A Comprehensive Review of the Hearing Conservation Program at XYZ Company

by

Michael D. Pettit

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Dr. Brian Finder

The Graduate School

University of Wisconsin-Stout

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The Graduate School
University of Wisconsin-Stout
Menomonie, WI

Author: **Pettit, Michael D.**

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ABSTRACT

The purpose of this study is to analyze the hearing conservation program at Company XYZ's SW Wisconsin plant to determine how employee noise exposures are being managed and to identify strategies which will further reduce such exposures. In 2006, seven people showed a Standard Threshold Shift on their annual audiometric exam. It was not until months later that six of the seven were deemed not work related. However, in that time the EHS department became concerned about the levels of sound produced in The Plant. A literature review was conducted to establish a knowledge base of topics that are directly related to the development and perpetuation of an effective hearing conservation program. Noise level measurements were measured using dosimeters and a sound level meter in order to ascertain whether or not employee exposures were above government based limits. As a result of the findings,

recommendations were made to update the organization's hearing conservation program as it relates to increasing the frequency of noise monitoring, performing periodic noise audits of employee hearing protection usage, increase the visibility/labeling of hearing conservation areas, make hearing protection devices more readily accessible, reduce the extent of radio based noise, and update the hearing conservation training program by requiring donning and doffing which was not previously being done. These recommendations are necessary for Company XYZ's continuous improvement efforts in The Plant's hearing conservation program.

The Graduate School

University of Wisconsin Stout

Menomonie, WI

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TABLE OF CONTENTS

Chapter I: Introduction

The topic of employee noise exposure minimization is one that appears to receive notable attention in American business and industry today. This may be, in part, because federal law states that employers have the responsibility to protect their employees from the effects of noise exposure. According to *29 CFR 1910.95*, employers must administer an effective on-going hearing conservation program, whenever employee noise exposures equal or exceed an eight hour time-weighted average (TWA) sound level of eighty-five decibels (dBA) as measured on the A scale (OSHA, 2008). Employee exposure to noise is a major concern because in addition to creating hearing loss, hazardous noise levels have been found to increase employee absentee rates, doctor's visits, worker compensation claims, induce antisocial behaviors, and reduce overall employee-based job satisfaction (NIOSH, 1998).

XYZ Company is a diversified technology company with a worldwide presence that possesses a manufacturing facility in Southwestern Wisconsin with approximately 550 fulltime and temporary employees. In order to minimize the redundancy of this long designation, Company XYZ's Southwestern Wisconsin facility will hereafter be referred to as The Plant. The Plant has existed for 41 years and occupies 513,000 square feet in area in two manufacturing buildings – Building A and Building B. A wide variety of products are manufactured at The Plant including surface conditioning products, vinyl matting, abrasives, and thermal insulation. Process technologies used in the manufacturing operations at The Plant include non-woven web making, coating, oven curing, die cutting, sawing, gluing, and packaging.

XYZ Company prides itself on being a world leader in the area of environmental, health, and safety (EHS). The Plant has typically met or exceeded corporate EHS performance expectations and recently experienced 3 million hours worked without a lost time incident. Unfortunately, the incident rate (i.e. the frequency of recordable medical treatment injuries per 200,000 hours worked) at The Plant has increased from 3.2 in 2006 to 9.4 in 2007. Of twenty-eight recordable incidents which incurred in 2007, seven were initially the result of a standard threshold shift (STS) that indicated numerous employees had suffered significant hearing loss. Prior to 2007, The Plant had only experienced two in the previous five years. While, follow-up medical evaluations of the employees who experienced a STS determined that six of the seven were not work related, a moderate amount of concern still exists with regard to the overall effectiveness of the hearing conservation program at The Plant.

Purpose of the Study

The purpose of this study was to assess the working conditions as well as practices at The Plant in order to identify opportunities to reduce employee risk for overexposure to occupational noise.

Goals of the Study

The goals of this study include:

1. Measure existing noise exposures in The Plant's Building B.
2. Identify specific sources of noise resulting in eight hour Time Weighted Average (TWA) readings above 85 dBA.
3. Analyze The Plant's Hearing Conservation Program.

Background and Significance

Company XYZ places a major emphasis on running their plants in a safe manner. Each plant at Company XYZ receives a quarterly metric scorecard in which the all aspects of each plants performance measured against a predetermined set of goals. These goals are set by Company XYZ's Executive Council. Loosely translated, this equates to a report card which indicates how each respective plant is performing. One of the major components of the scorecard is Environmental, Health and Safety (EHS) performance. The element of greatest concern to the leadership group is the year to date incident rate. The incident rate is computed by multiplying the number of recordable incidents by 200,000 and dividing the result by the total hours work by all employees in The Plant. This allows for a straight forward comparison of performance regardless of the size of the workforce.

