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Noise Monitoring Assessment of a Northwest Fabrication Company

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Problem Report submitted
to the Benjamin M. Statler College of Engineering and Mineral Resources at
West Virginia University

In partial fulfillment for the degree of Master
of Science in Industrial Hygiene

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Abstract

This report documents the findings, observations, and recommendations of the investigator's noise assessment survey, performed at a northwest company fabrication building located in Washington State. The assessment was performed at the request of the company's safety management staff and the fabrication building's industrial hygienist between June 6 and July 22, 2014. The goal of the noise assessment was to determine the risk of employees developing noise-induced hearing loss from their work at the company; to update the company's hearing conservation program; and to provide noise reduction recommendations.

During the assessment, noise monitoring data was collected through the use of personal noise dosimetry and through the use of a sound level meter. A total of 34 samples were collected from 32 employees using personal dosimetry. Samples collected represented a full shift time weighted averages, spanning both the 1st and 2nd shifts. A total of 147 sound level meter measurements were also collected throughout the assessment simultaneously with the personal noise dosimetry.

Data analysis of noise monitoring samples indicated the presence of a possible noise overexposure for 3 employees of the company. In accordance with internal company policy and Washington state health and safety regulations, the findings from the noise assessment reinforced the continued inclusion of the over-exposed employees into the company's hearing conservation program. Noise reduction strategy recommendations included a combination of engineering and administrative controls, in addition to the company's use of a broad range of hearing protection devices.

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Introduction

At the request of a northwest fabrication company a noise assessment was conducted between 6/20/2014 and 6/25/2014, as well as on 6/27/2014, 6/30/2014 and 7/22/2014 in the company's Tube, Duct, and Reservoir center (TDRC) manufacturing building. The goal of the noise assessment was to reassess jobs considered high risk, or "high concern", for the manifestation of a noise overexposure. Occupation of high concern had been previously identified in a 2005 noise assessment.

Purpose

The goal of this project was to perform a noise assessment for the company's TDRC building. The investigator's purpose included:

1. Identifying and evaluating the noise exposure of employees performing jobs of high concern. The criteria for noise overexposure was:
 - a. The Washington state 8-Hour time weighted average permissible exposure level of 85 dBA;
 - b. The Washington state extreme noise level of 115 dBA;
 - c. The company's internal noise threshold of 83 dBA;
2. Observe the company's use of a hearing conservation program including:
 - a. The use of personal hearing protection devices by the employees;
 - b. Compliance of the company to Washington state hearing conservation program requirements;
 - c. Observations of the company's use of engineering and administrative controls;
3. Provide recommendation based upon monitoring data and observations.

Background

Permanent hearing loss due to occupational noise exposure can be effectively and economically reduced through the use of preventative measures. Employers have the responsibility to monitor employee noise exposure and take corrective actions, to reduce noise-related hazards whenever an overexposure is discovered.

Noise Background

Noise or sound can be defined as oscillation above and below the medium atmospheric pressure. Industry professionals often measure sound through the observation of sound pressure: a measurement of the physical air pressure disturbance with respect to time. Expressed in Pascal (Pa), the range of human sound pressure detection spans 2×10^{-4} Pa to well over 20 Pa. Due to this large difference, a logarithmic transformation is used to convert the sound pressure to a sound pressure level (SPL) expressed in decibel(dB).^[1,2]

Sound pressure level against a reference standard is computed from:

$$SPL = 10 \log_{10} \left(\frac{P}{P_{ref}} \right) dB$$

Where $P_{ref} = 20 \mu Pa$

Noise-Induced Hearing Loss

According to the Bureau of Labor and Statistics and NIOSH, an estimated 18,000^[3] workers experienced “Noise Induced Hearing Loss” (NIHL) in 2010 alone. This accounted for 12% of recordable cases seen in the manufacturing sector that year. A total of 30 million Americans workers are estimated to be currently overexposed.^[4]

NIHL is the result of an overexposure to noise.^[1] Individuals with NIHL frequently experience a gradual reduction in the ability to understand speech as human speech frequencies are at most risk.^[5]

Compounded with the typical hearing loss from aging, those afflicted with NIHL can experience a world much different than that of their peers (see Figure 1).^[6]

Figure 1: The average 25-year old carpenter has the ears of a 50-year old person who has not been exposed to noise^[6]

Figure 1 shows the reduction of hearing sensitivity measured in decibel, for a 25-year old with NIHL (shown as a blue circle line); a typical 50-year old without NIHL (shown as a dotted triangle line); a 55-year old individual with NIHL (shown as a red circle Line). Also shown is the range of normal hearing.^[6]

Though the consequences of NIHL can be severe, the disease is almost entirely preventable. As the amount of noise experienced throughout a lifetime decreases, the risk of developing NIHL also decreases. With the proper tools, safety measures, and training, employers and individuals can minimize or prevent the development NIHL.^[7]

NIOSH Noise Recommended Exposure Limit

The current NIOSH recommended exposure level (REL) for occupational noise exposure using an 8-Hour time weighted average (8-Hr TWA) is 85 dBA. The 1998 NIOSH standard recommendation stated that NIHL in workers to be at 8% with a 40-year lifetime exposure to an 8-HR TWA of 85 dBA. NIOSH also recommends the use of a 3 dB exchange rate, where the allowed noise exposure time is halved for every 3 dB increase in noise. The calculation of the NIOSH daily noise dose is used to provide the NIOSH recommended TWA.^[8]

NIOSH Hazardous Noise Exposure Time is computed from:

$$T(min) = \frac{480}{2^{(L-85)/3}}$$

Where: T = Time in minutes

L = Measured SPL

The NIOSH Daily Dose is computed from:

$$D = \left(\frac{C_1}{T_1} + \frac{C_2}{T_2} + \dots + \frac{C_n}{T_n} \right) * 100 \%$$

