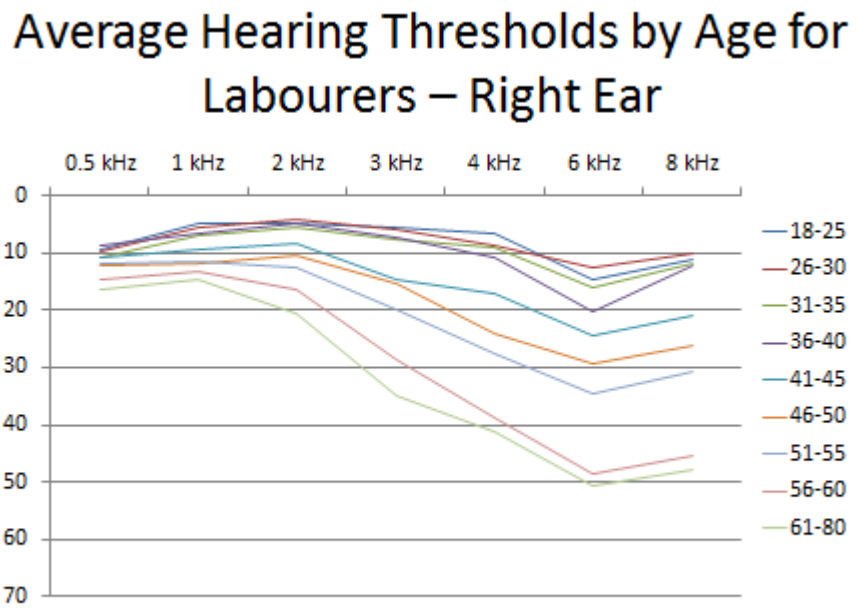

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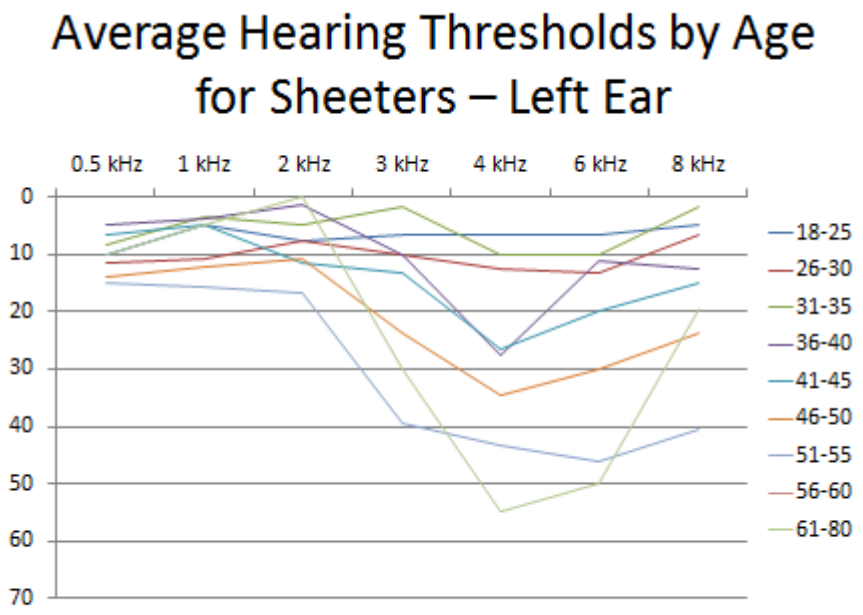

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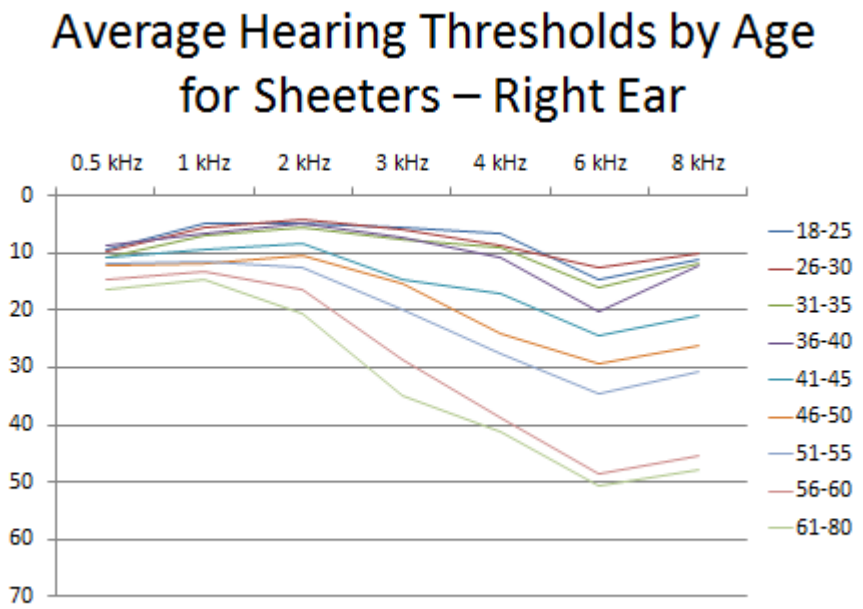

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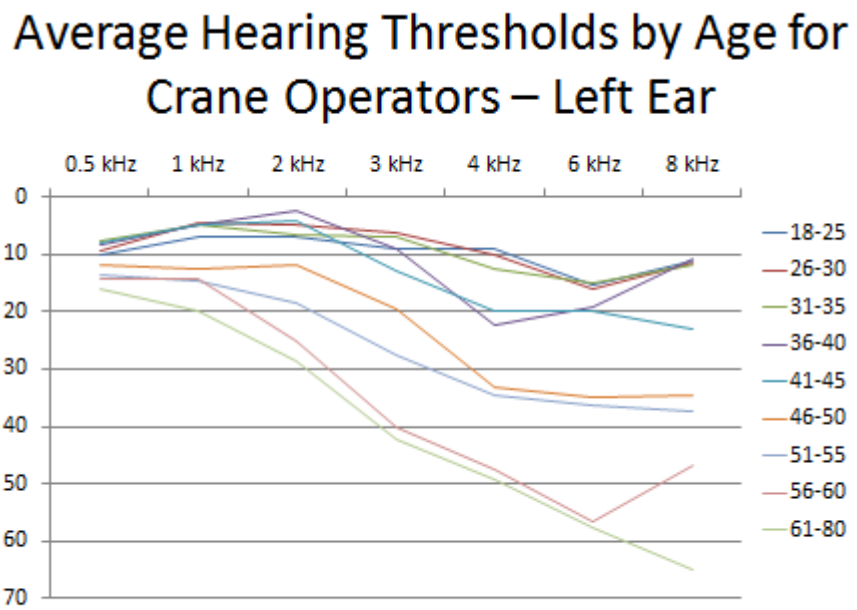

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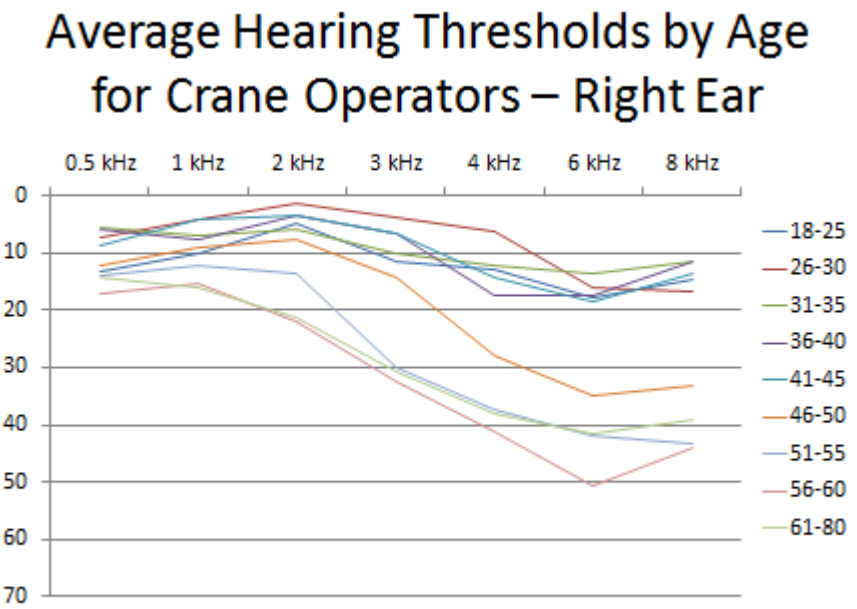

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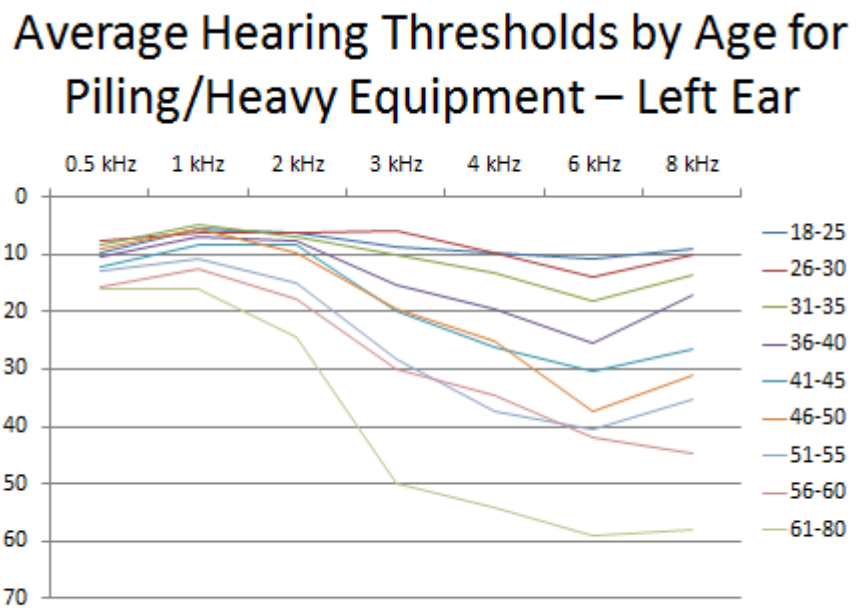

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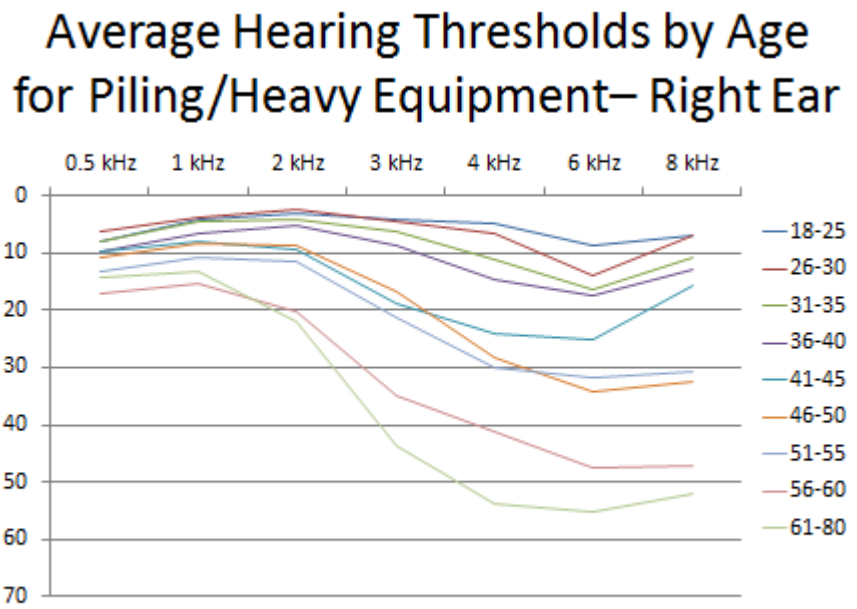

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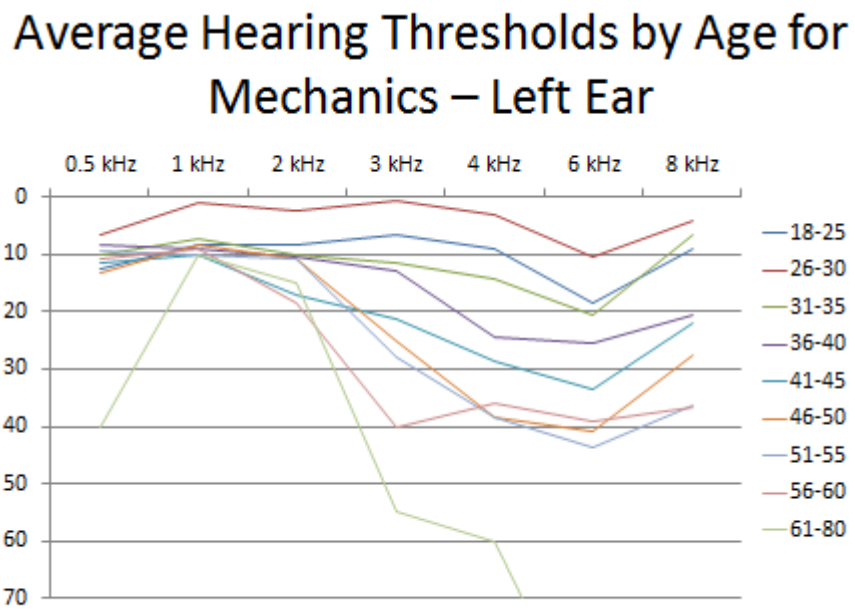

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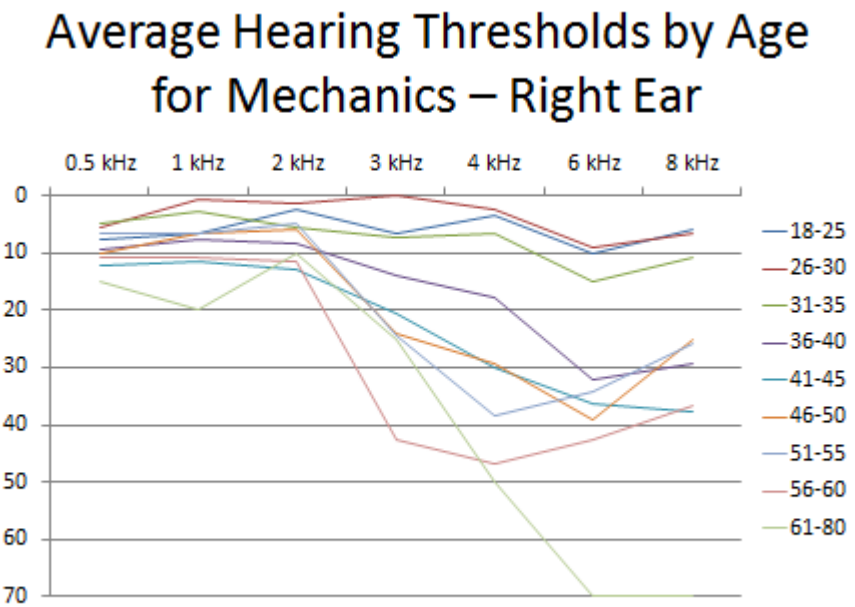

When evaluating hearing impairment, formulas are used that consider hearing loss at various frequencies. Two general principles underlie the formulas. Because speech is heard mainly in the lower frequencies, the formulas weigh hearing loss in the lower frequencies more heavily and do not consider hearing loss in the higher frequencies. Because occupational hearing loss is most commonly bilateral, hearing loss in the "better ear" is weighted more heavily than hearing loss in the "worse ear." It is assumed that one-sided hearing loss is more likely to be due to non-occupational noise exposure or, for example, infections.