New products introduced at Company XYZ are developed within small laboratory settings call pilot plants. Once it has been determined that the product can be manufactured for profit and when customer demands exceed the capabilities of the pilot plant, business units, within Company XYZ, then identify a manufacturing plant where production can be scaled up to meet required volumes. The incident rate tends to be the perceived indicator of how safe a plant operates their businesses. Since, noise induced hearing loss is one of the most common occupational problems and the second most self-reported illness or injury, it is extremely important to The Plant to maintain a low incident rate if they would like to have a chance at obtaining new business (DHHS, 1999).

Assumptions of the Study

While conducting this study the following assumptions were made:

1. It is assumed that no tampering of the noise monitoring instrumentation took place by employees who participated in noise dosimetry.
2. It is assumed that acoustical calibration equipment was within allowable tolerances.

Limitations of the study

Although several departments in both manufacturing buildings at The Plant are included in their Hearing Conservation Program, the scope of this project is limited to Building B. This building is comprised of three departments which are included in The Plant's Hearing Conservation Program: departments 5, 6, and 7. It was determined by the researcher that the scope of this project would have been too large and too time consuming if Building A was also included in the scope of this project.

Since the onset of this project, staffing changes occurred in The Plant's Environmental, Health, and Safety Department. Specifically, The Plant made the decision to hire a full time Industrial Hygienist. Additionally, the researcher's responsibilities have transitioned into the role of The Plant's Safety Engineer and the researcher's responsibilities no longer include Hearing Conservation or management of noise. Consequently, the decision was made by The Plant's management team to have the researcher coordinate a transition of hearing conservation improvement efforts to The Plant's full time Industrial Hygienist.

Based on the results of this project, a decision will be made by The Plant's management team to determine if the recommendations of this study will also be considered for Building A.

Chapter II: Literature Review

Noise-induced hearing loss can occur with nearly any employee in the workplace, however, it has been found that employees in certain industries are more likely to experience higher exposures to dangerous levels of noise. Industries with high numbers of exposed workers include, agriculture, mining, construction, manufacturing and transportation, and the military (DHHS, 1999). The purpose of this study was to asses the working conditions as well as practices at Company XYZ The Plant in order to identify opportunities to reduce employee risk for over exposure to occupational noise. The following literature review will discuss the harmful effects of noise, various types of hearing protective devices, the OSHA hearing conservation standard, and the measurement/analysis of noise.

Harmful Effects of Noise

It is recognized that noise, which is any unwanted or undesirable sound, has been a problem in the work place since the Industrial Revolution (CDC, 1990). In more recent times, work-related hearing loss is still a significant workplace safety and health issue (DHHS, 1999). The National Institute for Occupational Safety and Health (NIOSH) (1998) believes that hearing loss is 100 percent preventable, however, once acquired, it is permanent and irreversible (DHHS, 1999).

The three classes of noise that employees may be exposed to in the workplace include continuous, intermittent, and impulse noise. Continuous noise can be defined as noise that lasts one second or more the noise may be either constant or intermittent in nature. On the other hand, impulse noise is often times referred to as impact noise and is associated with a sudden change in sound pressure lasting less than one second. These types of noise can cause two types of hearing loss. First, there is a temporary threshold shift (TTS), which may occur following exposure to loud noises for a short period of time, like a rock concert (Ross, 2007). A TTS occurs immediately after an exposure to high noise levels and in most cases will disappear in a few hours or days. The second form of hearing loss is more permanent and is principally due to the intensity, frequency and duration of the noise exposure and is regarded as being the most common type of hearing loss in the workplace. The intensity of the noise involves the loudness. Frequency and duration of exposure to noise determines whether the hair cells in the cochlea are damaged and hearing loss occurs. Regardless of its nature, any noise-induced hearing loss (NIHL) is caused by continuous exposure to damaging noise levels, and once a person starts losing his/her hearing, it will never come back completely (Weede, 2004).

There are many risks for potential hearing loss; some of these risks can be controlled, such as consistently using hearing protection. Avoiding tobacco, getting regular exercise, and eating a healthy diet may decrease the risk of noise-induced hearing loss. Also, it is believed that diabetes, heart disease and tooth loss may increase the risk for hearing loss (Daniel, 2007). There are also some risks that cannot be controlled, including age, genetics, gender, and race. It appears that noise induced hearing loss increases with age. Individuals between the ages of 65 and 75 are at the highest risk along with males and non-whites when exposed to loud noise over a period of time in the workplace (Daniel, 2007).

Noise exposure has been known to induce tinnitus (ringing or buzzing in the ears), psychological stress, increased accident rates, and disruption of job performance, thus adversely affecting the quality of one's life. The World Health Organization (WHO) has documented seven categories of adverse health effects of noise on humans in the WHO Guideline on Community Health. These categories include hearing impairment, interference with spoken communication, sleep disturbances, cardiovascular disturbances, disturbances in mental health, impaired task performance, and negative social behavior and annoyance reactions (Goines & Louis, 2007).