Where: D = Daily Dose

C = total time of exposure at a specified noise level

T = exposure duration for which noise at this level becomes hazardous

The NIOSH recommended TWA is computed from:

$$TWA = 10 * \log \left(\frac{D}{100} \right) + 85, \text{ dBA}$$

Where: TWA = Time weighted Average

D = Daily Dose

Occupational Safety and Health Administration's Permissible Exposure Limit of Occupational Noise Exposure

The Occupational Safety and Health Administration's (OSHA) Noise Standard^[9] requires employers to have a hearing conservation program in place and provide hearing protection if workers are exposed to a 8-Hr TWA noise level of 85 dBA. The permissible exposure limit (PEL) currently set by OSHA 29 CFR 1910.95 is 90 dBA during an 8-Hr TWA with a 90 dBA threshold limit. If noise levels reach the PEL, then the use of hearing protection must be enforced.

According to NIOSH (1998)^[8], a 40 year lifetime exposure for a 90 dBA 8-Hr TWA causes the risk of NIHL to rise to 25%. OSHA also requires the use of a 5 dB exchange rate. The percentage of workers with full-shift exposures over 85 dBA or 90 dBA would have been 1.5-3 times higher if noise measurements had used a 3 dB exchange rate rather than the OSHA 5 dB exchange rate.^[7]

The OSHA Hazardous Noise Exposure Time is computed from:

$$T(Hours) = \frac{8}{2^{(L-90)/5}}$$

Where: T = Time in hours

L = Measured SPL

The OSHA TWA is computed from:

$$TWA = 16.61 * \log_{10} \left(\frac{D}{100\%} \right) + 90$$

Where: TWA = Time Weighted Average, dBA

D = Daily Dose

Washington State Division of Occupational Safety and Health Background

The Washington state division of occupational safety and health (DOSH) is part of the Washington state department of Labor and Industries. DOSH's primary duty is to develop safety and health rules and to enforce safety and health rules within Washington State. DOSH operates under the Washington Industrial Safety and Health Act of 1973 (WISHA), which produced the first fully operational state safety and health plan approved by the federal government.^[10,11] The plan is incorporated into the body of rules, the Washington administrative code (WAC).^[11]

Washington State Hearing Loss Prevention Standard

The Washington state hearing loss prevention standard (see Appendix 3)^[10] is the state equivalent of the OSHA noise standard.^[9] The hearing loss prevention standard calculates noise exposure identically to the OSHA standard. The Washington state standard requires:

1. The use of hearing loss prevention program, also known as a hearing conservation program, if one of more employee exposures equal or exceed an 85 dBA 8-Hr TWA^[10] (see WAC Hearing Conservation Program Requirements).
2. Hearing protection is to be provided and its use enforced at an 85 dBA 8-Hr TWA^[10] (see Hearing Protection Devices).
3. The use of noise controls (see NIOSH Hierarchy of Controls) to reduce employee noise exposures in the workplace if employee exposures equal or exceed a 90 dBA 8-Hr TWA.^[10]

4. The use of a 115 dBA threshold for extreme noise level (collected using a 1-second slow response time constant).^[3,10] Once the threshold is met or exceeded, a high noise area placard must be installed and hearing protection use in the high noise area must be required. ^[10]
5. The use of a 140 dBC threshold for extreme impulse or impact noise (less than one second in duration). During the noise assessment the investigator did not monitor impulse noise or impact noise.

Washington State Hearing Conservation Program Requirements

A hearing conservation program (HCP) otherwise known as hearing loss prevention program, is a common preventative workplace plan that is designed to protect workers with significant occupational noise exposures from NIHL.^[1,7,10,12] To achieve this goal, the HCP must include all of the following:

- Noise monitoring with data analysis:
It is critical to identify and detect potential hazardous exposure to noise. Through analysis of measuring instruments, such as personal noise dosimetry, the employer is able to potentially determine where or when an overexposure may occur.
- Audiometric testing:
According to NIOSH^[8], even with the implication of a HCP and hearing protection devices, NIHL remains a threat. Through the monitoring of an employee's current exposure level early detection and subsequent early prevention is possible.
- Training and education:
NIHL is a gradual disease that does not progress evenly across the frequency spectrum of human hearing.^[3] With symptom training and prevention techniques the employee is made aware of the risks of NIHL and the use of preventative measures.
- Hearing protection device use when noise exposure exceed 85 dBA 8-Hr TWA:
The use of personal hearing protection devices, such as earplugs or earmuffs, that when used correctly ^[13] can provide the employee with equipment to directly protect their hearing. Noise control methods are preferred to hearing protection devices.
- Noise control of employee exposure greater than 90 dBA 8-Hr TWA:
The use the NIOSH hierarchy of controls; substitution, engineering controls, or administrative controls to diminish or eliminate the likelihood of an accidental overexposure due to human error or ignorance. This is the preferred method. ^[14]
- Identification of deficiencies and recordkeeping:
To maintain adequate understanding of a company's HCP, potential noise overexposure threats,

and to allow periodic auditing by the company, records must be kept and periodically evaluated and updated.

NIOSH Hierarchy of Controls

The NIOSH hierarchy of controls can be summarized (from most effective to least effective) as:

- 1) Prevention or containment of the hazardous workplace agent at its source (engineering control).
- 2) Control employee exposure by relocating the worker to a safe area or reducing exposure time of worker (administrative controls).
- 3) Control the exposure with barriers between the worker and the hazard (e.g. personal protective equipment).