For this analysis, two hearing loss formulas were used: one that is used in Alberta (Workers' Compensation Board, 2006) and another that is very commonly used internationally (AAO, 1979). The latter formula is referred to as the AAO 1979 formula. These are not the only formulas that are used, but they were thought to be the most relevant for the present analysis.

The Alberta criteria (on pages 36-39 of the WCB 2006 manual) calculate the sum of the hearing thresholds at 0.5 kHz, 1 kHz, 2 kHz and 3 kHz for each ear. If the totals for the two ears differ by less than 20 dB, the hearing loss is considered bilateral. A spreadsheet is available with axes for the better and worse ear (page 39 of the WCB 2006 manual). Using the totals for each ear the spreadsheet lists the hearing loss percent rating.

If the totals of the hearing thresholds for the two ears differ by more than 20 dB, the hearing loss in the better ear is considered to be due to occupational noise exposure. That total is then applied to both axes of the spreadsheet.

For the AAO 1979 criteria, the average hearing threshold is computed for each ear for 0.5 kHz, 1 kHz, 2 kHz and 3 kHz. A disability rating is calculated for each ear by subtracting 25 dB from the average threshold for each ear and them multiplying the resulting number by 1.5. In other words, for each decibel beyond 25, a 1.5 percent disability rating is assigned for that ear. Obviously, if the average threshold is 25 dB or less, no disability is assumed for that ear. To calculate the overall percent disability (both ears), the disability rating for the worse ear is added to five times the disability rating for the better ear, and the total is divided by six. Thus, in calculating overall disability, the better ear is weighted five times more than the worse ear.

Table 4 lists the percent of workers who had any hearing impairment using the Alberta criteria by age category. This table includes only the 12,118 workers who had a valid entry for trade, whose age was known, and who had values recorded for all of the relevant frequencies. According to the Alberta criteria, there were very few workers with hearing impairment below the age of 50. One in seven of the workers over the age of 60 had hearing impairment.

It is obvious that the AAO 1979 criteria classified more workers as having hearing impairment than the Alberta criteria (Table 5). Whereas the Alberta criteria classified 2.1 percent as impaired overall, 12.3 percent (almost six times as many) were classified as impaired using the AAO 1979 criteria. Half of the workers over age 60 were classified by the AAO 1979 criteria as impaired.

Table 4: Percent of Workers with Any Hearing Impairment, by Age: Alberta Criteria

Age Category	Hearing impairment		
	n	%	Total in Age Category
18-25	4	0.2	1,740
26-30	6	0.4	1,560
31-35	5	0.3	1,490
36-40	8	0.6	1,395
41-45	11	0.8	1,331
46-50	22	1.5	1,481
51-55	45	3.1	1,449
56-60	64	6.3	1,019
61+	94	14.4	653
All ages	259	2.1	12,118

Table 5: Percent of Workers with Any Hearing Impairment, by Age: AAO 1979 Criteria

Age Category	Hearing Impairment		
	n	%	Total in Age Category
18-25	40	2.3	1,740
26-30	54	3.5	1,560
31-35	60	4.0	1,490
36-40	84	6.0	1,395
41-45	105	7.9	1,331
46-50	215	14.5	1,481
51-55	280	19.3	1,449
56-60	337	33.1	1,019
61+	318	48.7	653
All ages	1,493	12.3	12,118

The percentages of workers in the various trades with hearing impairment using the Alberta criteria are listed in Table 6. More than three percent of the fitters, structural ironworkers, millwrights and crane operators were classified as having hearing impairment. Smaller percentages of boilermakers, instrument technicians, plumbers, reinforcing ironworkers,

scaffolders, sheet metal workers and sheeters were classified as impaired. This analysis did not consider the age distribution of the trades.

When the AAO 1979 criteria were applied to the trades the percentages of workers was, as expected, much higher for each trade. In general the ranking of trades was similar to the ranking found with the Alberta criteria with a few exceptions. Using the AAO 1979 criteria, the carpenters had the highest percent with impairment (nearly one in five). None of the sheeters was classified by the Alberta criteria as being impaired while the AAO 1979 criteria found 16 percent impaired. Again, this analysis did not consider the age distribution of the workers in each trade.

Table 6: Percent of Workers with Any Hearing Impairment by Trade: Alberta Criteria

	Hearing impairment		
Trade	n	%	Total in Trade
Boilermaker	13	1.3	1,016
Welder	23	2.3	999
Electrician	46	1.8	2,570
Fitter	73	3.1	2,359
Instrument Technician	3	1.5	195
Plumber	1	0.4	248
Structural Ironworker	19	3.3	578
Reinforcing Ironworker	0	0.0	13
Carpenter	13	2.9	450
Scaffolder	22	1.5	1,485
Millwright	4	3.3	121
Insulator	17	2.6	642
Sheet Metal Worker	3	1.3	227
Sheeter	0	0.0	43
Labourer	13	1.7	757
Crane operator	4	3.4	116
Piling/Heavy Equipment	4	1.7	240
Mechanic	1	1.7	59
All Trades	259	2.1	12,118

Table 7: Percent of Workers with Any Hearing Impairment, by Trade: AAO 1979 Criteria

Trade	Hearing impairment		
	n	%	Total in Trade
Boilermaker	79	7.8	1,016
Welder	116	11.6	999
Electrician	259	10.1	2,570
Fitter	326	13.8	2,359
Instrument Technician	19	9.7	195
Plumber	15	6.0	248
Structural Ironworker	78	13.5	578
Reinforcing Ironworker	1	7.7	13
Carpenter	86	19.1	450
Scaffolder	202	13.6	1,485
Millwright	22	18.2	121
Insulator	97	15.1	642
Sheet Metal Worker	30	13.2	227
Sheeter	7	16.3	43
Labourer	95	12.5	757
Crane operator	18	15.5	116
Piling/Heavy Equipment	36	15.0	240
Mechanic	7	11.9	59
All Trades	1,493	12.3	12,118

The data in Tables 4-7 are combined in Tables 8 and 9. These tables display the percent of workers with any impairment by trade and age using the Alberta and AAO 1979 criteria, respectively. The blanks in the table indicate age categories where there were no workers tested for that trade. Some of the trends appear somewhat unusual; however, there were few workers tested in many of the trade-age subgroups. For example, while 7.1 percent of the crane operators 18-25 years old had some impairment, this represented only one of the 13 crane operators in that age category.

Table 8: Percent of Workers in the Trades with Any Hearing Impairment, by Age: Alberta Criteria

Trade	Age Category								
	18-25	26-30	31-35	36-40	41-45	46-50	51-55	56-60	61-80
Boilermaker	0.3	1.0	0.0	0.0	0.0	2.9	8.3	5.7	6.7
Welder	0.0	0.7	0.0	1.4	0.0	0.0	2.0	7.3	21.4
Electrician	0.4	0.3	0.0	0.5	0.6	1.3	1.6	6.3	14.3
Fitter	0.4	0.4	0.0	0.8	2.3	2.0	3.7	7.3	17.3
Instrument Technician	0.0	0.0	5.0	0.0	0.0	3.4	0.0	0.0	6.3
Plumber	0.0	0.0	2.1	0.0	0.0	0.0	0.0	0.0	0.0
Structural Ironworker	0.0	0.0	0.0	0.0	1.6	2.0	1.6	10.9	31.4
Reinforcing Ironworker	0.0	0.0	0.0	-	0.0	0.0	0.0	-	-
Carpenter	0.0	0.0	0.0	0.0	2.0	1.3	6.2	3.8	21.7
Scaffolder	0.0	0.0	1.2	0.0	0.6	0.5	2.7	7.7	6.3
Millwright	0.0	0.0	0.0	0.0	0.0	7.7	8.3	4.8	7.7
Insulator	0.0	0.0	1.6	2.1	0.0	1.1	6.3	3.4	11.1
Sheet Metal Worker	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.7	22.2
Sheeter	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-	0.0
Labourer	0.0	1.4	0.0	0.0	0.0	2.9	1.7	4.0	6.8
Crane operator	7.1	0.0	0.0	0.0	0.0	0.0	7.7	7.1	5.9
Piling/Heavy Equipment	0.0	0.0	0.0	0.0	0.0	0.0	3.2	3.8	6.7
Mechanic	0.0	0.0	0.0	11.1	0.0	0.0	0.0	0.0	0.0
All Trades	0.2	0.4	0.3	0.6	0.8	1.5	3.1	6.3	14.4

Again, the results of the breakdown using the AAO 1979 criteria (Table 9) show higher levels of hearing impairment. Among those over age 60, nearly half or more of the workers in most trades have some hearing impairment by the AAO 1979 criteria.

The AAO 1979 formula involved calculation of a percent impairment. The data for percent impairment are presented in Table 10. More than half of the workers with impairment were in the lowest category (< 5 %). Two or more percent of the fitters, structural ironworkers, and carpenters had 20+ percent hearing impairment.

Table 9: Percent of Workers in the Trades with Any Hearing Impairment, by Age: AAO 1979 Criteria

Trade	Age Category								
	18-25	26-30	31-35	36-40	41-45	46-50	51-55	56-60	61+
Boilermaker	2.4	4.7	4.6	5.8	3.3	13.2	30.0	34.3	53.3
Welder	3.7	2.1	3.0	7.4	7.1	11.2	16.2	40.2	46.4
Electrician	1.1	3.5	3.7	5.6	5.7	10.3	16.1	31.2	37.3
Fitter	3.4	4.0	4.4	7.2	8.3	14.0	19.7	27.5	51.8
Instrument Technician	0.0	4.3	5.0	11.1	0.0	17.2	8.8	23.1	25.0
Plumber	1.7	6.1	4.3	3.6	13.6	5.6	11.1	11.1	33.3
Structural Ironworker	1.2	6.7	1.0	5.8	6.5	20.4	22.6	37.0	62.9
Reinforcing Ironworker	0.0	0.0	0.0	-	0.0	0.0	100.0	-	-
Carpenter	3.6	2.1	6.7	5.7	10.0	23.4	26.2	42.3	69.6
Scaffolder	1.7	3.0	6.0	5.2	10.5	18.9	20.5	41.5	58.3
Millwright	0.0	0.0	5.6	7.7	0.0	46.2	25.0	23.8	46.2
Insulator	1.1	1.5	7.9	8.5	10.3	15.7	21.6	32.2	48.9
Sheet Metal Worker	0.0	3.6	3.8	7.7	8.7	14.7	29.0	30.8	66.7
Sheeter	0.0	0.0	0.0	25.0	0.0	27.3	33.3	-	0.0
Labourer	3.3	1.4	1.8	0.0	13.3	13.9	12.9	30.7	45.5
Crane operator	7.1	0.0	0.0	0.0	0.0	5.0	23.1	28.6	52.9
Piling/Heavy Equipment	4.8	2.6	0.0	0.0	11.1	9.1	16.1	42.3	46.7
Mechanic	16.7	0.0	0.0	11.1	14.3	0.0	28.6	16.7	100.0
All Trades	2.3	3.5	4.0	6.0	7.9	14.5	19.3	33.1	48.7

As noted above, the data in Tables 6 and 7 that presented the overall percentages of workers in each of the trades with hearing impairment did not consider the differences in the age distributions of the workers within each of the trades. The data in Tables 8 and 9 were used to calculate age-adjusted percentages of workers in each of the trades with any hearing impairment. Age-adjustment is a method of accounting for the differences in these age distributions by determining what the percentages with hearing impairment in each trade would be if every one of the trades had the same age distribution. For this calculation, the age distribution for the 12,118 workers with known values for trade and age were used. The age-adjusted percentages allow direct comparisons among the trades. The age-adjusted percentages are presented in Table 10. The trades are ranked from the highest percent to the lowest as determined by the Alberta criteria and the AAO 1979 criteria.