Hearing impairment is an increase in the threshold of hearing when assessed by audiometry. Typically people many not be aware of the problem in the early stages but as the problem intensifies testing should be done. Warning signs include not being able to hear someone three feet away, pain in the ears after leaving a noisy place, a ringing or buzzing (tinnitus) after exposure to noise, or possible having difficulty understanding speech. This interference with communication means that the person can hear someone talking, but they cannot understand what is being said (Danielson, 2008).

Communication problems are not only dangerous in the workplace, but can also lead to personal problems such as lack of concentration, fatigue, lack of self confidence, irritation, stress, and difficulty completing tasks (Goines & Louis, 2007). The occurrence of sleep disturbance is not related to the workplace noise. It is an effect of environmental noise, however, uninterrupted and undisturbed sleep does affect an employee's ability to cope at work. It does cause stress and therefore can raise a person's blood pressure (Goines & Louis, 2007).

Studies have been performed on the effects of long-term daily exposures to hazardous noise and hypertension, and there appears to be some controversy on the topic. One study on industrial noise examined its effect on heart rate and blood pressure in blue-collar workers. Their conclusion was that there was no residual or chronic effect of industrial noise on resting heart rate or blood pressure, but there was an acute effect. (Kristal-Boneh & Melamed, 1995). In comparison, Goines and Hagler believe there is growing evidence that confirms that noise exposure has both temporary and permanent negative effects on humans. They feel that although the increased risk for noise-induced cardiovascular disease is small, it is of importance because of the number of people at risk (2007).

Disturbances in mental health, impaired task performance and negative social behavior and annoyance reactions are closely related. Noise can create a "feeling of resentment, displeasure, discomfort, dissatisfaction, or offense when noise interferes with someone's thoughts feeling, or actual activities" (Passchier-Vermeer & Passchier, 2000). These areas are complicated and very difficult to measure individually. Also, the degree of annoyance and reactions can vary from individual to individual. Noise exposure does not necessarily cause attention problems and aggressive behavior, but when combined with preexisting attitudes or in combination with each other, it can produce negative social behaviors (Goines & Louis, 2007).

In summary, both the physical and psychological problems associated with developing some form of a hearing loss may affect employees in adverse ways that would alter their ability to lead a healthy normal life (NIOSH, 1998). It is therefore plausible to believe that noise exposures should be avoided in workplace and non-work settings wherever possible.

Hearing Protection Devices

A hearing protection device (HPD) is a personal safety product that is used to essentially block and thus reduce the harmful effects of an auditory sound. Using hearing protectors are typically regarded as a last resort approach when other methods have been tried and found to be either not practical or economical (Berger, 2000). When feasible engineering or administrative controls have been found to be inadequate, then hearing protectors are relied on to prevent hazardous noise levels from damaging an employee's hearing (Goines & Louis, 2007). Hearing protectors are defined as "anything that can be worn to reduce the level of sound entering the ear" (CDC,1990). A critical issue in the use of hearing protective devices, however, is how the employee perceives the importance of the device and thus the employee uses the device consistently and properly. Selecting the correct hearing protector and responding to the needs of each employee is very important and therefore a coordinated effort between management and the employees is essential to ensure maximum noise protection (CDC,1990).

The ability to work with employees involves education, motivation, supervision, enforcement, attention to detail, ergonomics, and a hands-on attitude toward hearing protection. Employers should try to develop a positive work-place attitude toward the proper use of these devices. Consideration should not only be given to the importance of using protectors through open communication channels, but also to the user's comfort, physical differences, cost, durability, style, and working conditions. A hearing protective device worn properly and consistently can provide effective protection against harmful noise to employees (Berger, 2000), but the above considerations are likely to be essential in order to minimize the company's overall cost of protecting the employee.

It should be noted that no HPD device can be effective if it is not worn by the employee or used correctly. There are some basic rules for safety professionals to bear in mind when selecting the best HPD for their situation. There are currently more than 200 hearing protection devices marketed in the United States, and they range from one-time use, disposable earplugs to custom electronic earmuffs with noise cancellation technology and two-way communication capabilities (National Safety Council, 2000). No matter which device is chosen, consideration should be given to the following 4 C's of use:

1. Comfort. If a hearing protection device is not comfortable, it will not be worn. A one-size-fits-all protector will not fit everyone comfortably, and workers should be provided the opportunity to first try on a protector and make sure it is comfortable for him/her.
2. Convenience. If an HPD is not available when and where it is needed or it is difficult to use, there is a great deal of likelihood that it will not be worn. HPD's should always be available where noisy work takes place.
3. Communication. If an HPD interferes with the employee's ability to understand instructions, or if he/she feels isolated on the job or is at risk due to the inability to hear warning signals, it most likely will not be used.
4. Caring. If users do not appreciate the need for using hearing protection, it will not be used (National Safety Council, 2000).

Modern hearing protection technology has improved greatly in the above 4C areas. Selecting HPDs with these concerns in mind will improve worker safety, improve regulatory compliance, and could also improve productivity and worker morale. In addition, regulatory compliance is an important issue when choosing hearing protective devices. OSHA's requirements for hearing protectors are fairly simple in that employers must provide a selection of hearing protective devices for all employees that are exposed to an 8-hour TWA of 85 dBA. Employers must also ensure that hearing protective devices are worn and employees are trained on how to properly use them (OSHA, 2008).