This hierarchy underscores the principle that the best of all prevention strategies is to have no exposure to agents that can cause or contribute to hearing loss.^[14] Noise monitoring sample results can be used in combination with work practice observation and the NIOSH hierarchy of controls to provide employers with effective noise reduction recommendations.

Hearing Protection Devices

If an overexposure is assessed and there is no feasible engineering or administrative controls to reduce the overexposure, the use of hearing protection devices remains the only option to prevent NIHL. Hearing protection devices (HPD) worn by the employee reduces but does not eliminate, the level of noise entering the ear.^[14]

There is a potential of employees misusing the HPDs by employees not fully inserting the device, repeatedly removing the HPD for communication purposes, or the use of old and worn equipment. Such a misuse by some employees would effectively reduce or eliminate the effectiveness of the HPD.^[14]

Typically HPDs fall in two major categories: over the ear muffs and ear-plugs. Both categories are manufactured in a variety of styles and sizes for use in various work environment and worker preference. Environmental Protection Agency (E.P.A.) regulation^[15] requires manufacturers to identify the noise reduction capability of the HPD through a Noise Reduction Rating (NRR). The calculation of the NRR is assessed in ideal lab settings, not practical work environments.^[3]

For a HPD to be considered effective, a combination of conditions is required:

- The employee must be trained to use the HPD correctly, and consistently without intermittent removal.^[14]

- HPDs must be in good condition and provide an adequate fit in an employee's ear without being compromised by the job task performed.^[14]
- To have validity, the HPD packaging must be labeled with the E.P.A. NRR.^[3,15]
- A NRR (dBA) needs to be selected with the potential exposure in mind. This allows the HPD to provide a sufficient level of protection without compromising the worker or the worker's hearing too greatly.
 - The NRR was developed for use in evaluating hearing protection from environmental sources. It is measured with a C-weighting. The corrections below are based on the typical differences between industrial noise as measured using A-weighting and the noise used in the laboratory to measure attenuation when the hearing protector is evaluated for determination of the NRR.^[10]
 - When a single HPD is worn, Washington state requires a NRR correction to be computed at 7 dB less than the manufacturer's assigned NRR.^[10]
 - When dual hearing protection is worn Washington state requires a NRR correction to be computed at 2 dB less than the higher NRR of the two protectors.^[10]
 - When an extreme noise level of 115 dBA or an extreme impulse level of 140 dBC is measured, Washington state requires that a minimum NRR rating of 20 be provided.^[10]
 - The OSHA Technical Manual^[3] suggests the use of the estimated exposure level to correct the NRR for use in a practical work environment.

$$\text{Estimated Exposure (dBA)} = \text{TWA(dBA)} - \{[(\text{Noise Reduction Rating}) - 7] * 50\%\}$$

OSHA requires that an employer must provide adequate hearing protection and requires overexposed employees to wear HPD.^[9] Apart from innovations in technology still not in widespread use, such as the QuietDose system from Howard Leight^[16], most employers are not able to monitor an employee's HPD level of protection. Instead the employer must rely on employees to self-assess that their own HPD fit properly.

Company – Background

The company is located in the state of Washington. It is a manufacturer of conveyance products, fabricating a majority of the components internally. The TDRC building primarily fabricates various diameters of hydraulic tubes, ducts, and oil reservoirs. The fabrication process primarily begins with hollow products usually comprised of metal. These products are then treated and shaped into the required configuration.

The company employed greater than 1,000 employees on site. The TDRC building has over 100 employees working three shifts with different staffing levels. The shifts are split as follows:

- The morning shift from approximately 6am to 3pm, with the most employees.
- The afternoon shift from approximately 3:30am to 11pm, with the second most employees.
- The night shift from approximately 11:30pm to 5:30am, with the fewest employees.

Company – Internal Sampling Protocol

The company stress employee protection and uses a conservative protocol for noise monitoring. The state of Washington requires employers to enforce the use of hearing protection at 85 dBA and above. Internal company sampling protocols follow NIOSH^[8] and DOSH^[10] recommendations. The company's protocols require the use a safety factor to reduce sampling variability and production variability. A 2 dBA safety factor was selected by safety management personal, consequently reducing the HCP inclusion threshold from the state's requirement of 85 dBA 8-Hr TWA to 83 dBA 8-Hr TWA.

The sound pressure level average (L_{avg}) is used to evaluate the noise exposure rather than the OSHA TWA for monitoring time less than 8 hours. The calculation of OSHA TWA^[3,9] assumes that no high noise exposure existed during any unmonitored period. When sampling time was less than 8 hours, the L_{avg} provided a higher noise exposure measurement than the OSHA TWA.

Company – Hearing Conservation Plan

Using the internal threshold of 83 dBA, the company is able to include only those employees who are above the threshold into the hearing conservation program. Allowing the company a practical way to protect the most employees from sampling and production variability during noise monitoring assessments.

The company's hearing conservation plan follows Washington state guidelines (see Washington State Hearing Conservation Program Requirements). Important highlights from the company's HCP include:

- An auditing of the company's hearing protection devices quarterly;
- Quarterly exposure monitoring of employees enrolled in the HCP;
- On-site 3rd party baseline audiograms of employees and annual audiograms of employees enrolled in the HCP;
- Employees with high concern jobs, but no recorded overexposures, are to be reassessed at least once in 10 years;
- Employees with no recorded overexpose are to be reassessed when work practices change.

Company – Hearing Protection Devices

The company provides all employees, regardless of HCP inclusion, with free and easy access to various sizes, types, and brands of hearing protection devices. Hearing protection training and education is available to all employees of the company through conventional scheduled trainings, one-on-one sessions and a walk-in, open door policy of the safety management team. Company policy does not allow the use of a personal music player with headphones but does allow the use of speakers at a low volume. Employees are also encouraged to take and use hearing protection devices in their homes.