Table 10: Age-Adjusted Percent of Workers in the Trades with Any Hearing Impairment using the Alberta Criteria and the AAO 1979 Criteria, Ranked from Highest to Lowest

	Alberta Criteria		AAO 1979 Criteria	
Rank	Trade	Percent	Trade	Percent
1	Structural Ironworker	3.22	Carpenter	16.68
2	Crane operator	2.86	Mechanic	15.48
3	Millwright	2.76	Millwright	14.70
4	Fitter	2.69	Scaffolder	14.52
5	Carpenter	2.61	Structural Ironworker	14.25
6	Boilermaker	2.36	Sheet Metal Worker	14.23
7	Welder	2.26	Boilermaker	13.52
8	Insulator	2.22	Insulator	13.28
9	Electrician	1.87	Fitter	12.47
10	Sheet Metal Worker	1.85	Reinforcing Ironworker	12.00
11	Scaffolder	1.59	Welder	11.99
12	Labourer	1.44	Piling/Heavy Equipment	11.37
13	Instrument Technician	1.37	Labourer	10.62
14	Mechanic	1.28	Sheeter	10.21
15	Piling/Heavy Equipment	1.06	Electrician	10.16
16	Plumber	0.26	Crane operator	9.66
17	Reinforcing Ironworker	0.00	Instrument Technician	8.89
18	Sheeter	0.00	Plumber	8.22
	All Trades	2.14	All Trades	12.33

The rankings of the trades according to the two criteria are generally consistent. Among the top five, structural ironworkers, millwrights, and carpenters appear in both lists. Similarly, among the lowest five, plumbers and sheeters appear in both lists. Some fairly substantial differences appear between the two lists. Mechanics are near the bottom of the list according to the Alberta criteria and second from the top on the AAO 1979 list. Scaffolders are ranked 11th on the Alberta list and 4th in the AAO 1979 list. Crane operators ranked 2nd in the Alberta list and 16th on the AAO 1979 list. None of the reinforcing ironworkers or sheeters was classified by the Alberta criteria as having any hearing impairment, and only a quarter of a percent of the plumbers were.

The large differences in the rankings of the trades between the two lists are more easily understood by reference to the data in Table 11. This table lists the percent impairment for the various trades according to the AAO 1979 criteria.

Table 11: Number and percent of workers at various levels of hearing impairment (AAO 1979 Criteria) by trade

Trade	Percent Impairment									
	None		< 5 %		5 - <10 %		10 - <20 %		20+ %	
	n	%	n	%	n	%	n	%	n	%
Boilermaker	959	92.2	47	4.5	14	1.3	12	1.2	8	0.8
Welder	908	88.6	61	6.0	19	1.9	19	1.9	18	1.8
Electrician	2332	89.9	145	5.6	49	1.9	32	1.2	37	1.4
Fitter	2072	86.1	176	7.3	57	2.4	46	1.9	55	2.3
Instrument Technician	180	90.5	10	5.0	4	2.0	2	1.0	3	1.5
Plumber	234	94.0	11	4.4	2	0.8	2	0.8	0	0.0
Structural Ironworker	502	86.6	37	6.4	14	2.4	13	2.2	14	2.4
Reinforcing Ironworker	12	92.3	1	7.7	0	0.0	0	0.0	0	0.0
Carpenter	367	80.7	49	10.8	13	2.9	17	3.7	9	2.0
Scaffolder	1284	86.3	134	9.0	28	1.9	29	2.0	12	0.8
Millwright	100	82.0	13	10.7	4	3.3	3	2.5	2	1.6
Insulator	547	84.8	50	7.8	22	3.4	15	2.3	11	1.7
Sheet Metal Worker	198	86.8	20	8.8	2	0.9	5	2.2	3	1.3
Sheeter	37	84.1	3	6.8	2	4.5	2	4.5	0	0.0
Labourer	670	87.5	51	6.7	25	3.3	11	1.4	9	1.2
Crane Operator	102	84.3	9	7.4	8	0.8	7	5.8	2	1.7
Piling/Heavy Equipment	207	85.2	22	9.1	9	3.7	4	1.6	1	0.4
Mechanic	52	88.1	5	8.5	1	1.7	0	0.0	1	1.7
Total	10763	87.7	844	6.9	266	2.2	219	1.8	185	1.5

There were relatively few mechanics in the data set. Of the seven mechanics classified by the AAO 1979 criteria as having some impairment, only one was classified as having impairment by the Alberta Criteria. Similarly, of the scaffolders classified as having impairment by the AAO 1979 criteria, most were in the lower categories of impairment and were not considered impaired using the Alberta criteria. Of the crane operators considered impaired using the AAO 1979 criteria, relatively large percentages were in the higher impairment categories and were also considered impaired by the Alberta criteria.

Overall, the data in Table 11 show that, of the 12.3 percent of workers classified as having some hearing impairment using the AAO 1979 criteria, more than half had less than 5 percent impairment. Only 1.5 percent of the workers had more than 20 percent impairment.

As noted in the introduction, Hessel et al (2000) studied hearing thresholds in construction workers in Edmonton in the 1990s. That study was limited to workers with at least 20 years of membership in one of three unions. The study population included workers aged 38 to 65. Those data were re-analyzed, using the AAO 1979 criteria to determine how many would have been classified as having hearing impairment. Likewise, the present data set was re-analyzed, including only those workers aged 38 to 65. Although some of the data are not exactly comparable, the contrast between the two sets of results is very informative (Table 12).

Table 12: Percent of Workers Aged 38-65 with Any Hearing Impairment Using AAO 1979 Criteria for Construction Workers Studied by Hessel et al (2000) and the Current Data Set

Hessel, 2000		Current Data Set	
Union	Percent	Trade	Percent
Boilermaker	47.5	Boilermaker	17.3
		Welder	18.4
Plumber/Pipefitter	33.7	Fitter	18.7
		Plumber	11.0
Electrician	20.0	Electrician	14.0

Nearly half of the members of the boilermakers' union were classified as having at least some hearing impairment in the 2000 study. In the current study, members of the boilermakers' unions were generally classified either as boilermakers or as welders. Regardless of the classification in the current study, the prevalence of hearing impairment was markedly lower in the present analysis. One-third of the plumbers and pipefitters union had some impairment in the 2000 study. The present analysis found 18.7 percent of the fitters and only 11.0 percent of the plumbers had impairment. The decline in the prevalence of hearing impairment was less dramatic for the electricians; however, there was still a marked reduction in the prevalence of hearing impairment between the former study and the current study.

Discussion

The CIATP data set represents an important source of health information for an essential group of Alberta workers. "Construction work" comprises a variety of occupations and work situations. Unlike many other industrial workers, construction workers often encounter unpredictable situations. Construction equipment is often noisy and construction workers often work in the proximity of other workers who are producing noise. Noise exposures are often difficult to control and personal hearing protection is sometimes the only practical method for limiting exposures.

This analysis, the first thorough exploration of the CIATP data set, brought several issues to light. A relatively large percent of the workers could not be classified by trade. Unlike the "employer" field in the database, there was no drop-down menu for the technician to use to assign the trade. This field had to be completed by typing the worker's response. As seen in Appendix B, there were many different entries for the same trade, including misspelled entries. It is also evident from Appendix B that some of the people tested were not construction trades workers. Despite these limitations, the database included very large numbers of workers in most of the trades, providing reliable estimates of hearing acuity within trades.

A marked difference was found between the Alberta criteria for assessing hearing impairment and the more commonly used AAO 1979 criteria. Overall, the AAO 1979 criteria classified approximately six times has many workers as having impairment compared to the Alberta criteria. Most of those classified by the AAO 1979 criteria as impaired had less than five percent impairment. Because the Alberta criteria classified far fewer workers as impaired, it was difficult to reliably compare trades using those criteria. According to the AAO 1979 criteria, more than 14 percent of carpenters, mechanics, millwrights, scaffolders, structural ironworkers and sheet metal workers had at least some impairment.

The strongest determinant of hearing acuity is age. Beyond age, occupational exposures are certainly capable of damaging hearing. The differences in hearing acuity across the trades would suggest that the occupational environment is having adverse effects, as differences between trades were found even after accounting for differences in age across trades. Some information on non-occupational noise exposures has been routinely collected within the CIATP. Because this was not computerized, it was not possible to assess the potential impact of activities such as snowmobiling, shooting, chain sawing, etc.

The difference in hearing loss between the earlier study (Hessel, 2000) and the present analysis was substantial. Among the boilermakers, welders, plumbers and fitters, the percent of workers with any hearing impairment was around twice as great in the earlier study. The data for the earlier study were collected in 1995. The present tests were completed between 2006 and 2012 (11 to 17 years later). Although there were some differences in the testing, it is clear that there has been a dramatic reduction in hearing loss during that 11- to 17-year period.

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Appendix A

Previous Study of Hearing Loss in Alberta Construction Workers (Hessel, 2000)

Hearing Loss Among Construction Workers in Edmonton, Alberta, Canada

Patrick A. Hessel, PhD

Hearing acuity among electricians, plumbers and pipefitters, and boilermakers with ≥ 20 years of union membership was compared with that of telephone workers. Automated pure tone audiometry was performed and a questionnaire was administered. Most construction workers were exposed to occupational noise and wore hearing protection. Median thresholds for electricians and telephone workers were comparable. Thresholds of plumbers and pipefitters were higher but comparable to expected values. Boilermakers had high levels of hearing loss. Thresholds at 4000 Hz among older workers were similar for all groups and were above expected values, suggesting a cohort effect. Audiometric screening seems to be warranted for some construction workers.

Excessive noise is common in many occupational settings. A 1990 Consensus Conference in the United States noted that more than 20 million Americans were exposed to hazardous noise levels on a regular basis,[1] stating that occupational noise exposure was the most common cause of noise-induced hearing loss. Hearing loss beyond the levels expected with aging have been documented in truck drivers,[2,3] mineworkers,[4] autoworkers,[5] steel fabricators,[6] farmers,[7,8] railway workers,[9,10] symphony orchestra musicians,[11] and others. There is evidence that noise-induced hearing loss continues to worsen after termination of exposure through retirement.[12]

A recent study of older construction workers in Germany found a prevalence ratio for hearing loss of 1.5 (95% confidence interval = 1.29 to 1.82) for construction workers compared with white-collar employees.[13] Hearing loss was defined as a sum of thresholds at 2000, 3000, and 4000 Hz greater than 105 dB in at least one ear. The highest prevalence ratios were found in carpenters (prevalence ratio = 1.77, 95% confidence interval = 1.48 to 2.12) and unskilled workers (prevalence ratio = 1.75, 95% confidence interval = 1.47 to 2.09).

The present study arose from concerns raised by the International Brotherhood of Electrical Workers, Local 424; the United Association of Journeymen and Apprentices of the Plumbing and Pipefitting Industry of the United States and Canada, Local 488; and Local 146 of the Interna-

From the Department of Public Health Sciences, University of Alberta, Edmonton, Alberta, Canada.
Address correspondence to: Patrick A. Hessel, PhD, Professor and Director, Epidemiology Program, rtment of Public Health Sciences, 13–103 Clinical Sciences Building, University of Alberta, Edmonton, Alberta, Canada T6G 2G3; e-mail: pat.hessel@ualberta.ca.

TABLE 1
Description of the Study Population

	Electricians	Plumbers and Pipefitters	Boilermakers	Telephone Workers
n	100	98	101	100
Response rate (%)	80.2	77.9	77.4	72.7
Age ($\bar{X} \pm$ SD)	51.9 ± 5.2	51.9 ± 6.8	52.7 ± 6.2	50.0 ± 5.2
Years of employment ($\bar{X} \pm$ SD)				
Construction	26.8 ± 6.0	26.9 ± 7.3	27.6 ± 6.6	29.3 ± 5.7
Other	2.7 ± 4.1	2.5 ± 4.8	3.6 ± 4.5	1.7 ± 2.8
Total	29.6 ± 6.7	29.5 ± 8.1	31.2 ± 7.3	30.9 ± 6.1

TABLE 2
Background Noise Levels in Testing Area

Octave Band (Hz)	Maximum dB Measured	Maximum dB Allowed*
500	15	19.5
1000	15	26.5
2000	20	28.0
4000	25	34.5
8000	30	43.5

* See reference 15.

tional Brotherhood of Boilermakers, Iron Shipbuilders, Blacksmiths, Forgers and Helpers. Members of the three unions will be referred to as the electricians, plumbers and pipefitters, and boilermakers, respectively. The members of these unions worked in industrial (primarily), commercial, and residential settings. Most of their work involved new construction, however, and most were also involved in some maintenance work, often during plant shutdown. Because they worked out of union halls and moved from site to site throughout their careers, their occupational health concerns were not the responsibility of any one employer. The union representatives were concerned because of the numerous sources of noise exposure in the construction industry in general, and within these trades specifically. The present analysis describes the hearing acuity of the construction workers by comparing them with a group of local telephone workers.

Materials and Methods

Identification of Study Participants

This was a cross-sectional study that compared members of the three union locals who had at least 20 years of union membership with workers at Edmonton Telephones who had 20 years of union membership. It was felt that the construction workers with longer experience would be more likely to exhibit occupational hearing loss if hearing loss was associated with employment in those trades. The workers at Edmonton Telephones were chosen for comparison because, although they spend some of their time on construction sites, they are usually not present when conditions are very noisy. Also, because they were represented by one of the construction unions involved in planning the study, access was facilitated.

For each of the groups, all members with 20 or more years of union membership were identified from union rosters. The number of workers initially identified in each group was in excess of 100, the target sample size. The target sample size was determined by the budget rather than by a formal sample size calculation. Only members residing in the greater Edmonton area, and only active workers, were included. For a few of the older workers, it was difficult to determine whether they were "between jobs" or retired. Judgment was exercised in these cases. Only men younger than 65 years of age were included in the present analysis.