There are several types of hearing protectors, and each type requires a slightly different fitting technique. NIOSH recommends that hearing protectors should be personally fit to each employee (National Safety Council, 2000). Hearing protective devices can be divided into two main categories; earplugs and earmuffs. Earplugs are placed into or against the entrance of the ear canal and form a seal and block sound; they are inserted or semi-inserted. Earmuffs, on the other hand, fit over and around the ears to provide an acoustic seal against the head. "Utilization of HPDs in the U.S. shows that about 85% of employees wearing hearing protection on a regular basis for protection from occupational noise select earplugs over earmuffs" (Berger, 2000). It is possible that this statistic is due to the comfort that earplugs provide, although the cost of earmuffs may also be a factor. Earplugs are inserted to block the ear canal; these can be premolded or moldable. These devices include expandable foam plugs, pre-molded reusable plugs, and canal caps. Expandable foam plugs are made of a formable material which is designed to expand and conform to the shape of each person's ear canal. They are available in a variety of colors and shapes, and come either with or without attached cords. Many types of earplugs are designed to be disposable in that they can be used once and then thrown away. To properly insert expandable earplugs, they should be rolled into a thin, crease-free cylinder so that about half the length will fit easily into the ear canal. Employees with small ear canals, especially women, have trouble sometimes rolling the plugs small enough to fit comfortably, and therefore a smaller sized expandable ear plug is available for such individuals (National Safety Council, 2000).

Another type of earplug is the pre-molded and thus reusable device typically made from silicone, plastic, or rubber. These plugs are available in four different sizes: small, medium, large, or one-size-fits-most. A special carrying case is also available to keep them clean when they are not being worn. These types of hearing protectors are sometimes called "Christmas tree plugs" because of their appearance. The plugs should seal the ear canal without being uncomfortable. To insert these plugs, a person should reach over the top of the head with one hand and pull up the ear. The other hand is then used to insert the plug with a gentle rocking motion until the ear canal is sealed. Removing the plug is performed with a gentle twist while pulling them out. Advantages of pre-molded plugs are that they are fairly inexpensive, reusable, washable, convenient to carry, and come in a variety of different sizes. Pre-molded plugs are often selected for use in a dusty or dirty environment because they do not need to be handled and/or rolled (National Safety Council, 2000).

Canal caps resemble earplugs but are typically mounted on a flexible or metal band. The headbands can be worn over the head, behind the neck, or under the chin and can be formable or pre-molded. The main advantage of canal caps is convenience, especially in a workplace where the noise is intermittent. When there is no noise, employees can remove the plugs and wear the band around their neck. As needed, they can quickly insert the plugs when hazardous noise starts again. A disadvantage is that employees must understand it is essential to use the canal caps whenever there is noise present and be conscious of using them when the situation demands (National Safety Council, 2000).

In contrast to earplugs, the earmuff is another type of hearing protector which has hard outer cups that are connected by a sturdy head band. Earmuffs are available in many different models, are designed to fit most people, and they work to block out noise by completely covering the outer ear. They can range from small to large ear cups that hold extra sound absorbing materials for use in extremely hazardous noise areas. Some earmuffs include electronic devices that help workers to communicate. It should be noted that workers who have beards, sideburns, glasses, or very angular faces sometimes have difficulty in getting a good seal around their ears. Some workers feel that earmuffs are too hot, heavy, or awkward in some situations, (National Safety Council, 2000) and therefore avoid the use of these protective devices.

In summary, the use of hearing protective devices can be an effective strategy to reduce hearing loss due to the presence of occupational noise. While earplugs appear to be the preferred protection device chosen by employees in the United States, effective hearing conservation programs must consider the areas of fitting and issuing, training and motivation, and enforcement. The best hearing protectors are ones that are actually worn consistently and correctly, but the protectors need to match the type of noise, the environment, and especially the person. All HPD's have advantages and disadvantages; however, research continues to improve the devices to make them more comfortable and convenient (Berger, 2000).

OSHA Hearing Conservation Regulations

Hearing Conservation Standard is related to occupational noise exposure that is focused on hearing loss and conservation when controlling occupational noise (Penney, 2004). In the United States, all applicable workplace hearing conservation programs

(HCPs) must be implemented according to the standards set forth in the OSHA hearing conservation regulations which are located in the Code of Federal Regulations, specifically found in 29 CFR 1910.95. OSHA requires that employers implement a HCP if employee noise exposures are greater than a time-weighted average (TWA) of 85 decibels that is measured on the A scale (dBA) or else a dose of fifty percent (OSHA, 2008). Acceptable exposure times based on given noise levels can be determined by using Appendix A of OSHA's noise standard (see Appendix A). In situations where the above noise exposure limits are exceeded, OSHA requires employers to monitor noise in the workplace, perform annual audiograms, control noise exposures, provide PPE, train, and keep records on activities that are related to a hearing conservation program (OSHA, 2008)

Monitoring Noise Levels

Per OSHA's hearing conservation standard, applicable employers must develop and implement a program to monitor continuous, intermittent, and impulse sound levels on a regular basis. In addition, testing should also be immediately initiated when 1) there is a change in production, 2) a new process is added, or 3) when new equipment is purchased. To ensure noise exposure measurements are accurate, it is required that all monitoring equipment should be maintained and calibrated regularly per the equipment manufacture's recommendations (OSHA, 2008).