Current company management safety policies are similar to the “Total Quality Management” system developed by W. Demings.^[17] This top-down approach requires every employee from the CEO to the lowest intern maintain and abide by hearing loss prevention policy. Employees are encouraged to approach anyone performing an unsafe activity, including the misuse or lack of use of hearing protection devices, and to respectfully correct or address proper use.

Company – Jobs of High Concern

A previous noise assessment was conducted by the company in 2005. The findings of the assessment helped to improve the company’s hearing conservation program to provide protection required by WAC (see WAC Hearing Conservation Program Responsibility). The 2005 assessment included the enrollment of jobs with an overexposure into the hearing conservation program. The report also stressed the possibility that overexposure can manifest in jobs with job tasks determined to be of high concern. High concern jobs were identified through the primary performance of the following tasks:

1. Loading/unloading of the product into a basket for use in a dip tank. This task also includes the use of an overhead crane, the silencing of alarms for dip tank timers, and rolling carts to their destination elsewhere in the factory.
2. Use of a band saw in the removal of excess length of the product. The use of compressed air used to clean off shavings from the saw.
3. Use of a forklift to deliver various machine components used in the shaping of the product.
4. Impregnation of fairings, threading, and grooves onto the product.
5. Quality inspection of the product through the use of water pressure testing and compressed air.
6. Stacking of parts for various treatment using different methods than that of Task 1.
7. Pneumatically bending of the product into desired final shapes.
8. Fairing of tubes using different methods than that of Task 4.

9. Loading/unloading of the product into a vacuum furnace.
10. Loading/unloading of the product into non-vacuum furnace.
11. Inspection of pipe length and use of an end trimming saw. With compressed air used to clean off shavings.
12. Management tasks primarily comprised of clerical work. The sitting area is located on the factory floor next to a high noise area.
13. Loading/unloading of the product into a specialized furnace.
14. Loading/unloading of the product into specialized a cleaning apparatus.
15. Spot weld operator using convection.
16. Oil reservoir tank fabrication. Including drilling, sanding, and grinding of the tank to required standards.

Methods

The noise sampling data was collected during regular work days between 6/20/2014 and 6/25/2014, as well as on 6/27/2014, 6/30/2014 and 7/22/2014. Data collection occurred during 1st shift operations, with the exception of data collected on 6/25/2014 and 7/22/2014. During the later days 2nd shift operation data was collected.

A typical work shift was eight hours long. The work shift included a thirty-minute lunch and two fifteen-minute breaks. An effort was made to begin sampling promptly at shift start and to conclude sampling at shift end. Sampling was also paused for lunch. Any deviation from the employee's from normal work shift tasks, such as meetings or other extenuating circumstances, were not included in sampled times.

The noise monitoring data collected included personal noise dosimetry samples and area sound level meter samples. Samples were collected with permissions from the employee being monitored, the supervisor of the employee, and the site industrial hygienist. Prior to the beginning of data collection, all monitoring equipment usage and limitations were explained to the employee. The investigator provided additional information if the employee had any questions or concerns. All monitoring equipment was operated solely by the investigator.

To follow internal sampling protocol during the the sampling period the sound pressure level average (L_{avg}) was used to evaluate the noise exposure rather than the OSHA TWA (see Company - Internal Sampling Protocol).

Apparatus

Noise monitoring equipment (see Appendix 1) used during the assessment included:

- Five -- 3M Edge5 Personal Noise dosimeters;
- Two -- 3M NoisePro dosimeter;
- One -- Quest 2200 Sound Level Meter;
- One -- QC10 calibrator.

Consistent with the Washington state standard^[10] and the OSHA hearing conservation program^[9], the use of a noise threshold of 80 dBA was selected to measure the potential of an employee exceeding 85 dBA. Table 1 shows all dosimetry settings used during the noise assessment.

Table 1: Instrument Channel Setting

Field	Setting
Criterion Level	85
Criterion Duration (Hrs)	8
Exchange Rate	5
Threshold	80
Upper Limit	115
Weighting	A
Time Constant	Slow

Calibration

Prior to the beginning of the noise assessments, all monitoring equipment and calibration equipment were factory calibrated in accordance with WAC^[3,10] and manufacturer recommendations.

Prior to each sampling period, and again at the conclusion of each sampling period, all monitoring equipment was calibrated against the QC20 calibrator. Calibration was conducted using 114 dB at 1000 Hz in accordance with manufacturer instructions.

Personal noise dosimetry calibration and sound level meter calibration information is included in Appendix 2.

Observation procedure

The company's adherence to WAC requirement of a hearing conservation was assessed through:

- Observations, and interviews with management and employees;
- Observations of engineer and administrative noise control measures;
- Observation of posted signage for high noise areas and employee adherence to signage;
- Observation in the use of HPD for all employees;
 - To preclude bias during this noise assessment, the investigator was unaware of which employees were enrolled in the HCP and consequently which employees were required to use HPD;
 - Only general descriptions were recorded of the HPD; brand and noise reduction rating were not included in the observation.

During noise sampling, observations of the employee work practices for use with sound level meter measurement was also conducted. When an employee undergoing noise dosimetry sampling was not in direct line of sight, a walking route was conducted by the investigator to maintain maximum visual contact

with the employee. Employees were periodically asked to explain tasks and to estimate workflow compared to previous work days.

Personal Noise Dosimeter Procedure

All dosimeters were placed on the lapel of an employee on the same side as the dominant hand. Care was taken to only activate data recording only once the microphone was in position. The device was then locked according to manufacturer's instruction to prevent tampering. Any employee undergoing personal noise dosimetry sampling was observed frequently by the investigator to discourage data disruption.