Workers were selected at random from each of the lists by using a table of random numbers. The construction workers were contacted by members of the union staffs. The telephone workers were contacted by the administrative staff of Edmonton Telephones, following an explanatory letter from their union. Members were selected and recruited in random order until the target sample size was achieved (approximately). The response rates were as follows: plumbers and pipefitters, 77.9%; boilermakers, 77.4%; electricians, 80.2%; and telephone workers, 72.7% (Table 1). Some of the nonrespondents were working outside of the Edmonton area during the time of the study. All participants gave written, informed consent. The study protocol was approved by the Research Ethics Board of the Faculty of Medicine at the University of Alberta.

The staff members who were recruiting participants were assigned specific testing days and were asked to schedule workers from their group on that day. Testing days alternated for the four groups to avoid possible time-related biases.

Testing Procedures

Testing took place in the offices of the plumbers and pipefitters' union from February through October 1995. Most of the testing was performed on Fridays and Saturdays to accommodate the schedules of the participants. On two occasions, the testing equipment was moved to the offices of Edmonton Telephones to facilitate testing of that group.

An occupational questionnaire was developed to document the types of work environments and specific jobs worked by the participants. The work environments were divided into: (1) industrial, (2) commercial/institutional, and (3) residential. Within the industrial sector, information was obtained on specific industries common in Alberta, eg, gas and

TABLE 3
Noise Exposure and Use of Hearing Protection at Present Job

	Electricians		Plumbers and Pipefitters		Boilermakers		Telephone Workers	
	n	%	*n*	%	*n*	%	*n*	%
Exposed to noise*	81	81.0	93	94.9	96	95.0	49	49.5
Ringing or noise in ears	20	20.6	29	29.9	40	39.6	9	9.2
Use hearing protection†	74	91.4	87	93.5	94	97.9	28	57.1
Amount of time hearing protection is used†								
Always	40	53.3	42	46.7	67	70.5	5	11.1
Usually	17	22.7	23	25.6	17	17.9	21	46.7
Sometimes	15	20.0	18	20.0	9	9.5	2	4.4
Seldom	3	4.0	3	3.3	1	1.1	1	2.2
Never	0	–	4	4.4	1	1.1	16	35.6
Years of hearing protection use, mean ± SD†	17.1 ± 7.3		16.6 ± 8.1		17.5 ± 7.3		13.8 ± 8.2	

* All $P \leq 0.00001$, except years of hearing protection use ($P > 0.05$).
† Includes only those exposed to noise on the job.

TABLE 4
Regression Coefficients and 95% CIs for Use of Hearing Protection and Hearing Thresholds for Construction Workers Exposed to Noise on the Job*

	Right Ear		Left Ear	
Frequency (Hz)	Coefficient	95% CI	Coefficient	95% CI
500	−0.010	−0.058,+0.038	−0.043	−0.084,−0.002
1000	−0.026	−0.076,+0.024	−0.035	−0.080,+0.010
2000	−0.042	−0.105,+0.021	−0.066	−0.135,+0.003
3000	−0.090	−0.166,−0.014	−0.087	−0.169,−0.005
4000	−0.074	−0.154,+0.006	−0.130	−0.212,−0.048
6000	−0.065	−0.147,+0.017	−0.090	−0.174,−0.006
8000	−0.058	−0.142,+0.026	−0.063	−0.147,+0.021

* CI, confidence interval. Linear regression model was fit with hearing threshold as the dependent variable and age and cumulative hearing protection use (see text for derivation) as independent variables. The coefficients listed are for cumulative hearing protection use.

oil, forest products, and so forth. Information was also requested on jobs outside of their primary trade. A noise history was completed that requested information on occupational noise exposure, use of hearing protection, non-occupational noise exposure (eg, shooting, military service), head injuries, and other exposures that might affect hearing.

Audiometric measurements were performed with a Maico, MA-27 audiometer using Ear Links. The audiometer was calibrated at the start of the study according to guidelines of the American National Standards Institute.[14] Biological calibration was performed daily at the start of testing. A soundproof booth was not available. The background noise levels in the testing area are shown in Table 2.

The audiometric tests were preceded by an examination of the ears with an otoscope to check for wax and any obvious pathology. Hearing thresholds were determined for each ear at 500, 1000, 2000, 3000, 4000, 6000, and 8000 Hz. The audiometer had an automatic readout that specified the threshold in 5-dB increments and was capable of recording thresholds from −10 to 90 dB.

Data Analysis

Analysis of categorical variables (eg, history of ear infection) was conducted initially using standard contingency table techniques. Statistical significance of group differences in hearing thresholds were assessed by comparing mean values using analysis of variance techniques and controlling for age. However, median hearing thresholds are presented in the figures and tables for consistency with other reports.

To test whether use of hearing protection had an effect on hearing thresholds, a semiquantitative variable was calculated by multiplying the number of years that hearing protection was used by 0 (if hearing protection was never used), 1 (if hearing protection was seldom used), 2 (if hearing protection was sometimes used), 3 (if hearing protection was usually used), or 4 (if hearing protection was always used). This variable, referred to as cumulative hearing protection use, was then tested in a multiple linear regression with the hearing threshold as the dependent variable and age as the other independent variable.

Results

The four groups were comparable with regard to age and years of employment both within and outside of the construction industry (Table 1). The minimum age was 38 years old, owing to the requirement for at least 20 years of union membership for inclusion in the study.

The construction workers were much more likely to have been ex-

TABLE 5
Recreational and Non-Construction Noise Exposures

	Electricians		Plumbers and Pipefitters		Boilermakers		Telephone Workers	
	n	%	*n*	%	*n*	%	*n*	%
Snowmobiles	37	37.4	34	35.1	28	27.7	45	45.0
Motorcycles	40	40.4	38	39.6	33	32.7	49	49.5
Loud music*	39	39.4	39	39.8	30	29.7	52	52.0
Shooting	68	68.0	70	71.4	65	64.4	63	63.0
Military service	21	21.0	18	18.4	30	29.7	26	26.0
Noise in military	14	14.0	13	13.3	19	18.8	18	18.0
Farming	47	47.0	49	50.0	52	51.5	47	47.0

* $P = 0.015$.

TABLE 6
History of Self-Reported Ear Problems

	Electricians		Plumbers and Pipefitters		Boilermakers		Telephone Workers	
	n	%	*n*	%	*n*	%	*n*	%
Ear infection	26	26.3	34	34.7	32	31.7	21	21.0
Ear injury*	7	7.0	10	10.2	14	13.9	2	2.0
Ear surgery	1	1.0	3	3.1	3	3.0	3	3.0
Vertigo	9	9.0	14	14.3	9	8.9	10	10.0
Head injury	12	12.0	18	18.4	21	20.8	13	13.0

* $P = 0.018$.

posed to noise at their present jobs and to have reported ringing or noise in the ears following noise exposure at work (Table 3). Forty percent of the boilermakers reported ringing or noise in the ears following occupational noise exposure. The vast majority of construction workers and just over half of the telephone workers who were exposed to noise on the job wore hearing protection. Approximately three-quarters of the electricians and the plumbers and pipefitters wore hearing protection always or usually, whereas almost 90% of the boilermakers wore hearing protection always or usually. Years of hearing protection use did not differ significantly among groups.

Among the construction workers who reported being exposed to noise on the job, negative associations were found between cumulative hearing protection use and hearing thresholds at all frequencies (Table 4). The negative relationship indicated that, when controlling for age, those who wore hearing protection more frequently and for more years had better hearing. Although all of the regression coefficients were negative for the right ear, only the regression coefficient for 3000 Hz differed significantly from zero. For the left ear most of the regression coefficients were statistically significant. In general, the coefficients were greater for those frequencies most affected by industrial noise.

Noise exposures from recreational sources and non-construction occupational exposures (including military exposures) were generally comparable for the four groups (Table 5). The telephone workers more often reported exposure to loud music.

Ear injuries were reported more often by the construction workers (Table 6). The other ear problems were reported by similar proportions of all of the groups.

Hearing thresholds were similar for the electricians and the telephone workers (Figs. 1 and 2). The average thresholds were significantly greater for the plumbers and pipefitters compared with the telephone workers for all frequencies above 2000 Hz for the left ear and above 1000 Hz for the right ear, controlled for age. For the boilermakers, average thresholds were significantly greater than the telephone workers for all frequencies above 1000 Hz for the left ear and for all frequencies for the right ear.

With the exception of the 60+ age group, the median hearing thresholds at 4000 Hz for the electricians and the telephone workers were close to those predicted for otologically normal (highly screened) individuals of the same age[16] and were better than those predicted on the basis of an unscreened population that might include some people with occupational exposures (Table 7). However, the median thresholds at 4000 Hz for electricians and telephone workers exceeded median thresholds predicted by both the otologically normal and the unscreened populations. Median thresholds for the plumbers and pipefitters at 4000 Hz resembled those predicted for the unscreened population and exceeded those for the otologically normal group, with the exception of the 60+ age group,

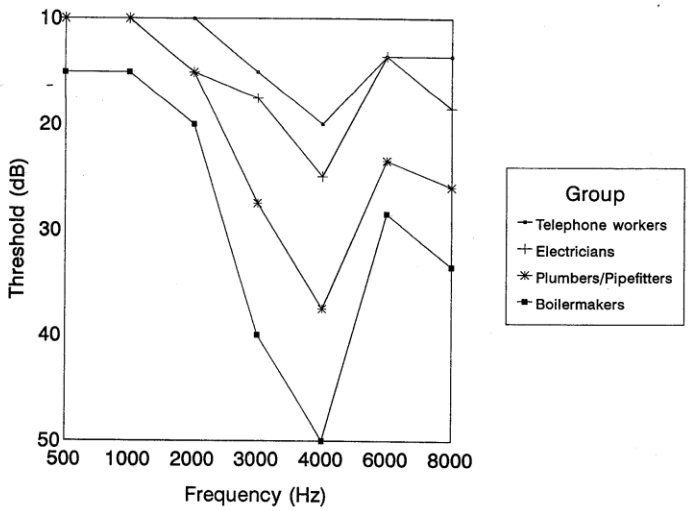

Fig. 1. Median hearing thresholds for the left ear.

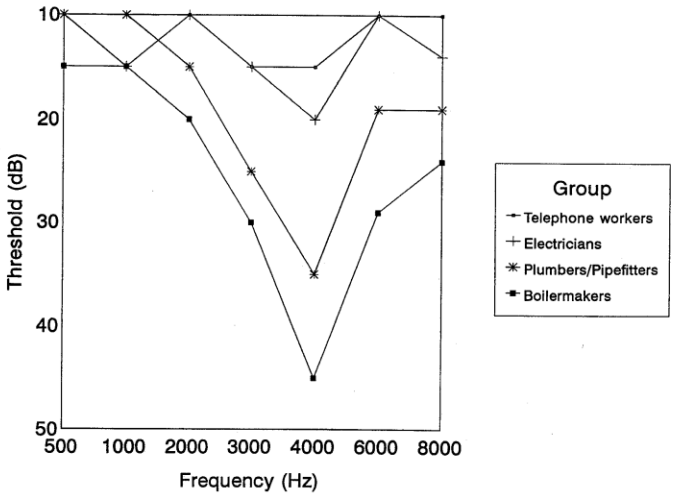

Fig. 2. Median hearing thresholds for the right ear.

for which median thresholds exceeded those predicted by both groups. Median thresholds for the boilermakers exceeded those predicted by both reference populations for all age groups. The median threshold at 4000 Hz for the boilermakers 60 years and older did not differ markedly from the other construction workers or the telephone workers.

Using the formula for hearing loss employed by Arndt et al[13] in their study of German construction workers, it can be seen that, with the exception of the boilermakers, the construction workers in Edmonton had less hearing loss than their German counterparts. The only group in which overlap of occupations is obvious is the plumbers and pipefitters in Edmonton (37.8% of whom had hearing loss, as defined) and the plumbers in Germany (46.3% of whom had hearing loss). Prevalence of hearing loss was much lower among the reference group in Edmonton (the telephone workers, with 13.0% having hearing loss) compared with Germany (white-collar workers, with 33.9% having hearing loss).

Discussion

As with any cross-sectional study, there is a danger that the workers most affected by the work environment would have left the occupation before initiation of the study and would not be included. However, it was felt that the effects of work exposures would be evaluated best in long-term workers. No attempt was made to locate past workers, and all participants were current members of the union.

The lack of a soundproof room was a potential problem. However, the background sound levels in the examination room were quite low.[15] In addition, hearing acuity levels among the controls (telephone workers) were consistent with expected norms, even values expected from a highly screened population.[16]

Exposure to noise was common among construction workers, and many of the workers reported ringing in the ears following occupational noise exposure. As with any potentially harmful exposure, the most effective method for reducing adverse health effects is to eliminate the source. This is often difficult for construction workers, who can be on-site before plants are operational and noise abatement measures associated with production are in place. They also frequently work during plant shutdown, when the work environment may be very different from what is encountered normally. In addition, the nature of construction work is such that some noise exposures (those produced by the worker and by others working in the area) are difficult to prevent. This

TABLE 7
Median Hearing Thresholds by Decade for the Better Ear at 4000 Hz*

Age (y)	Electricians	Plumbers and Pipefitters	Boilermakers	Telephone Workers	Otologically Normal	Unscreened
<50	10.0	20.0	30.0	15.0	12.7	21.5
50–59	25.0	30.0	42.5	20.0	21.1	31.0
60+	57.5	47.5	55.0	50.0	31.4	36.0
All	20.0	30.0	40.0	15.0	18.1	26.0

* Otologically normal (highly screened) population was from ISO 1999,[15] database A for males. Median expected thresholds were determined using the equation: $H_{0.50} = 0.016$ (age-18).[2] Age was the average age within age category for population summed across worker groups. Medians for unscreened population were from ISO 1999,[15] database B for males. For <50-year age category, the medians for 40 years and 50 years were averaged. For 50- to 59-year age category, the medians for 50 years and 60 years were averaged. For the 60+ age category, the median for 60 years was used. For the All category, the value for 50 years was used.

points to the need for personal hearing protection in many situations.