Audiometric Testing

In alignment with the OSHA hearing conservation requirements, audiometric testing must be provided for every employee that is exposed to a noise level above a TWA of 85 dBA. An audiogram is the standard means to measure ones level of hearing across a set of standard frequencies (DHHS, 1999). OSHA requires that a baseline audiogram be performed within six months of the employee's first exposure to harmful noise, and then the employee must be retested annually. A licensed or certified audiologist must perform the test. The collected data must be reviewed, analyzed, and evaluated to determine if the individual suffered a standard threshold shift (OSHA, 2008).

Noise Exposure Control

The OSHA standard requires that employers with hearing conservation programs incorporate a variety of administrative and engineering controls to reduce noise exposure to the employees. Noise controls are needed whenever there is a noise level that exceeds 90 dBA. Administrative controls may be used until the noise levels reach 100 dBA. It is the employer's responsibility to use engineering controls for all situations beyond 100 dBA (OSHA, 2008). Administrative controls can include approaches such as work rotation, flexible work scheduling, and limiting time in high nose areas. On the other hand, engineering controls are directly applied to the equipment, either by enclosing noise producing equipment, replacing noisy parts, applying mufflers and automating the process.

Personal Protective Equipment

OSHA requires that hearing protectors be made available to all employees who have been exposed to noise at an eight-hour TWA of 85 dBA. If hearing protection is required, then it is the employer's responsibility to provide proper initial fitting and provide training in the use and care of the protectors. Employees should be given the opportunity to select the hearing protectors from a variety of acceptable devices that have a noise reduction rating that would reduce employee's exposure to noise levels that are below a eight-hour TWA of 90 dBA. Hearing protectors should be replaced as necessary at no cost to the employee (OSHA, 2008).

Employee Education and Training

Annual training must be provided for every employee that is in an organization's hearing conservation program. Training content needs to be current and consistent with the work processes, the hearing conservation areas, and the use of protective equipment. The employer must also provide information about the harmful effects of noise, the purpose of hearing protectors, and the purpose of audiometric testing (OSHA, 2008). Given that training must be performed on an annual basis, one could ascertain the additional work required to make such instructional efforts interesting to the employee.

Record keeping

OSHA requires records to be maintained on employee exposure measurements that include the dates, location, number and result of measurements, description of noise measurement equipment and calibration of equipment. Employee audiograms, audiometric test room's calibration records, and type/serial number of the audiometers used must also be recorded. Record retention requirements are two years for noise exposure measurements, five years after the workers employment period for audiometric tests, and five years for background sound pressure levels and audiometer calibration in audiometric test rooms (Cheremisinoff, 1996). In light of these record keeping requirements, it may be possible that the act of employing reasonable engineering controls would be cheaper in the long run, than to employ a HCP.

Measurement of Noise

"Sound is formally defined as the fluctuations in pressure above and below the ambient pressure of a medium that has elasticity and viscosity" (Berger, 2000). The most common medium that sound is associated with is air. Sound pressure is determined by the variations in pressure below and above the ambient pressure of the medium. The amplitude of that pressure is measured by the difference the sound pressure wave fluctuates from the ambient pressure (Berger, 2000).

A vibrating object is typically what introduces the disturbance in the medium, which in turn produces the sound wave. The object causing the disturbance can be just about anything. A person clapping his/her hands together or slamming a door are two examples of objects introducing disturbance. This disturbance is not easily observed in the air, however, the same principal can be applied to fluids as well. For example, a person could throw a rock into a calm pool of water and see what happens. The rock will disturb the surface of the water and create waves. The waves in the water will act similar to sound pressure waves in the air. The waves will start at the point of disturbance and propagate outward until they dissipate (Berger, 2000). The distance the wave travels to complete one cycle is commonly referred to as the wavelength. Wavelengths are often measured in feet or meters. The frequency of the wave is determined by the number of times it oscillates over the same point in space. Frequency is often expressed in hertz (Hz). Therefore, one hertz is equal to one cycle of the wave in a one second period of time (Berger, 2000).