Sound Level Meter Procedure

Sound level meter (SLM) measurements were conducted with the investigator holding the device at arm's length. SLM measurements of the background noise, and any other relevant task noise, was collected. Tasks of high concern including highly repetitive tasks were also sampled. Personal samples were taken at ear height above the shoulder with adequate clearance from the employee. SLM settings were set to a slow response to detect extreme noise levels^[10] consequently the SLM could not measure impulse noise.

Results

Data recorded during the noise assessment included personal noise dosimetry, sound level meter measurements and work practice observations for 32 different employees. Observation included the company's hearing conservation program, the company's use of noise controls, and employee use of personal hearing device (see Discussion for observations). Employee numbers were assigned by the investigator to maintain anonymity and to allow easy reference. Any occupational noise overexposure detected through personal noise dosimeter or sound level meter measurements was also recorded.

Personal Noise Dosimetry

Over the course of the survey, 34 samples were collected from the 32 different employees. Personal noise dosimetry average results can be seen in Table 2 and to Figure 2. During sampling no tampering or misuse of the dosimeters was observed. Employees did not remove the dosimeters without the supervision of the investigator.

Three dosimetry average results from two employees were found to show noise exposures greater than 83 dBA. The remainder of the sampled employees did not show average exposure to 83 dBA or greater during the sampling period. Noise exposure greater than 83 dBA is highlighted in Table 2. The work task descriptions of overexposed employees are listed in Table 4.

Table 2: Personal Noise Dosimetry Average Results from Sampling on 6/20/2014-7/23/2014

[remove the yellow]

Sample Date	Employee Number	Dosimeter	8-Hr TWA (dBA)	L _{avg} (dBA)	Dose (%)	Run Time (Min)
6/20/2014	1	95	77	80.9	16.6	280
	2	96	76.7	80.6	15.8	278
	3	97	65.6	69.9	3.4	265
	4	98	81.7	83.7	31.8	366
	5	99	74	78.9	10.9	245
6/23/2014	6	95	78.5	79.2	20.4	434
	7	96	66	66.7	3.6	432
	8	97	76.3	77.2	15	422
	4	98	79.3	83.6	22.7	263
	10	99	74.4	75.3	11.6	422
6/24/2014	11	95	73.1	74.1	9.6	419
	12	96	75.3	76	13	432
	13	97	76.8	77.7	16	420
	14	98	84.8	85.9	49.3	412
	15	99	69.6	70.9	5.9	401
6/25/2014	16	95	71.1	71.1	7.3	483
	17	96	81.1	81	29.3	484
	18	97	76.1	76.1	14.6	475
	19	98	77.1	77.3	16.8	466
	20	99	78.9	79.2	21.5	454
6/27/2014	21	63	73	76.6	9.5	294
	22	95	65.7	67.5	3.4	373
	23	96	72.8	74.7	9.3	372
	24	97	74.8	76.6	12.1	371
	25	98	70.3	72.2	6.6	369
6/30/2014	26	99	77.1	79	16.7	364
	27	63	71.4	72.4	7.6	395
	1	65	67.4	69.7	4.3	347
	29	95	80.2	80.4	25.8	463
	30	96	68.5	68.9	5.1	454
7/22/2014	31	97	76.6	77	15.6	453
	32	98	76.1	76.6	14.6	446
	33	99	75	75.9	12.5	424
	34	98	76.7	82.2	15.8	224

Noise exposures with a L_{avg} greater than 83 dBA are highlighted in yellow.

Figure 2: Personal Noise Dosimetry Average Results from Sampling on 6/20/2014-7/23/2014 with the internal 83 dBA threshold of the company shown as a dotted line.

Repeat sampling was done on Employee 1, who reported having an uncommonly low amount of work to perform. Repeat sampling was also performed on Employee 4, who had concerns about the validity of his initial survey results.

Sound Level Meter Results

With the help of the employee, each employee's job was broken down to tasks performed during the completion of the job. As the employee performed each job task a sound level reading was taken to assess each tasks extreme noise level risk.

SLM monitoring and observation of job tasks showed that the 19 of 32 employees did not perform tasks which had SLM reading greater than 90 dBA. SLM monitoring and observation of job tasks for 13 of 32 employees did perform tasks which had SLM reading greater than 90 dBA (see Table 3 and Figure 3). SLM monitoring recorded one employee to have noise exposures greater than 115 dBA.

Table 3: Sound Level Meter Results with Greater Than 90 dBA [remove yellow]

Date Sampled	Employee Number	Dosimetry L _{avg} (dBA)	SLM SPL (dBA)	Task Description
6/20/2014	2	80.6	95	Compressed Air Use
6/20/2014	4	83.7	95	Forklift Horn (High Use)
6/20/2014	5	78.9	90	Compressed Air Use
6/23/2014	4	83.6	95	Forklift Horn (High Use)
6/23/2014	7	66.7	95	Compressed Air Use
6/23/2014	10	75.3	91	Car Rolling
6/24/2014	11	74.1	90	Band Saw Use
6/24/2014	13	77.7	90	Machine filling
6/24/2014	14	85.9	109	Compressed Air Use
6/24/2014	14	85.9	110	Band Saw Use
6/24/2014	15	70.9	110	Band Saw Use
6/24/2014	15	70.9	101	Compressed Air Use
6/27/2014	25	72.2	90	Horizontal Band Saw
6/27/2014	26	79	105	Compressed Air Use
6/30/2014	29	80.5	101	Compressed Air Use
7/22/2014	34	82.2	119.5	Routing on oil reservoir

Table 3 shows the occurrence of an extreme noise level measurement, greater than 115 dBA, highlighted in yellow.