Use of hearing protection was common, and the cumulative effect of duration and frequency of hearing protection use was protective. Bauer et al[17] compared those who did and did not wear hearing protection and found that those who wore hearing protection had worse hearing. In the present study, a similar finding was observed when frequency of use was analyzed (without duration) and age was not considered. It is interesting to note that the protective effect of hearing protection use was most evident in the left ear, where occupational hearing loss is usually more rapid.[18,19] Compared with those who did not wear hearing protection, those who always wore hearing protection for 20 years would, on average, have hearing thresholds at 4000 Hz that were 10.4 dB better in the left ear and 5.9 dB better in the right ear.

For construction workers exposed to noise on the job, the multiple linear regression models for hearing threshold at 4000 Hz were repeated, including age and cumulative hearing protection use and adding individually terms for non-occupational noise exposures (Table 5) and ear problems (Table 6). None of these additional terms was statistically significant (all P values > 0.05).

The hearing thresholds of the boilermakers and the plumbers and pipefitters differed from those of the electricians and the telephone workers. The latter two groups did not differ from one another, nor did they show hearing loss in excess of expected levels.[16] Despite overall differences between the plumbers and pipefitters and the boilermakers compared with both the telephone workers and the electricians (Figs. 1 and 2), age-specific changes at 4000 Hz presented a somewhat different picture. For the two youngest age groups (<50 and 50 to 59 years) the electricians and the telephone workers showed less hearing loss than expected. The hearing thresholds of the plumbers and pipefitters were slightly higher for these two age groups and were higher still for the boilermakers. Surprisingly, there was little difference between groups for the age group 60 years and older. All groups had median hearing thresholds at 4000 Hz in the better ear that were higher than expected, using either of the International Standards Organization reference groups.[16] It has been suggested that hearing loss is more rapid during the early years of excessive noise exposure[20,21] and that the rate of loss decreases as the amount of sensorineural damage increases, perhaps because there are fewer susceptible receptors. Comparison of hearing thresholds to expected levels in the present study indicates the opposite, especially for the electricians and the telephone workers and, to a lesser extent, for the plumbers and pipefitters. It is possible that this represents a cohort effect, with the older workers in all groups having lived through times of higher occupational noise levels and/or lack of personal hearing protection in the past.

TABLE 8
Comparison of Hearing Loss Among Construction Workers in Edmonton and in Germany*

	% With Hearing Loss
Edmonton	
Electricians	19.0
Plumbers and pipefitters	37.8
Boilermakers	50.5
Telephone workers	13.0
Germany	
Plumbers	46.3
Carpenters	62.6
Painters/varnishers	39.8
Plasterers	45.3
Unskilled	60.7
Bricklayers	53.4
White-collar workers	33.9

* Sum of thresholds at 2000 Hz, 3000 Hz, and 4000 Hz greater than 105 dB in at least one ear (definition from reference 13).

These factors may also be relevant when comparing the results of the present study with those of Arndt et al,[13] who found higher levels of hearing loss among construction workers in Germany than were found in Edmonton (Table 8). Although the average ages of the German construction workers were comparable with those in the present study, the German workers were tested between 1986 and 1988, which was 7 to 9 years earlier than in the present study. Clarification of this issue

would require longitudinal investigation or, at least, a series of cross-sectional studies of representative populations over time. However, the median hearing thresholds among workers in all groups were lower (better) than the mean thresholds of older men identified in a population-based cross-sectional study in Beaver Dam, Wisconsin.[22]

The data for the boilermakers suggest a significant noise problem in this occupational group. Boilermakers are responsible for building, maintaining, and repairing boilers and other vessels. This includes welding, shaping, and cutting steel and other metals. The work is sometimes performed within the vessel, and the potential for high continuous and impulse noise is high.

For the boilermakers, but also for the plumbers and pipefitters, these data suggest the need for routine audiometric screening. The fact that these tradesmen work out of a union hall means that their occupational health concerns are not the responsibility of any single employer. Innovative programs involving unions, employers, and government bodies are required to ensure that these significant concerns are not overlooked.

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Appendix B

Frequency Distribution of Trades Listed in the Original Database

Trade

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid		4847	27.7	27.7	27.7
	GD SANDRINGHAM NL	3	.0	.0	27.8
	1st Yr Carpenter Apprentice	1	.0	.0	27.8
	1ST YEAR APPRENTICE	2	.0	.0	27.8
	1st Yr Pipefitter Apprentice	2	.0	.0	27.8
	1W GF	1	.0	.0	27.8
	39300	1	.0	.0	27.8
	ACCOUNT ADMINISTRATOR	1	.0	.0	27.8
	Accountant	1	.0	.0	27.8
	ACCOUNTANT	3	.0	.0	27.8
	Accounting	1	.0	.0	27.8
	Accounts Receivable	1	.0	.0	27.8
	ACCTS PAYABLE ADMIN	1	.0	.0	27.8
	ACCTS PAYABLE CLRK	1	.0	.0	27.8
	Accts Payable/Payroll Admin	1	.0	.0	27.8
	Admin	5	.0	.0	27.9
	ADMIN / RETAIL SALES	2	.0	.0	27.9
	Admin Assistant	10	.1	.1	27.9
	ADMIN ASSISTANT	6	.0	.0	28.0
	ADMIN ASST.	3	.0	.0	28.0
	Admin Staff	2	.0	.0	28.0
	Administration	13	.1	.1	28.1
	ADMINISTRATION	1	.0	.0	28.1
	ADMINISTRATION SPECIALIST	1	.0	.0	28.1
	Administration Staff	2	.0	.0	28.1
	ADMINISTRATIVE ASST.	1	.0	.0	28.1
	Align Mech/Foreman	1	.0	.0	28.1
	Align Tech	1	.0	.0	28.1
	Appr Welder	1	.0	.0	28.1
	APPR. WELDER	1	.0	.0	28.1
	Appr.Labourer 92	1	.0	.0	28.1
	APPRENTICE ELECTRICIAN	1	.0	.0	28.1
	APPRENTICE FITTER	1	.0	.0	28.2
	Apprentice Mechanic	2	.0	.0	28.2
	Apprentice Plumber	3	.0	.0	28.2
	APPRENTICE Scaffolder	1	.0	.0	28.2
	APPRENTICE WELDER	2	.0	.0	28.2
	Apprentice Welder 2yr.	1	.0	.0	28.2

Assembly	2	.0	.0	28.2
ASST CONST MANAGER	1	.0	.0	28.2
AUTO TECH	1	.0	.0	28.2
Autocad Rebar Detailer	1	.0	.0	28.2
Axles	1	.0	.0	28.2
B-PRESSURE WELDER	1	.0	.0	28.2
b	1	.0	.0	28.3
B	1	.0	.0	28.3
B WELDER	4	.0	.0	28.3
BENDER / CRANE OPER	4	.0	.0	28.3
BENDER OPERATOR	6	.0	.0	28.3
BMGF	1	.0	.0	28.3
BMJM	4	.0	.0	28.4
BMW	5	.0	.0	28.4
Boileermaker	1	.0	.0	28.4
Boiler	1	.0	.0	28.4
Boiler maker	1	.0	.0	28.4
boilermaker	5	.0	.0	28.4
Boilermaker	486	2.8	2.8	31.2
BOILERMAKER	18	.1	.1	31.3
Boilermaker Superintendent	1	.0	.0	31.3
BOILERMAKER/APPRENTICE 1	1	.0	.0	31.3
Boilermaker/Fitter	2	.0	.0	31.3
boilermaker/welder	2	.0	.0	31.4
Boilermaker/welder	1	.0	.0	31.4
Boilermaker/Welder	28	.2	.2	31.5
BOILERMAKER/WELDER	2	.0	.0	31.5
Boilermakers	2	.0	.0	31.5
Boilermker	1	.0	.0	31.6
BRANCH ADMIN	1	.0	.0	31.6
BUYER	2	.0	.0	31.6
C WELDER	1	.0	.0	31.6
Caledonia	2	.0	.0	31.6
Caprenter/Scaffolder	1	.0	.0	31.6
Carpender	2	.0	.0	31.6
Carpenter	240	1.4	1.4	33.0
CARPENTER	135	.8	.8	33.7
CARPENTER / SCAFFOLDER	39	.2	.2	34.0
Carpenter 1325-1209	1	.0	.0	34.0
Carpenter 1325	31	.2	.2	34.2
Carpenter 1644	1	.0	.0	34.2
Carpenter 2103	3	.0	.0	34.2
CARPENTER APPR	1	.0	.0	34.2
Carpenter Foreman	1	.0	.0	34.2

CARPENTER FOREMAN	1	.0	.0	34.2
Carpenter Foreman 2103	1	.0	.0	34.2
Carpenter Foreman/1325	2	.0	.0	34.2
Carpenter Superintendent	1	.0	.0	34.2
Carpenter/ Scaffolder	10	.1	.1	34.3
Carpenter/ Scafolder	1	.0	.0	34.3
Carpenter/General Foreman	1	.0	.0	34.3
CARPENTER/SAFETY ADV	1	.0	.0	34.3
Carpenter/Scaffolder	90	.5	.5	34.8
Carpenter/Scaffolder 2103	4	.0	.0	34.8
Carpenter/Scaffolder/ 1325	60	.3	.3	35.2
Carpenter/Scaffolder/ 1325 2yr	1	.0	.0	35.2
Carpenter/Scaffolder/ 2103	3	.0	.0	35.2
Carpenter/Scaffolder/1325(1209	1	.0	.0	35.2
CARPENTER/SCAFFOLDI NG	1	.0	.0	35.2
Carpenter/Supervisor	1	.0	.0	35.2
Carpentry	2	.0	.0	35.2
CARPENTRY FOREMAN	1	.0	.0	35.2
Cement Finisher	1	.0	.0	35.2
Cement Mason	12	.1	.1	35.3
CEMENT MASON	2	.0	.0	35.3
Civil Supertintendent	1	.0	.0	35.3
Civil Supt	1	.0	.0	35.3
Cladding	1	.0	.0	35.3
CM	1	.0	.0	35.3
CNC Operator	13	.1	.1	35.4
CNC PROGRAMMER	1	.0	.0	35.4
CNC/PC Based Operator	16	.1	.1	35.5
Co-ordinator	1	.0	.0	35.5
CO-ORDINATOR	1	.0	.0	35.5
Combination Welder/Electrician	1	.0	.0	35.5
Common services	1	.0	.0	35.5
Compliance Management	1	.0	.0	35.5
Construction Manager	2	.0	.0	35.6
CONSTRUCTION MANAGER	3	.0	.0	35.6
CONTRACT PROJECT MANAGER	1	.0	.0	35.6
Coordinator	5	.0	.0	35.6
Corrosion Technician	1	.0	.0	35.6

Cost Specialist	1	.0	.0	35.6
Crane	2	.0	.0	35.6
Crane operator	4	.0	.0	35.6
Crane Operator	45	.3	.3	35.9
CRANE OPERATOR	17	.1	.1	36.0
Crane Operator (1st 3	2	.0	.0	36.0
Crane Operator Level	2	.0	.0	36.0
CSR	1	.0	.0	36.0
DATA ENTRY	1	.0	.0	36.0
Dept Head	1	.0	.0	36.0
Detail	3	.0	.0	36.1
DETAILER	8	.0	.0	36.1
DISPATCHER	1	.0	.0	36.1
Document Centrol Clerk	1	.0	.0	36.1
Document control	1	.0	.0	36.1
DRAFTER	1	.0	.0	36.1
DRAFTS PERSON	2	.0	.0	36.1
Drill Rig Operator	7	.0	.0	36.2
DRILLER	3	.0	.0	36.2
Driver	4	.0	.0	36.2
e	1	.0	.0	36.2
EH&S	1	.0	.0	36.2
EHS Advisor	1	.0	.0	36.2
Elecrtician	1	.0	.0	36.2
Electician	1	.0	.0	36.2
Electrian	1	.0	.0	36.3
Electrical	29	.2	.2	36.4
Electrical Apprentice 1st Yr	2	.0	.0	36.4
Electrical Intrumentation	1	.0	.0	36.4
Electrical Journeyman	4	.0	.0	36.5
Electrical QC	1	.0	.0	36.5
Electrical/Instrument Mechanic	3	.0	.0	36.5
Electricial	1	.0	.0	36.5
electrician	6	.0	.0	36.5
Electrician	2301	13.2	13.2	49.7
ELECTRICIAN	26	.1	.1	49.8
ELECTRICIAN / WELDER	1	.0	.0	49.8
Electrician IBEW 424	17	.1	.1	49.9
Electrician IBEW 424 Foreman	1	.0	.0	49.9
Electrician IBEW 424/Welder	2	.0	.0	50.0
Electrician IBEW3A 424	1	.0	.0	50.0
Electrician Journeyman	1	.0	.0	50.0
Electrician/Instrumentation	26	.1	.1	50.1