There are two types of instruments that are use to measure noise. A sound level meter (SLM) is used to quantify sound pressure levels at a specific location at one point in time. A noise dosimeter is a specialized SLM which is designed to measure noise exposures over a period of time. Both instruments are commonly used to quantify employee's exposure to noise (Cheremisinoff, 1996). SLM's commonly consist of a microphone, a calibrated attenuator, an indicating meter, and in some case an octave band analyzer. A noise dosimeter is a specialized SLM that is intended specifically to measure noise exposure over time. Dosimeters are most often used to measure a personal noise exposure. This personal exposure is often expressed in percent dose (Berger, 2000). OSHA has set specific guidelines to prevent employees from being exposed to a dose greater than 100%. A dose of 100% is equal to being exposed to 90 dBA for 8 hours. If employees work a shift longer than 8 hours, their exposure still must still remain under 100% dose. On the other hand, if the employees are exposed to greater the 90 dBA, the employer must limit their exposure by requiring hearing protection or reducing the time they are exposed (OSHA, 2008) (see Figure 2-1).

Figure 2-1

TABLE G-16 - PERMISSIBLE NOISE EXPOSURES (1)

Duration per day, hours	Sound level dBA slow response
8	90
6	92
4	95
3	97
2	100
1 1/2	102
1	105
1/2	110
1/4 or less	115

Source (OSHA, 2008)

There are many settings that must be considered while using a SLM or dosimeter; primarily the settings of most concern are the response time, weighting filters, precision, calibration, and exchange rate (Cheremisinoff, 1996). Most SLM are equipped with a fast and slow response setting. Although it may seem desirable to know the exact sound level at any given time, such is rarely the case. A SLM is designed to average the different frequencies using a root-mean-square method were the frequency average is logarithmically converted into decibels (dB). The slow response setting allows the SLM to slow that calculation to one second intervals. The slow response setting is used to determine the average or slowly changing sound levels in a given area. On the other hand, the fast setting is calculated at .125 second intervals. The fast response setting is use in identifying variability of sound levels on a much faster scale (Berger, 2000). SLM's employ frequency-selective weighting filters which are designed to mimic the perception of loudness on the human ear. A and C weighted filters are most commonly used. However, the A weighting filter continues to be the most widely accepted means of representing the human ear; hence it is the required setting by OSHA (Berger, 2000).

The current SLM standard (ANSI S1.4-1983) denotes 4 different types of SLM's and they are type 0, type 1, type 2, and type S. Type 2 is the General Purpose SLM and is most commonly used for general field use. The tolerances are not as tight as the type 1 SLM; however, for practical field use they are acceptable. Type 2 SLM's are required by the standard to meet or exceed an error rate of 2 dB (Berger, 2000). Type 0 and type S SLM's are not used on the field. Type 0 is the Laboratory standard and is extremely precise, and Type S may contain a variety of tolerance and is designed for special purposes as needed.

Instrument calibration is another important aspect of measuring sound. SLM's are supplied with the means to perform an internal electronic calibration check. This check is performed on an annual basis by the applicable manufacturer. Additionally, acoustical calibration is required before and after each noise monitoring event to ensure the accuracy of data. Modern equipment is very reliable, however, documented acoustical checks are necessary to maintain regulatory compliance. (Cheremisinoff, 1996).

Another setting that needs to be considered is the exchange rate. The exchange rate is the trade-off relationship between an increase or decrease in sound level and the corresponding change in allowable exposure time. In the U.S., OSHA requires the use of a 5 dBA exchange rate. For example, an employee may be exposed to 90 dBA for 8 hours. If the amount of time that a person was exposed to was doubled to 16 hours, then the employee may only be exposed to an average of 85 dBA. The other common exchange rate used is the 3 dBA. NIOSH and American Conference of Governmental Industrial Hygienist (ACGIH) both recommend using the 3 dBA exchange rate (Berger, 2000).

Proper use of a dosimeter or SLM is as important as applying the correct settings. To ensure accurate measurements, there are some precautions that must be followed. Most dosimeters and SLMs measure sound most accurately without the presence of sound reflecting or absorbing objects. Nearby objects or surfaces, including the operator, could act as a reflector or absorber of the sound being measured. To minimize these errors, certain monitoring-based techniques should be followed. For a SLM, the operator should stand in a plane parallel to the direction of sound travel and hold the device in the vertical position with the arm fully extended (Quest Technologies, 2005). In the case of a dosimeter, the microphone should be secured on the top of the shoulder and away from the neck if possible. It is important that the microphone not be obstructed by protective clothing, and that clothing will not rub against the microphone housing . It is also recommended that a wind screen be used, on both the dosimeter microphone and the SLM microphone. This will reduce the risk of documenting increased noise readings from wind or clothing (Quest Technologies, 2008).

Summary

OSHA requires employers to protect their employees from a broad range of hazardous situations while they are working. One of these workplace hazards is noise, which can be defined as any unwanted sound (Gearing up to solve workplace noise problems, 2007). The harmful effects of noise definitely affects a worker's health. Both the physical and psychological problems associated with developing some form of a hearing loss will affect employees in adverse ways that could alter their ability to lead a healthy normal life (NIOSH, 1998). Industrial noise cannot be completely controlled or eliminated, but it can be managed with various hearing conservation policies and regulations. Prevention of hearing loss should be the goal of employers through the use of hearing protection devices, engineering controls, and training programs that maintain a strict compliance to the regulations. Hearing protection devices such as ear plugs and ear muffs, when used consistently and properly is essential. There are many factors to consider when choosing a HPD, such as; comfort, convenience, communication and caring (National Safety Council, 2000).