Figure 3: Dosimetry L_{avg} (Blue) and 90 dBA or Greater SLM Readings (Red). The 115 dBA extreme noise level threshold^[10] and the 83 dBA internal company threshold are shown as a dotted line.

Overexposures Found

An overexposure was recorded when personal noise dosimetry averages were at or above the company's internal threshold of 83 dBA. An overexposure was also recorded when sound level meter task measurements indicated the presence of extreme noise levels greater than 115 dBA (see Table 4).

Table 4: Employees with an Overexposure High Noise Task Breakdown.

Employee Number	Date	Dosimetry L _{avg} (dBA)	Task	Location/Notes	Sound Pressure Level (dBA)
4	6/20/2014	83.7	Background	Minimal noise in the background	72-75
			Forklift horn		87-95
	6/23/2014	83.6	Background	Minimal noise in the background	70
			Forklift horn	High use. Up to 42 uses per min. More usage when leaving main work area.	95
14	6/24/2014	85.9	Background	Minimal noise in the background	66-75
			Compressed air	High use	109
			Band Saw	High use	110
34	7/22/20104	82.2	Background	Fan On	67-68
			¾" Diameter Router	Routing on reservoir	119.5

Discussion

Full shift personal noise dosimetry average results showed that Employees 4, and 14 had noise overexposures (see Table 4). Only Employee 14 would be considered overexposed using Washington state standard of 85 dBA^[10]. Employee 34 was determined to be overexposed through the use of SLM measurements, which showed extreme noise levels greater than 115 dBA (see Table 4).

Overexposures of Employee 4, Employee 14 and Employee 17

A 1st shift forklift operator, Employee 4 regularly delivered components to many areas of the plant. Employee 17 performed an identical role but was on 2nd shift. Employee 17 was exposed to an average of 81 dBA and Employee 4 was exposed to an average of 83.6 dBA and 83.7 dBA. With dosimetry average results greater than the company's internal threshold, an overexposure was recorded for Employee 4.

Observations of Employee 4 showed that during the two sampling periods the employee was much busier than Employee 17. Plant activity throughout the building was seen to be greater in the 1st than the 2nd shift, presumably because of the lower number of employees and responsibilities.

SLM monitoring and observations showed that the most common high noise task for both Employees 4 and 17 was using the forklift horn. Both Employees used ear-plugs while operating the forklift. When not operating the forklift, they removed their HPD and stored them around their necks. The job task of Employees 4 and 17 were enrolled in the company's hearing conservation program from a previous noise assessment due to similar monitoring results.

Employee 14, a part-trimmer, was observed using a bandsaw to cut metal tubing to proper length. The bandsaw was enclosed for protection of the operator and presumably to reduce machine noise. Employee 14 was also observed using compressed air to remove filings during the cutting process. Dosimetry average results showed an average exposure of 85.9 dBA. The results were above the company's internal threshold and above the Washington state standard threshold of 85 dBA^[10]. An overexposure was recorded for Employee 14.

Observations conducted throughout the assessment showed that Employee 14 performed tasks similar to her peers but at an increased volume of work. The employee had relatively little down time compared to her peers. Management confirmed that Employee 14 was consistently busy. Observations and SLM measurements of Employee 14 showed the volume of work performed, rather than task conducted, was the major contributing factor in the employee's overexposure.

Employee 14 wore ear-plugs while performing all work tasks. The employee was not regularly observed to have removed her hearing protection. Employee 14 was enrolled in the company's hearing conservation program from a previous noise assessment due to similar monitoring results.

Overexposure of Employee 34

Employee 34, the reservoir production specialist, was observed using a drill press with various sized drill bits to expand precast holes to a required diameter. Employee 34 was also observed using a router to smooth out the expanded holes. Dosimetry average results showed a L_{avg} of 82.2 dBA, which is just below the internal company threshold. Sound level meter measurements showed that Employee 34 had a greater than one second exposure to 119.5 dBA during the routing task. An extreme noise level overexposure was recorded for Employee 34 and Employee 34's work area.

A reservoir is a nearly hollow metal sphere-like container approximately 36 inches in diameter. The body of the reservoir has various size holes. The hollow chamber within the reservoir directed noise out of the reservoir and toward Employee 34. Observation of Employee 34's work practice showed that the use of a router was needed on every reservoir for an average of one minute or greater. With the employee fabricating several reservoirs per shift.

During hole-routing Employee 34 wore dual hearing protection, both ear-plugs and over the ear muffs. The employee was not regularly observed to have removed his ear-plugs but did remove hearing muffs after the completion of the routing task. The hearing muffs were stored on a hook at the wall. Employee 34 was enrolled in the company's hearing conservation program from a previous noise assessment due to similar monitoring results. The area surrounding Employee 34 was placarded as a High Noise Area from a previous assessment. Observations of the area during routing task showed that the high noise area was adequately sectioned off as no extreme noise levels were detected at or outside the high noise perimeter.

Observation of Noise Controls – Engineering and Administrative Controls

Engineering control methods observed included the use of:

- Machine enclosures;
- Low revolution saws;
- Sound barriers;
- Noise isolation booths.

No administrative controls methods were observed.

Observation of Noise Controls – Hearing Protection Devices

A diverse selection of hearing protection devices were provided at every entrance to the building. The HPD were observed to be regularly stocked, kept in manufactures wrapping until use and in new condition. Employee were encouraged to use HPD at the daily pre-shift meetings but use was not enforced when required.

The investigator did not assess if the NRR rating of the company's HPDs were in compliance with the Washington state requirement. A review of records did show that prior audits of HPDs were conducted. During all prior audits the NRR rating was in compliance with Washington state code, but was not calculated in the method specified by the OSHA technical manual.