Electrician/Instrumentation Tech	5	.0	.0	50.1
Electrician/Instumentation Tech	1	.0	.0	50.2
Electrician/Safety	1	.0	.0	50.2
Electrician/Welder	27	.2	.2	50.3
Electricion	1	.0	.0	50.3
Elextrician	1	.0	.0	50.3
Engineer	3	.0	.0	50.3
Engineer/Quality Control	1	.0	.0	50.3
Engineering Student	1	.0	.0	50.4
Equipment Administration	1	.0	.0	50.4
Equipment Coordinator	1	.0	.0	50.4
Equipment operator	2	.0	.0	50.4
Equipment Operator	3	.0	.0	50.4
EQUIPMENT OPERATOR	1	.0	.0	50.4
Estimator	1	.0	.0	50.4
ESTIMATOR	9	.1	.1	50.5
ESTIMATOR & SALES	1	.0	.0	50.5
ESTIMATOR SUPV	1	.0	.0	50.5
Estimator/Project Manager	1	.0	.0	50.5
EXECUTIVE ASSISTANT	1	.0	.0	50.5
Fabricator	2	.0	.0	50.5
Field Admin	1	.0	.0	50.5
FIELD ASSISTANT	4	.0	.0	50.5
Field Engineer	1	.0	.0	50.5
FIELD ENGINEER	5	.0	.0	50.6
FIELD ENGINEER Coop Student	1	.0	.0	50.6
Field Engineering Student	1	.0	.0	50.6
Field Technician	1	.0	.0	50.6
Fitter	80	.5	.5	51.0
FITTER	2	.0	.0	51.0
Fitter 1st Year Appre	3	.0	.0	51.1
Fitter 2nd Year Appre	4	.0	.0	51.1
Fitter 3rd Year Appre	2	.0	.0	51.1
Fitter Journeyman I	4	.0	.0	51.1
Fitter Journeyman II	19	.1	.1	51.2
Fitter/Welder	1	.0	.0	51.2
Fitting Inspector	1	.0	.0	51.2
Flight & Camp Coordinator	1	.0	.0	51.2
Floor Layer	1	.0	.0	51.2
FMCM STAFF	1	.0	.0	51.3
Foreman	30	.2	.2	51.4
FOREMAN	15	.1	.1	51.5

FOREMAN / IRONWORKER	1	.0	.0	51.5
Gasfitter	1	.0	.0	51.5
Gen. Mgr. - Internal Services	1	.0	.0	51.5
General Foreman	3	.0	.0	51.5
GENERAL FOREMAN	1	.0	.0	51.6
General Forman	1	.0	.0	51.6
General Helper - Deta	1	.0	.0	51.6
General Helper - Draw	1	.0	.0	51.6
General Helper	13	.1	.1	51.6
General Helper (1st 3	14	.1	.1	51.7
General Helper (after	4	.0	.0	51.7
General Labour	3	.0	.0	51.8
GENERAL LABOURER	4	.0	.0	51.8
General Manager	1	.0	.0	51.8
GENERAL MANAGER	1	.0	.0	51.8
General Superintendant	1	.0	.0	51.8
GENERAL SUPT	3	.0	.0	51.8
H.D. Mechanic	9	.1	.1	51.9
H.D. Technician	4	.0	.0	51.9
Hazardous Materials Specialist	1	.0	.0	51.9
HD Mechanic	2	.0	.0	51.9
HD Technician	2	.0	.0	51.9
Health and Safety	1	.0	.0	51.9
Heath & Safety Advisor	1	.0	.0	51.9
Heavy Duty Mechanic	1	.0	.0	51.9
HEAVY DUTY MECHANIC	2	.0	.0	52.0
Heavy Duty Tech	1	.0	.0	52.0
HEAVY EQUIP OPER	6	.0	.0	52.0
Heavy Equipment Operator	1	.0	.0	52.0
Heavy Equiptment Operator	1	.0	.0	52.0
Helper	12	.1	.1	52.1
HELPER	3	.0	.0	52.1
HET	2	.0	.0	52.1
HS2E	1	.0	.0	52.1
HSE	5	.0	.0	52.1
HSE Advisor	4	.0	.0	52.2
HSE Coordinator	3	.0	.0	52.2
HSE COORDINATOR	3	.0	.0	52.2
HSE Manager	1	.0	.0	52.2
HSE MANAGER	1	.0	.0	52.2
HSE Supervisor	2	.0	.0	52.2
http://www.1023nowradio.com/	1	.0	.0	52.2

HV Tech	1	.0	.0	52.2
HVAC Tech	1	.0	.0	52.2
Hydraulics	12	.1	.1	52.3
Industrial Electrician	2	.0	.0	52.3
Industrial Mechanic	1	.0	.0	52.3
Industrial Painter	2	.0	.0	52.3
Inside Sales	3	.0	.0	52.3
Inspector	1	.0	.0	52.4
INSPECTOR	2	.0	.0	52.4
Inspector, Quality Control	1	.0	.0	52.4
Instrument	2	.0	.0	52.4
Instrument Apprentice 1st Yr	1	.0	.0	52.4
Instrument Fitter	2	.0	.0	52.4
Instrument Mechanic	6	.0	.0	52.4
INSTRUMENT MECHANIC	1	.0	.0	52.4
Instrument Pipefitter	1	.0	.0	52.4
INSTRUMENT PIPEFITTER	1	.0	.0	52.4
Instrument Tech	3	.0	.0	52.5
Instrumentaion	1	.0	.0	52.5
Instrumentation	125	.7	.7	53.2
Instrumentation Fitter	4	.0	.0	53.2
Instrumentation Mechanic	20	.1	.1	53.3
Instrumentation Tech	27	.2	.2	53.5
Instrumentation Welder	1	.0	.0	53.5
Instrumentation/Fitter	1	.0	.0	53.5
Instrumentation/Pipefitter	2	.0	.0	53.5
Instrumentation/Steam/Pipefitter	1	.0	.0	53.5
Instrumentation/Steamfitter	1	.0	.0	53.5
Insulator	590	3.4	3.4	56.9
INSULATOR	46	.3	.3	57.2
Insulator/Mechanic	1	.0	.0	57.2
Inventory Control	1	.0	.0	57.2
Iron Worke	1	.0	.0	57.2
Iron worker	1	.0	.0	57.2
Iron Worker	83	.5	.5	57.7
IRON WORKER	118	.7	.7	58.3
IRON WORKER FOREMAN	1	.0	.0	58.3
IRON WORKER SUPT	1	.0	.0	58.3
Iron Worker/General Foreman	1	.0	.0	58.3
Iron Worker/Welder	3	.0	.0	58.4
Iron Workers	1	.0	.0	58.4

Ironworker	256	1.5	1.5	59.8
IRONWORKER	7	.0	.0	59.9
Ironworker 720	45	.3	.3	60.1
Ironworker 720 Appr.	1	.0	.0	60.1
Ironworker 720(725)	1	.0	.0	60.1
Ironworker 720pre appr	1	.0	.0	60.1
Ironworker 721	1	.0	.0	60.2
Ironworker Foreman	2	.0	.0	60.2
Ironworker Foreman 720	1	.0	.0	60.2
Ironworker Superintendent	1	.0	.0	60.2
Ironworker/ Welder	4	.0	.0	60.2
Ironworker/Welder	7	.0	.0	60.2
IronWorker/welder	3	.0	.0	60.3
Ironworkers	1	.0	.0	60.3
ISM LATHER	4	.0	.0	60.3
IT COORDINATOR	1	.0	.0	60.3
IW GF	1	.0	.0	60.3
IW JM	7	.0	.0	60.3
IW JMW	2	.0	.0	60.3
IWA1	3	.0	.0	60.4
IWA4	2	.0	.0	60.4
IWFM	4	.0	.0	60.4
IWGF	2	.0	.0	60.4
IWJM	19	.1	.1	60.5
IWSUPT	1	.0	.0	60.5
IWW	10	.1	.1	60.6
Janiitor	1	.0	.0	60.6
JANITOR	1	.0	.0	60.6
Journeyman Electrician	3	.0	.0	60.6
Journeyman Fitter	2	.0	.0	60.6
JOURNEYMAN INSULATOR	1	.0	.0	60.6
Journeyman Welder	2	.0	.0	60.6
l	1	.0	.0	60.6
Labourer's Union	1	.0	.0	60.6
Labourer	549	3.1	3.1	63.8
LABOURER	121	.7	.7	64.5
Labourer 92	43	.2	.2	64.7
Labourer Foreman 92	1	.0	.0	64.7
Labourer/Foreman	2	.0	.0	64.7
lagger	1	.0	.0	64.8
Lagger	10	.1	.1	64.8
Lead hand	1	.0	.0	64.8
LEAD HAND	1	.0	.0	64.8
LeadHand	1	.0	.0	64.8
LOADER	1	.0	.0	64.8

Machine Operator	2	.0	.0	64.8
MACHINE OPERATOR	3	.0	.0	64.9
Machinist	2	.0	.0	64.9
MACHINIST	2	.0	.0	64.9
Mack	1	.0	.0	64.9
Maintenance	9	.1	.1	64.9
MAINTENANCE	2	.0	.0	65.0
Maintenance Coordinator	1	.0	.0	65.0
Maitenance	1	.0	.0	65.0
MAITENECE	1	.0	.0	65.0
Manager	5	.0	.0	65.0
MANAGER	10	.1	.1	65.1
Manager of Operations	1	.0	.0	65.1
Mang. Safety & Loss Prevention	1	.0	.0	65.1
Mason	18	.1	.1	65.2
MASON	3	.0	.0	65.2
Mason 222	2	.0	.0	65.2
Masonry	4	.0	.0	65.2
Material Control	3	.0	.0	65.2
Material Handler	1	.0	.0	65.2
Materials & Procurement Mgr	2	.0	.0	65.3
MATERIALS COORDINATOR	1	.0	.0	65.3
Mech Tech	1	.0	.0	65.3
Mechanic	29	.2	.2	65.4
MECHANIC	6	.0	.0	65.5
MECHANIC/WELDER	1	.0	.0	65.5
Metal	6	.0	.0	65.5
Metal Trade	2	.0	.0	65.5
Metal Trades	22	.1	.1	65.6
Metal Trends	1	.0	.0	65.7
Millwright	97	.6	.6	66.2
Millwright/Welder	1	.0	.0	66.2
MILWRIGHT	1	.0	.0	66.2
MWA1	1	.0	.0	66.2
MWA2	1	.0	.0	66.2
MWA3	1	.0	.0	66.2
MWFM	1	.0	.0	66.2
MWGF	1	.0	.0	66.2
MWJM	10	.1	.1	66.3
n/a	1	.0	.0	66.3
None	1	.0	.0	66.3
Nurse	1	.0	.0	66.3
Nuse	1	.0	.0	66.3
O/ E Crane	1	.0	.0	66.3

O/E	9	.1	.1	66.4
OE	6	.0	.0	66.4
OE FM	1	.0	.0	66.4
OE Foreman	1	.0	.0	66.4
OE JM	3	.0	.0	66.4
OEFM	1	.0	.0	66.5
OEG1	14	.1	.1	66.5
OEPRATOR	2	.0	.0	66.5
Office	6	.0	.0	66.6
OFFICE ADMIN	6	.0	.0	66.6
Office Administrator	1	.0	.0	66.6
OFFICE ASST.	1	.0	.0	66.6
Office Staff	5	.0	.0	66.7
OPER ENGINEER	11	.1	.1	66.7
Operating Engineer	62	.4	.4	67.1
OPERATING ENGINEER	5	.0	.0	67.1
Operating Engineer 955	7	.0	.0	67.1
Operating Engineer Foreman	1	.0	.0	67.1
Operating Engineer/Mechanic	1	.0	.0	67.1
OPERATIONS MANAGER	2	.0	.0	67.2
Operator	90	.5	.5	67.7
OPERATOR	31	.2	.2	67.9
OPERATOR (CRANE)	2	.0	.0	67.9
OPERATOR (HEAVY EQUIP	1	.0	.0	67.9
OPERATOR (HEAVY EQUIP App	1	.0	.0	67.9
Operator Engineer	3	.0	.0	67.9
Operators	1	.0	.0	67.9
Operatpr	1	.0	.0	67.9
OPREATOR (CRANE)	6	.0	.0	67.9
P/F	2	.0	.0	68.0
Paint Shop Lead Hand	1	.0	.0	68.0
Painter	28	.2	.2	68.1
PAINTER	3	.0	.0	68.1
Paramedic	2	.0	.0	68.1
Parts	5	.0	.0	68.2
PARTS PERSON	2	.0	.0	68.2
Parts Technician	1	.0	.0	68.2
PARTY CHIEF	1	.0	.0	68.2
PAYROLL ADMINISTRATOR	2	.0	.0	68.2
PAYROLL CLERK	1	.0	.0	68.2
Payroll/Administration	1	.0	.0	68.2
PCL Staff	9	.1	.1	68.3
PF A1	1	.0	.0	68.3

PF A3	2	.0	.0	68.3
PF A4	2	.0	.0	68.3
PF AP1	1	.0	.0	68.3
PF FM	1	.0	.0	68.3
PF GF	1	.0	.0	68.3
PF JM	7	.0	.0	68.4
PF JMW	7	.0	.0	68.4
PF/W	2	.0	.0	68.4
PFA1	13	.1	.1	68.5
PFA2	4	.0	.0	68.5
PFA3	4	.0	.0	68.5
PFA4	5	.0	.0	68.6
PFFM	26	.1	.1	68.7
PFGF	6	.0	.0	68.7
PFJM	148	.8	.8	69.6
PFSUPT	1	.0	.0	69.6
PFW	39	.2	.2	69.8
PILE DRIVER	1	.0	.0	69.8
Piling	3	.0	.0	69.8
Pip	1	.0	.0	69.8
pipe	2	.0	.0	69.9
Pipe Fitter	11	.1	.1	69.9
PIPE FITTER HELPER	1	.0	.0	69.9
Pipe Welder	1	.0	.0	69.9
Pipefiter	2	.0	.0	69.9
pipefitter	11	.1	.1	70.0
Pipefitter	1340	7.7	7.7	77.7
PIPEFITTER	217	1.2	1.2	78.9
PIPEFITTER / RIGGER	2	.0	.0	78.9
PIPEFITTER / WELDER-FOREMAN	1	.0	.0	78.9
PIPEFITTER / WELDER	8	.0	.0	79.0
Pipefitter /Welder	1	.0	.0	79.0
PIPEFITTER 3RD Year	1	.0	.0	79.0
Pipefitter 488	87	.5	.5	79.5
Pipefitter 488 appr.	1	.0	.0	79.5
Pipefitter 488(170)	1	.0	.0	79.5
Pipefitter 4881 appr	1	.0	.0	79.5
PIPEFITTER APPRENTICE	1	.0	.0	79.5
PIPEFITTER APPRENTICE 2ND YEAR	1	.0	.0	79.5
Pipefitter Foreman	4	.0	.0	79.5
Pipefitter Foreman 488	6	.0	.0	79.6
PIPEFITTER GENERAL FOREMAN	1	.0	.0	79.6
PIPEFITTER JOURNEYMAN	1	.0	.0	79.6