A proactive and positive approach by management to protect worker's hearing is essential; however, keeping workers safe from hazardous noise in the workplace is definitely a challenge in many industries. OSHA's Hearing Conservation Standard provides a foundation for employers to build a successful hearing conservation program.

The Standard provides a frame work of requirements that employers must comply with such as monitoring noise levels, audiometric testing, noise exposure control, personal protective equipment, employee education and training, and record keeping. The bottom line is that employers should value a good hearing conservation program, and controlling noise will save money and can reduce worker stress as well as improve morale (Zalewski, 2006).

Chapter III: Methodology

The purpose of this study was to assess the working conditions as well as practices at Company XYZ's The Plant in order to identify opportunities to reduce employee risk for overexposure to occupational noise. The goals of this study included measuring existing noise exposures in The Plant's Building B, identifying specific sources of noise resulting in eight hour Time Weighted Average measurements above 85 dBA, and analyzing The Plant's Hearing Conservation Program.

Subject Selection and Description

Subjects chosen for noise monitoring activities were limited to employees in Building B and involved a representative sample for each of the seven departments within this facility. The majority of the dosimetry effort was focused around the areas in Building B that were included in The Plant's Hearing Conservation Program. Areas included in The Plant's Hearing Conservation Program are those departments or areas which potentially have an eight hour equivalent Time Weighted Average exposures of 85 dBA or greater (see Appendix B).

Instrumentation

A sound level meter was used to quantify area noise levels and a noise dosimeter was utilized for personal sampling. All monitoring was conducted according to OSHA protocol. All noise monitoring equipment was calibrated before and after each use. If the calibration showed a drift of greater than two dBA the instrument was not used in the survey and was sent back to the manufacturer for repair. Additionally, both types of monitors were sent in to their respective manufactures annually for electronic calibration to ensure they were within acceptable tolerances. Data was collected on multiple shifts (day shift, afternoon shift, and midnight shift) in order to determine if variations in noise exposure existed.

A Larsen Davis SoundTrack LxT® Type 2 sound level meter (SLM) was used to construct a sound level map of Building B (see Appendix E). Type 2 sound level meters are accurate to plus or minus two dBA. A sound level meter is very useful in determining the sources of noise but it is impractical for calculation of eight hour time weighted averages. During the research, the SLM was operated at a height of approximately four to five feet off the floor, with the researcher's arms fully extended in front of the body. The readings were then allowed to stabilize, to best represent the sound pressure level at that position, before being recorded.

Quest Q300 noise dosimeters were used for performing the personal noise monitoring. Dosimeters integrate continuous readings to calculate an equivalent time weighted average. They are the most readily available instrument used to calculate employee dose in the industrial setting. Dosimeter settings were adjusted in accordance with the requirements set fourth in Company XYZ's Noise Control and Hearing Conservation Manual. Those settings include a Criterion Level of 90 dBA, a response threshold of 80 dBA, and an exchange rate of 5.

Data Collection Procedures

The initial step of monitoring consisted of performing facility-wide sound level measurements with a Larsen Davis Soundrack LxT® Type 2 sound level meter. The purpose of this step was to perform a preliminary analysis to see if any major changes to noise levels had occurred (i.e. either noisy equipment was added or removed from an area). Additionally, this step was performed to validate prior decisions to include a department or area in The Plant's Hearing Conservation Program. As an example, if initial sound level monitoring revealed readings above 85 dBA in a department that was not included in the Hearing Conservation Program, it would trigger the need for additional dosimetry to quantify full shift exposures. Alternately, if excessively loud equipment had been removed from an area or department, it may cause the area to be removed from inclusion in the Hearing Conservation Program. The consequences of this may include non occupational hearing losses being recorded as occupational hearing loss on the OSHA 300 log. Additionally, it is important that resources (time and money) are allocated and utilized in areas where the potential for occupational hearing loss was greatest. In a competitive business climate it is essential that companies spend their money wisely and get the greatest return on their investment. This is why prioritizing noise reduction projects in a manner that reduces the greatest employee exposure to noise for the money the spent.

Noise dosimetry readings were collected and recorded for each department in Building B. The dosimeters were used in accordance with directions provided by Quest Technologies. Prior to participating in noise monitoring, subjects were given an explanation on the purpose of sampling and their role when wearing dosimeters. All subjects were provided basic guidance on how to wear the dosimeters and were instructed to not remove them from their body at any time during their shift. The dosimeters were checked periodically to ensure that they were working correctly, and that the microphone was not obstructed by clothing. The dosimeters were clipped onto the subject's belts, and the microphone was placed at the middle of the top side of the shoulder and parallel to the plane of the shoulder. Upon completion of sampling, the dosimetry data was extracted and entered into Microsoft Excel. Once in Excel, the data was sorted into by department as well as by TWA. This allows the researcher to quickly review the details of each department's dosimetry data separately.