Observations of Employee Use of Hearing Protection Devices

Only 4 of the 32 employees sampled were observed to be wearing any hearing protection devices during their shift. The employees using HPD were numbers 4, 14, 17, and 34. These employees were enrolled in the company's hearing conservation program prior to the noise assessment and were required to use HPD. Employees not enrolled in the company's HCP did not wear HPD and avoid high noise areas.

A review of training procedures and observation of employees showed that when employees inserted ear-plugs they followed the procedure taught to them. All employees enrolled in the hearing conservation program were confirmed to undergo training in the proper use of HPD; however, no such confirmation existed for employees not enrolled in the HCP. Management and employees alike were observed to follow posted extreme noise level signage. No employee was seen to enter the extreme noise level.

Throughout the assessment employees not included in the hearing conservation program reported concerns with their own personal hearing. When the questioned on their voluntary use of HPD, management and non-management alike expressed that HPDs are uncomfortable, reduced effective communication, and the ability to hear music were the primary reason in not utilizing the provided HPD.

Throughout the assessment period E.P.A.^[15] labeling or the use of the estimated exposure computation^[3] was not observed to be stressed by management staff or shown to employees. This ignorance resulted in employees often questioning whether MP3 headphones would protect their hearing.

Observation of Hearing Conservation Program

Observation of the company's hearing conservation program showed that the company had implemented the use of noise controls to accommodate a variety of work areas and tasks. When feasible engineering

and hearing protection device use was observed. However no use of Administrative controls was observed. No deficiencies were observed during an audit of internal company records.

Recommendations

- The job tasks of Employees 4, 14, and 17 should remain included in the hearing conservation program. These job take exposure should be further monitored and compared to other shift counterparts. Work practice changes should be discussed with management and affected employees to find possible methods to eliminate the sources seen in table 4.
- Employee rotation is a recommended administrative changes that would benefit Employees 4, 14, and 17. Employees in a rotation would spend part of their work time in a high noise task and part of their time in low noise tasks. A rotation stratify can reduce the time an employee spends in the high noise area consequently, reducing their overall exposure.^[3] A manager confirmed that an employee rotation was not always feasible due to training of the employee and unequal pay-grades.
- Employees who perform the forklift operation task would also benefit from engineering controls such as the lowering of the forklift horn volume. Care must be taken to not create a situation where the horn is too quiet. The addition of a visual notification system, such as a flashing light, may provide adequate warning.
- Employee 14 and employees who had SLM readings greater than 90 dBA would benefit from a substitution to the use of compressed air to clean cuttings.
- Employee 34's job should remain included in the HCP. The area around Employee 34 should remain placarded as a high noise area. Periodic monitoring of employees who frequently come into the high noise area is recommended. Either the elimination of routing or the reduction in speed of the routing motor is recommended to produce less noise in Employee 34's high noise area.
- Continued use of hearing protection devices is recommended for employees who are included in the hearing conservation program. During future noise exposure assessments the specific make, model, and NRR rating of the HPD should be recorded to assess the HPD's effectiveness. Hearing protection devices selection should follow the Washington state noise standard^[10] and the OSHA Technical Manual guideline calculation for Estimated Exposure^[3], and each must have E.P.A. approval^[15]
- Continued use of the "Total Quality Management System"^[17] is recommended in order to reduce potential noncompliance of hearing protection devices.

Limitations

The primary limitation of the sampling was the lack of replication. Each survey sample result was captured by one device, during one round of sampling per person. This only provides the investigating industrial hygienist with a snapshot of the noise for that particular day during the particular conditions of the survey day for that particular person. Inferences should not be drawn on such limited data. replications a confidence interval cannot be drawn. Repeating the sampling over the course of multiple days, spread across multiple different work conditions, across multiple individuals performing the same work would add confidence to the survey results.

Conclusion

Workers were observed to self-assess the proper fit of their HPD. Neither the investigator nor management observations could determine if a HPD properly fitted the employee through external evaluation. By relying on self-assessment a misuse of the HPD can be caused by ignorance or through intentional sabotage, though neither was apparent during the survey.

Unfortunately once engineering and administrative controls are exhausted PPE remains the only alternative control. The need of employees to perform self-assessments of their HPD fit appears to be a lasting underlying facet in the use HPD. To help maintain compliance in HPD use the company has focused on the use of the “Total Quality Management System”^[17] in an attempt to instill the idea of personal employee responsibility for safety. The empowering of employees, and providing an open-door-policy to, the company may be able to reduce or eliminate incorrect use of HPD over the course of the coming years.

The noise assessment was able to achieve all proposed goals:

1. The noise exposure of employees performing jobs of high concern was evaluated with regard to Washington state standards;
 - a. When compared to the 2005 noise assessment no new overexposure were identified;
2. An audit of the company hearing conservation plan that it met all the requirements set forth by the company and Washington state;
 - a. Observation of the hearing conservation plan’s use showed that it was followed by employees and management;
3. Recommendation were provided based on the monitoring data and observation.