PIPEFITTER SUPT	1	.0	.0	79.6
PIPEFITTER SUPV	1	.0	.0	79.6
Pipefitter, Staff	1	.0	.0	79.6
Pipefitter/ Steamfitter	5	.0	.0	79.6
Pipefitter/ Wedler	1	.0	.0	79.6
Pipefitter/ Welder	4	.0	.0	79.7
Pipefitter/HYDRO	1	.0	.0	79.7
Pipefitter/Instrumentation	3	.0	.0	79.7
Pipefitter/Rigger	1	.0	.0	79.7
Pipefitter/Scaffolder	2	.0	.0	79.7
Pipefitter/Steamfitter	16	.1	.1	79.8
Pipefitter/Steamfitter 1A 488	2	.0	.0	79.8
Pipefitter/Steamfitter 2A 488	2	.0	.0	79.8
Pipefitter/Steamfitter 488	16	.1	.1	79.9
Pipefitter/Superintendent 488	1	.0	.0	79.9
Pipefitter/Wedler	1	.0	.0	79.9
Pipefitter/Welder	106	.6	.6	80.5
Pipefitter/Welder 1A 488	1	.0	.0	80.5
Pipefitter/Welder 488	16	.1	.1	80.6
Pipefitter/Welder 488 I	1	.0	.0	80.6
Pipefitter`	1	.0	.0	80.6
pipefitting	1	.0	.0	80.6
Pipefitting	1	.0	.0	80.6
Pipeftitter	1	.0	.0	80.6
Pipeiftter	3	.0	.0	80.7
Pipeiftter/Plumber	1	.0	.0	80.7
Pipeiftter/Welder	1	.0	.0	80.7
Pipeitter	1	.0	.0	80.7
Pipfitter Apprentice	1	.0	.0	80.7
Piping Staff Coordinator	1	.0	.0	80.7
Planner	1	.0	.0	80.7
PLANNER	1	.0	.0	80.7
PLANT OFFICE COORDINATOR	1	.0	.0	80.7
Plating	18	.1	.1	80.8
Plumber	221	1.3	1.3	82.1
PLUMBER	4	.0	.0	82.1
PLUMBER / PIPEFITTER	1	.0	.0	82.1
Plumber 740	1	.0	.0	82.1
PLUMBER, JOURNEYMAN	1	.0	.0	82.1
Plumber/Gasfitter	11	.1	.1	82.2
Plumber/Pipefitter	4	.0	.0	82.2
Plumbing	2	.0	.0	82.2
PRESIDENT	1	.0	.0	82.2

PRODUCTION MANAGER	2	.0	.0	82.2
Project Accountant	1	.0	.0	82.2
Project Controls	1	.0	.0	82.2
Project Coordinator	6	.0	.0	82.3
PROJECT COORDINATOR	3	.0	.0	82.3
PROJECT COORDINATOR/ESTIMATER	1	.0	.0	82.3
PROJECT ENGINEER	2	.0	.0	82.3
Project Manager	13	.1	.1	82.4
PROJECT MANAGER	5	.0	.0	82.4
PROJECT SUPV	3	.0	.0	82.4
PSE	1	.0	.0	82.4
PTA	9	.1	.1	82.5
Purchaser	1	.0	.0	82.5
PURCHASER	3	.0	.0	82.5
Purchasing	1	.0	.0	82.5
Purchasing Agent	1	.0	.0	82.5
Q/F	1	.0	.0	82.5
QA	4	.0	.0	82.6
QA/QC Coordinator	1	.0	.0	82.6
QC	4	.0	.0	82.6
QC Admin Asst	1	.0	.0	82.6
QC Coordinator	1	.0	.0	82.6
QC Manager	1	.0	.0	82.6
QC/QA COORDINATOR	1	.0	.0	82.6
Quality	1	.0	.0	82.6
Quality Assurance / Acctg Mgr	3	.0	.0	82.6
Quality Assurance Clerk	2	.0	.0	82.6
Quality Assurance Inspector	2	.0	.0	82.7
Quality Assurance Manager	1	.0	.0	82.7
Quality Control	36	.2	.2	82.9
QUALITY CONTROL	3	.0	.0	82.9
Quality Control Administraor	1	.0	.0	82.9
Quality Control Administration	1	.0	.0	82.9
Quality Control Coordinator	1	.0	.0	82.9
Quality Control Inspector	5	.0	.0	82.9
QUALITY CONTROL INSPECTOR	8	.0	.0	83.0
Quality Control Supv	1	.0	.0	83.0
Quality Examiner	1	.0	.0	83.0
REBAR BENDER	1	.0	.0	83.0

Receiver	1	.0	.0	83.0
Receptionist	1	.0	.0	83.0
RECEPTIONIST	2	.0	.0	83.0
Refrigeration	5	.0	.0	83.0
Regional Manager	2	.0	.0	83.1
Reinforcing Ironworker	1	.0	.0	83.1
RETAIL SALES	1	.0	.0	83.1
Rigger	2	.0	.0	83.1
RIGGER	7	.0	.0	83.1
ROAD BUSTER	1	.0	.0	83.1
Robot Operator	1	.0	.0	83.1
ROD BUSTER	3	.0	.0	83.1
Rod Mad	1	.0	.0	83.1
Rodbuster	3	.0	.0	83.2
Rodman	3	.0	.0	83.2
Safety - Loss Prevention	1	.0	.0	83.2
Safety	43	.2	.2	83.4
SAFETY	2	.0	.0	83.4
Safety Administrator	1	.0	.0	83.5
Safety Advisor	3	.0	.0	83.5
SAFETY ADVISOR	3	.0	.0	83.5
Safety Coordinator	7	.0	.0	83.5
Safety COORDINATOR	1	.0	.0	83.5
SAFETY COORDINATOR	4	.0	.0	83.6
Safety Coordinator (HSE)	1	.0	.0	83.6
SAFETY MANAGER	1	.0	.0	83.6
Safety Officer	1	.0	.0	83.6
SAFETY OFFICER	1	.0	.0	83.6
Safety Supervisor	1	.0	.0	83.6
Safey	1	.0	.0	83.6
Sales	2	.0	.0	83.6
SALES	1	.0	.0	83.6
SALES ADMIN ASSISTANT	1	.0	.0	83.6
SALESMAN	1	.0	.0	83.6
Sandblaster	1	.0	.0	83.6
SCAFFOLD DESIGNER/ESTIMATOR	1	.0	.0	83.6
Scaffoldeer	2	.0	.0	83.6
scaffolder	4	.0	.0	83.7
Scaffolder	1135	6.5	6.5	90.2
SCaffolder	1	.0	.0	90.2
SCAFFOLDER	37	.2	.2	90.4
Scaffolder / Labourer	1	.0	.0	90.4
Scaffolder / Safety	1	.0	.0	90.4
SCAFFOLDER APPRENTICE	1	.0	.0	90.4

SCAFFOLDER FOREMAN	1	.0	.0	90.4
SCAFFOLDER JM	1	.0	.0	90.4
Scaffolder/ Carpenter	2	.0	.0	90.4
Scaffolder/Carpenter	31	.2	.2	90.6
Scaffolder/Pipefitter	2	.0	.0	90.6
Scaffolding	3	.0	.0	90.6
Scaffoldr	1	.0	.0	90.6
Scheduler	2	.0	.0	90.6
SECRETARY	2	.0	.0	90.7
SENIOR WAREHOUSEMAN	1	.0	.0	90.7
Service Advisor	1	.0	.0	90.7
Service Mechanic	1	.0	.0	90.7
Service Superintendent	1	.0	.0	90.7
Service Technician	2	.0	.0	90.7
Service Writer	2	.0	.0	90.7
Serviceman	1	.0	.0	90.7
SHEAR HELPER	4	.0	.0	90.7
SHEAR OPERATOR	12	.1	.1	90.8
Shee	1	.0	.0	90.8
Sheet Metal	1	.0	.0	90.8
Sheet metal	2	.0	.0	90.8
Sheet Metal	64	.4	.4	91.2
SHEET METAL	3	.0	.0	91.2
SHEET METAL APPR. 1	1	.0	.0	91.2
Sheet Metal Apprentice	3	.0	.0	91.2
SHEET METAL APPRENTICE	3	.0	.0	91.2
SHEET METAL JOURNEYMAN	7	.0	.0	91.3
Sheet metal mechanic	2	.0	.0	91.3
Sheet Metal Mechanic	14	.1	.1	91.4
SHEET METAL MECHANIC	18	.1	.1	91.5
SHEET METAL MECHANIC APPR 4	1	.0	.0	91.5
SHEET METAL MECHANIC APPR.	1	.0	.0	91.5
Sheet Metal Worker	4	.0	.0	91.5
SHEET METAL WORKER	15	.1	.1	91.6
Sheet Metalist	65	.4	.4	92.0
Sheet Metalist/Cladder	1	.0	.0	92.0
Sheet Metalist/Insulator	2	.0	.0	92.0
Sheet Metalist/Welder	1	.0	.0	92.0
Sheeter	8	.0	.0	92.0
SHEETER	36	.2	.2	92.2
Shipper	12	.1	.1	92.3
Shipper / Receiver	9	.1	.1	92.4

SHIPPER / RECEIVER	2	.0	.0	92.4
Shipper 1	1	.0	.0	92.4
Shipper 2	7	.0	.0	92.4
Shipper/Receiver	2	.0	.0	92.4
SHIPPER/RECEIVER	1	.0	.0	92.4
SHIPPER/RECEIVER/TOOL CRIB	1	.0	.0	92.4
Shipping	4	.0	.0	92.5
SHIPPING / RECEIVING	1	.0	.0	92.5
Shipping Clerk	1	.0	.0	92.5
Shipping/QC	2	.0	.0	92.5
Shipping/Receiving	2	.0	.0	92.5
Shop Assistant	1	.0	.0	92.5
SHOP CO-ORDINATOR	1	.0	.0	92.5
Shop Coordinator	1	.0	.0	92.5
Shop D Lead Hand	1	.0	.0	92.5
Shop Foreman	6	.0	.0	92.6
SHOP FOREMAN	1	.0	.0	92.6
Site Accountant	1	.0	.0	92.6
Site Administration	1	.0	.0	92.6
Site Administrator	1	.0	.0	92.6
Site Buyer	1	.0	.0	92.6
Site Clerk	1	.0	.0	92.6
SITE CONSTRUCTION MGR.	1	.0	.0	92.6
SITE COORD	1	.0	.0	92.6
Site Manager	1	.0	.0	92.6
Site Superintendent	1	.0	.0	92.6
SITE SUPERVISOR	1	.0	.0	92.6
Spray	12	.1	.1	92.7
SPRAY WELDER	1	.0	.0	92.7
Springmaker	1	.0	.0	92.7
Sprinkler Fitter	2	.0	.0	92.7
SR ELECTRICAL ESTIMATOR	1	.0	.0	92.7
SR. ADMINISTRATION SPECIALIST	1	.0	.0	92.7
Staff	45	.3	.3	93.0
stea	1	.0	.0	93.0
Steam Fitter	4	.0	.0	93.0
STEAM FITTER	7	.0	.0	93.0
Steamfiitter	1	.0	.0	93.1
steamfitter	5	.0	.0	93.1
Steamfitter	206	1.2	1.2	94.3
STEAMFITTER	13	.1	.1	94.3
Steamfitter / Pipefitter	1	.0	.0	94.3
Steamfitter Apprentice	1	.0	.0	94.3

STEAMFITTER APPRENTICE	1	.0	.0	94.4
STEAMFITTER FOREMAN	1	.0	.0	94.4
Steamfitter/ Pipefitter	2	.0	.0	94.4
Steamfitter/Gasfitter	1	.0	.0	94.4
Steamfitter/Gasfitter/Plumber	1	.0	.0	94.4
Steamfitter/Pipefitter	41	.2	.2	94.6
Steamiftter	1	.0	.0	94.6
Steel Fabricator/Welder	1	.0	.0	94.6
Stemafitter	2	.0	.0	94.6
STRUCTURAL FITTER	2	.0	.0	94.6
STRUCTURAL SUPT	1	.0	.0	94.7
sUBCONTRACTS aDMINISTRATOR	1	.0	.0	94.7
Super Indentant	1	.0	.0	94.7
Superintendant	1	.0	.0	94.7
Superintendent	6	.0	.0	94.7
SUPERINTENDENT	5	.0	.0	94.7
Supervisor	7	.0	.0	94.8
SUPERVISOR	7	.0	.0	94.8
SUPERVISOR/SAFETY REP	1	.0	.0	94.8
Survey Helper	1	.0	.0	94.8
SURVEY MANAGER	1	.0	.0	94.8
SURVEY TECH	1	.0	.0	94.8
Surveyor	3	.0	.0	94.9
SURVEYOR	4	.0	.0	94.9
SURVEYOR APPRENTICE	1	.0	.0	94.9
SURVEYOR ASSISTANT	1	.0	.0	94.9
SURVEYOR ASST	1	.0	.0	94.9
SURVEYOR G/F	1	.0	.0	94.9
Swamper	17	.1	.1	95.0
SWAMPER	4	.0	.0	95.0
Team Leader	2	.0	.0	95.0
Teamster - 382	1	.0	.0	95.0
Teamster	10	.1	.1	95.1
TEAMSTER	5	.0	.0	95.1
Teamster Warehouseman	5	.0	.0	95.2
Teamsters	1	.0	.0	95.2
Tech Field Pro.	1	.0	.0	95.2
Technician	2	.0	.0	95.2
Timekeeper	2	.0	.0	95.2
Tool Crib	4	.0	.0	95.2
TOOL CRIB	1	.0	.0	95.2
TOOL EQUIP	1	.0	.0	95.2