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Appendix 1: Apparatus and Instrumentation

Table 5: Apparatus and Instrumentation Information

Equipment	Serial Number	Text Reference
3M Edge 5 Personal Noise Dosimeter	ESM060095	95
3M Edge 5 Personal Noise Dosimeter	ESM060096	96
3M Edge 5 Personal Noise Dosimeter	ESM060097	97
3M Edge 5 Personal Noise Dosimeter	ESM060098	98
3M Edge 5 Personal Noise Dosimeter	ESM060099	99
3M NoisePro Personal Noise Dosimeter	NLK100063	63
3M NoisePro Personal Noise Dosimeter	NLK100065	65
Quest 2200 sound level meter	SLM0001	SLM
3M QC20 114dB 1000Hz Calibrator	QIM050120	Calibrator

Appendix 2: Calibration Data

Table 6: Calibration log of Personal Noise Dosimeters

Dosimeter	6/20/2014		6/23/2014		6/24/2014		6/25/2014	
	Pre-Calibration	Post-Calibration	Pre-Calibration	Post-Calibration	Pre-Calibration	Post-Calibration	Pre-Calibration	Post-Calibration
63	-	-	-	-	-	-	-	-
65	-	-	-	-	-	-	-	-
95	114.0	113.9	114.0	113.8	114.1	114.0	114.0	114.2
96	114.0	114.0	114.0	114.0	114.0	114.0	114.0	114.2
97	113.9	113.9	114.0	114.1	114.0	114.0	114.0	114.4
98	113.9	113.9	114.0	113.9	114.0	114.0	114.0	114.2
99	113.9	114.1	114.0	114.1	114.0	114.1	114.0	114.2

Table 7: Calibration log of Personal Noise Dosimeters Continued

Dosimeter	6/27/2014		6/30/2014		7/22/2014	
	Pre-Calibration	Post-Calibration	Pre-Calibration	Post-Calibration	Pre-Calibration	Post-Calibration
63	113.9	113.8	114.0	114.0	-	-
65	-	-	113.9	113.9	-	-
95	114.0	114.1	114.1	114.2	-	-
96	114.0	114.0	113.9	114.1	-	-
97	114.0	114.1	114.0	114.1	-	-
98	114.0	114.1	114.0	114.0	114.0	114.1
99	114.0	114.1	114.0	114.0	-	-

Table 8: Calibration log of Sound Level Meter

Date	Pre-Calibration	Post-Calibration
6/20/2014	114.0	114.0
6/23/2014	114.0	114.0
6/24/2014	114.0	114.0
6/25/2014	114.0	114.0
6/27/2014	114.0	114.0
6/30/2014	114.0	114.0
7/22/2014	114.0	114.0

Appendix 3: Washington state safety standard for Hearing Loss Prevention (Noise)

Chapter 296-817 WAC

Safety Standards for Hearing Loss Prevention (Noise)

(Scope and Summery)

LAST UPDATED 07/21/09

WAC 296-817-100 Scope.

The purpose of this chapter is to:

- Prevent employee hearing loss by minimizing employee noise exposures
- AND
- Make sure employees exposed to noise are protected.

These goals are accomplished by:

- Measuring and computing the employee noise exposure from all equipment and machinery in the workplace, as well as any other noise sources in the work area
- Protecting employees from noise exposure by using feasible noise controls
- Making sure employees use hearing protection, if you cannot feasibly control the noise
- Training employees about hearing loss prevention
- Evaluating your hearing loss prevention efforts by tracking employee hearing or periodically reviewing controls and protection
- Making appropriate corrections to your program.

Reference: Table 1 will help you determine the hearing loss prevention requirements for your workplace. For the specific requirements associated with Noise Evaluation Criteria, see WAC 296-817-30010 of this chapter.

Table 1		
Noise Evaluation Criteria		
Criteria	Description	Requirements
85 dBA TWA ₈	Full-day employee noise exposure dose. If you have one or more employees whose exposure equals or exceeds this level, you must have a hearing loss prevention program	<ul style="list-style-type: none"> – Hearing protection – Training – Audiometric testing
90 dBA TWA ₈	Full-day employee noise exposure dose. If you have one or more employees whose exposure equals or exceeds this level, you must reduce employee noise exposures in the workplace	<ul style="list-style-type: none"> – Noise controls <p>AND</p> <ul style="list-style-type: none"> – Hearing protection – Training – Audiometric testing
115 dBA measured using slow response	Extreme noise level (greater than one second in duration)	<ul style="list-style-type: none"> – Hearing protection – Signs posted in work areas warning of exposure
140 dBC measured using fast response	Extreme impulse or impact noise (less than one second in duration)	Hearing protection

[Statutory Authority: RCW 49.17.010, .040, .050, and .060. 03-11-060 (Order 02-16), § 296-817-100, filed 05/19/03, effective 08/01/03.]

HEARING LOSS PREVENTION PROGRAM WAC 296-817-200 Summary.

Your responsibility:

To prevent employee hearing loss by minimizing, and providing protection from, noise exposures.

You must:

Conduct employee noise exposure monitoring
WAC 296-817-20005

Control employee noise exposures that equal or exceed 90 dBA TWA₈ WAC
296-817-20010

Make sure employees use hearing protection when their noise exposure equals or exceed 85 dBA TWA₈
WAC 296-817-20015

Make sure exposed employees receive training about noise and hearing protection
WAC 296-817-20020

Make sure warning signs are posted for areas with noise levels that equal or exceed 115 dBA
WAC 296-817-20025

Arrange for oversight of audiometric testing
WAC 296-817-20030

Identify and correct deficiencies in your hearing loss prevention program
WAC 296-817-20035

Document your hearing loss prevention activities
WAC 296-817-20040.

[Statutory Authority: RCW 49.17.010, .040, .050, and .060. 03-11-060 (Order 02-16), § 296-817-200, filed 05/19/03, effective 08/01/03.]

A Full copy of the WAC Noise Code available on the WISHA web site:

- WISHA Core Rules
- Other General WISHA Rules
- Industry and Task-specific Rules
- Proposed rules and hearings
- Newly adopted rules and new rule information.
- WISHA Regional Directives (WRDs)
- WISHA Interim Operations and Interpretive Memoranda (WIIM)
- Memoranda of Understanding (MOU)