Trades	2	.0	.0	95.2
Trades Assistant	1	.0	.0	95.2
Trades Helper - Detai	1	.0	.0	95.2
Trades Helper	10	.1	.1	95.3
Trades Helper (1st 3	3	.0	.0	95.3
Trailer Mechanic	1	.0	.0	95.3
TRAINING	1	.0	.0	95.3
Truck Driver	2	.0	.0	95.3
TRUCK DRIVER	12	.1	.1	95.4
Turnaround & Maintenance Manager	1	.0	.0	95.4
Vice-President	1	.0	.0	95.4
VICE PRESIDENT	1	.0	.0	95.4
Warehouse	1	.0	.0	95.4
WAREHOUSE FOREMAN	1	.0	.0	95.4
WAREHOUSE MANAGER	1	.0	.0	95.4
Warehouse person	6	.0	.0	95.5
Warehouse Personel	1	.0	.0	95.5
Warehouse Supervisor	1	.0	.0	95.5
WAREHOUSEMAN	4	.0	.0	95.5
wel	1	.0	.0	95.5
weld	1	.0	.0	95.5
welder	5	.0	.0	95.6
Welder	586	3.4	3.4	98.9
WELDER	89	.5	.5	99.4
Welder (B Pressure)	1	.0	.0	99.4
Welder 1st Year Appre	4	.0	.0	99.4
Welder 2nd Year Appre	6	.0	.0	99.5
Welder 3rd Year Appre	7	.0	.0	99.5
Welder 488	9	.1	.1	99.6
Welder Apprentice	3	.0	.0	99.6
WELDER APPRENTICE	3	.0	.0	99.6
Welder Journeyman I	4	.0	.0	99.6
Welder Journeyman II	16	.1	.1	99.7
Welder.Scaffolder	1	.0	.0	99.7
WELDER/ APPRENTICE 3	1	.0	.0	99.7
WELDER/ APPRRENTICE 1	1	.0	.0	99.7
Welder/ Pipefitter	2	.0	.0	99.7
Welder/ Steamfitter	1	.0	.0	99.8
Welder/Boilermaker	1	.0	.0	99.8
WELDER/BOILERMAKER	1	.0	.0	99.8
Welder/Electrician	8	.0	.0	99.8
Welder/Fitter	4	.0	.0	99.8
WELDER/FITTER	1	.0	.0	99.8
Welder/Pipefitter	3	.0	.0	99.9

Welder/Steamfitter	2	.0	.0	99.9
Welding Foreman	1	.0	.0	99.9
Welding Inspector	1	.0	.0	99.9
Welding Lead Hand	1	.0	.0	99.9
Wheels Operator	1	.0	.0	99.9
Yard	1	.0	.0	99.9
Yard Man 1	1	.0	.0	99.9
Yard Manager	1	.0	.0	99.9
YARD PERSONEL	1	.0	.0	99.9
YARD PERSONNEL	1	.0	.0	99.9
YARD SUPERVISOR	1	.0	.0	99.9
YARD WORKER	1	.0	.0	99.9
Yardman	11	.1	.1	100.0
Zoom Boom OPerator	1	.0	.0	100.0
Total	17476	100.0	100.0	

Appendix C

Frequency Distribution of Union Affiliation Listed in the Original Database

Union

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid		5725	32.8	32.8	32.8
	* Carpenters Local 174 (USA)	1	.0	.0	32.8
	* Local 18 (IAHFIAW - Indianapolis)	6	.0	.0	32.8
	*805	3	.0	.0	32.8
	*Asbestos Workers Union Local 95	3	.0	.0	32.8
	*Boilermakers Local 128 (THM)	110	.6	.6	33.5
	*Boilermakers Local 555	52	.3	.3	33.8
	*Boilermakers Local 73	47	.3	.3	34.0
	*Boilermakers Lodge 359	5	.0	.0	34.1
	*Capenters Local 1209	1	.0	.0	34.1
	*Carpenters Local 1273	1	.0	.0	34.1
	*Carpenters Local 1669	2	.0	.0	34.1
	*CMTC Local 83	2	.0	.0	34.1
	*Construction & General Workers' Union Local No. 92	274	1.6	1.6	35.7
	*Edmonton Ironworkers' Union Local 720	170	1.0	1.0	36.6
	*HFIAW, Local 32 JAC	1	.0	.0	36.6
	*HFIAW, Local 36 JATC	1	.0	.0	36.6
	*HFIAW, Local Union 60	2	.0	.0	36.7
	*IAHFI Local 110	425	2.4	2.4	39.1
	*IAHFI Local 116	1	.0	.0	39.1
	*IAHFIAW Local 131	3	.0	.0	39.1
	*IAW Local 37	1	.0	.0	39.1
	*IAW Local 5	3	.0	.0	39.1
	*IAW Local 67	2	.0	.0	39.1
	*IAW Local 85	2	.0	.0	39.2
	*IAW Local 87	2	.0	.0	39.2
	*IBEW Local 1003	2	.0	.0	39.2
	*IBEW Local 105	13	.1	.1	39.3
	*IBEW Local 115	1	.0	.0	39.3
	*IBEW Local 120	5	.0	.0	39.3
	*IBEW Local 1739	3	.0	.0	39.3
	*IBEW Local 1852	6	.0	.0	39.3
	*IBEW Local 213	11	.1	.1	39.4
	*IBEW Local 2166	12	.1	.1	39.5
	*IBEW Local 230	4	.0	.0	39.5
	*IBEW Local 258	1	.0	.0	39.5
	*IBEW Local 353	18	.1	.1	39.6

*IBEW Local 424	2327	13.3	13.3	52.9
*IBEW Local 568	2	.0	.0	52.9
*IBEW Local 625	2	.0	.0	52.9
*IBEW Local 993	2	.0	.0	53.0
*ILWU Local 500	1	.0	.0	53.0
*International Brotherhood of Boilermakers Local 146	384	2.2	2.2	55.2
*International Union of Painters & Allied Trades Local 177	12	.1	.1	55.2
*Ironworkers Local 725	5	.0	.0	55.3
*Ironworkers Local 764	2	.0	.0	55.3
*IUOE 955	140	.8	.8	56.1
*Local 1325 UBC	884	5.1	5.1	61.1
*Local 1338 UBC	6	.0	.0	61.2
*Local 1386	2	.0	.0	61.2
*Local 1392 Carpenters	4	.0	.0	61.2
*Local 1460 Alberta Millwrights	91	.5	.5	61.7
*Local 1588	1	.0	.0	61.7
*Local 2103 UBC	33	.2	.2	61.9
*Local 22 (TEXAS)	2	.0	.0	61.9
*Local 71	3	.0	.0	61.9
*Local 80 (USA)	2	.0	.0	61.9
*Local 800	1	.0	.0	62.0
*Local 805	69	.4	.4	62.3
*Local 949	1	.0	.0	62.4
*NFLD Local 137	1	.0	.0	62.4
*None	44	.3	.3	62.6
*Plasterers' and Cement Masons Local 222	8	.0	.0	62.7
*SMWIA Local 8	75	.4	.4	63.1
*Teamsters Union Local 362	6	.0	.0	63.1
*THM - Unknown	106	.6	.6	63.7
*UA Local 144	14	.1	.1	63.8
*UA Local 170	4	.0	.0	63.8
*UA Local 244 Plummers & Pipe	3	.0	.0	63.8
*UA Local 254	1	.0	.0	63.9
*UA Local 290	2	.0	.0	63.9
*UA Local 324	1	.0	.0	63.9
*UA Local 325	4	.0	.0	63.9
*UA Local 488 - Plumbers & Pipefitters	2389	13.7	13.7	77.6
*UA Local 496	3	.0	.0	77.6
*UA Local 508	1	.0	.0	77.6

*UA Local 552	3	.0	.0	77.6
*UA Local 56	1	.0	.0	77.6
*UA Local 579	15	.1	.1	77.7
*UA Local 628	4	.0	.0	77.7
*UA Local 666	1	.0	.0	77.7
*UA Local 67	1	.0	.0	77.7
*UA Local 682	2	.0	.0	77.7
*UA Local 721	1	.0	.0	77.7
*UA Local 740	6	.0	.0	77.8
*UA Local 800	1	.0	.0	77.8
*UFCW CANADA LOCAL 1288P	1	.0	.0	77.8
*United Association Of Plumbers & Steamfitters Local 682	3	.0	.0	77.8
6241	3	.0	.0	77.8
63-02	13	.1	.1	77.9
6341	3	.0	.0	77.9
951	13	.1	.1	78.0
ABSA	2	.0	.0	78.0
Admin - Clerk	1	.0	.0	78.0
Admin	8	.0	.0	78.1
Admin Payroll	1	.0	.0	78.1
Admin QC	1	.0	.0	78.1
Administration	51	.3	.3	78.4
AdminPurchasing	1	.0	.0	78.4
Alberta Local 1325 United Brotherhood of Carpenters Joiners and Allied Workers	627	3.6	3.6	82.0
Alberta Union Of Provincial Employees - 520	2	.0	.0	82.0
Annex	2	.0	.0	82.0
Boilermaker	297	1.7	1.7	83.7
Boilermakers' Union Local 146 (THM)	65	.4	.4	84.0
Carpenters' Union	1	.0	.0	84.1
Carpenters' Union #1625	1	.0	.0	84.1
Carpenters Union Local 2103	46	.3	.3	84.3
Cement Masons Union Local 222	14	.1	.1	84.4
CNRL 15033	69	.4	.4	84.8
Construction	42	.2	.2	85.0
Construction & General Workers Union Local No 92	302	1.7	1.7	86.8
Construction Field	2	.0	.0	86.8

Detailing	9	.1	.1	86.8
East Mod Yard	235	1.3	1.3	88.2
Electrical	10	.1	.1	88.2
Engineering	4	.0	.0	88.3
Estimating	5	.0	.0	88.3
Fab	25	.1	.1	88.4
Fabrication	3	.0	.0	88.4
Fabrication Shop	94	.5	.5	89.0
Field	10	.1	.1	89.0
Field/ Shop	1	.0	.0	89.0
Foundations	1	.0	.0	89.0
Geeko	6	.0	.0	89.1
Head Office	10	.1	.1	89.1
IAHFI Local 110	101	.6	.6	89.7
IAHFI Local 116	2	.0	.0	89.7
IAHFI Local 118	2	.0	.0	89.7
IAHFI Local 137	20	.1	.1	89.9
IAHFI Local 95	2	.0	.0	89.9
Insulation	6	.0	.0	89.9
International Union of Operating Engineers Local No. 955	113	.6	.6	90.5
Iron Workers' Union Local 720	236	1.4	1.4	91.9
Iron Workers Local 771	13	.1	.1	92.0
Iron Workers Shopmen's Local Union 805 (THM)	259	1.5	1.5	93.5
Iron Workers Union Local 721	1	.0	.0	93.5
Maintenance	26	.1	.1	93.6
Masonry Union	2	.0	.0	93.6
Mechanical	9	.1	.1	93.7
Millwright	11	.1	.1	93.7
Mod Yard 2	9	.1	.1	93.8
Modular	102	.6	.6	94.4
Module Yard 1	5	.0	.0	94.4
Non Union	11	.1	.1	94.5
Office	9	.1	.1	94.5
Operations	21	.1	.1	94.6
Paint Shop	3	.0	.0	94.6
Painters' Union	2	.0	.0	94.7
Payroll	1	.0	.0	94.7
Piling	17	.1	.1	94.8
Pipefitter Union Local 488 (THM)	449	2.6	2.6	97.3
Pipefitter Union Local 496	11	.1	.1	97.4
Placer	1	.0	.0	97.4

Plasterer's Union Local 222 OPCMIA	8	.0	.0	97.4
Projects	2	.0	.0	97.5
Purchasing	3	.0	.0	97.5
QA/QC	5	.0	.0	97.5
Rebar	1	.0	.0	97.5
Safety- Non Union	1	.0	.0	97.5
Safety	2	.0	.0	97.5
Sales	2	.0	.0	97.5
Sheet Metal Workers' International Association Local 8	161	.9	.9	98.5
Shipping	7	.0	.0	98.5
Shipping/ Receiving	2	.0	.0	98.5
Shop	67	.4	.4	98.9
Shop A&B Fitting	5	.0	.0	98.9
Shop A&B Welding	5	.0	.0	99.0
Shop C	5	.0	.0	99.0
Shop C Fitting	8	.0	.0	99.0
Shop C Welding	3	.0	.0	99.0
Shop D	2	.0	.0	99.1
Shop Detail	10	.1	.1	99.1
Shop E	2	.0	.0	99.1
Shop/ Yard	2	.0	.0	99.1
Staff	42	.2	.2	99.4
Supply	1	.0	.0	99.4
SWQR 15019	9	.1	.1	99.4
Teamsters Union Local 362	10	.1	.1	99.5
Tool Crib	2	.0	.0	99.5
United Brotherhood of Carpenters & Joiners of America Local 1338	2	.0	.0	99.5
Utilities	2	.0	.0	99.5
W	1	.0	.0	99.5
Warehours #1 Non Union	3	.0	.0	99.5
West Mod Yard	47	.3	.3	99.8
Winterization	32	.2	.2	100.0
Total	17476	100.0	100.0	