Evaluation of the Hearing Conservation Program

The final step in the methodologies section was comprised of a thorough review of the organization's administrative controls as well as a review of hearing protective device use. Observations were conducted in the affected hearing conservation areas. The observations were conducted to see if employees were properly use hearing protective devices and also to document if hearing protective devices were being used and enforced by the area supervision. The final step was a coordinated review conducted with The Plant's Health Care Supervisor to ensure the accuracy of the Standardized Employee Exposure List (SEEL). The SEEL is basically a list of everyone that is included in the sites Hearing Conservation Program. This step was conducted to ensure that audiometric testing was being provided for all employees who were in The Plant's Hearing Conservation Program and also to ensure that audiometric testing was not being conducted for employees with a eight hour Time Weighted Averages below 85 dBA.

Data Analysis

The data collected was compared to historical monitoring data for The Plant. This comparison was made to determine if recent changes had altered noise levels and consequently triggered the need to adjust the departments and/or areas in The Plant's Hearing Conservation Program. Additionally, noise monitoring was compared to Company XYZ's Noise Control and Hearing Conservation Manual to determine if changes needed to be made to The Plant's existing Hearing Conservation Plan.

Chapter IV: Results

The purpose of this study was to assess the working conditions as well as practices at Company XYZ's The Plant in order to identify opportunities to reduce employee risk for overexposure to occupational noise. The goals of this study included measuring existing noise exposures in The Plant's Building B, identifying specific sources of noise resulting in eight hour Time Weighted Average measurements above 85 dBA, and analyzing deficiencies in The Plant's Hearing Conservation Program. This chapter will discuses the results of the study performed by the researcher.

Results of Sound Level Meter Measurements

A sound level survey of Building B was conducted with a Larsen Davis Soundrack LxT® Type 2 sound level meter. Results of this survey are represented in Appendix E. Measurements in black represent readings below 85dBA for areas working an eight hour work shift and measurements below 82.5 dBA for areas working a 12 hour work shift. Measurements in red represent readings above 82.5 dBA for areas working a 12 hour work shift and 85 dBA for areas working an 8 hour work shift, both of which necessitate the need to include the affected area in The Plant's Hearing Conservation Plan. The purpose of this step was to perform a preliminary analysis to see if any major changes to noise levels had occurred. The researcher was only able to locate one existing documented sound level survey of Building B, which was conducted in February of 2002 and is represented in Appendix C.

In general terms, sound levels had not varied drastically in the previous five years for most areas surveyed. The noticeable exception was in the compounding area of Department #5. Sound level measurements taken in Department #5 in February of 2002 indicated a maximum sound level reading of 89 dBA. Sound level measurements taken by the researcher in November of 2007, indicated a maximum reading of 81.4 dBA. The researcher inquired about the identified reduction in noise and was informed that the most likely reason for this change was due to an exhaust blower being moved from the floor of the compounding to the mezzanine directly above the compounding area in 2005.

Results of Dosimeter Measurements

Quest Q300 noise dosimeters were used to provide time weighted average measurements for each department in Building B. A total of 57 noise dosimetry samples were collected during this study. For the most part, all departments in The Plant's Building B work three, eight hour shifts. The only exception to this is Department #2 which works two, 12 hour shifts. Measurements were taken on all three eight hour work shifts as well as on the 12 hour work shift that Department # 2 works. The a.m. shift starts at 7:00 a.m. and concludes at 3:00 p.m. The p.m. shift starts at 11:00 p.m. and concludes at 7:00 a.m. Department # 2 works a 12 hour work shift which starts at 5:00 a.m. and concludes at 5:00 p.m. Results of noise dosimetry are documented in Appendix D. Dosimetry taken in Department #2 indicated a mean time weighted average reading of 83.3 dBA. Because Department #2 works a 12 hour work shift, it can be concluded that the threshold limit value of 82.1 was exceeded (refer to Figure 4-1).

Figure 4-1

Work Shift Duration (Hours)	Noise Exposure Limit in dBA	
	Using 3 dB Exchange Rate	Using 5 dB Exchange Rate
8	85	85
10	84	83.4
12	83.2	82.1

Source: Company XYZ's Noise Control and Hearing Conservation Manual

Also worth noting is that the mean time weighted average for measurements for Department # 5 is 75.4 dBA. A time weighted average of 85 dBA is the Threshold Limit Value for inclusion in The Plant's Hearing Conservation Program, therefore it appears as though Department #5 does not need to be included.

The radio is transmitted over speakers throughout the building for employees to listen to. The results of the noise dosimetry suggest a reduction of 2-4 dBA with the radio turned off. Discussions with several employees indicated that other workers are turning up the speakers to their maximum capacity to hear the radio over noisy equipment, as well as to compensate for the use of Hearing Protective Device. Additionally, because the speakers are used to cover great distances in The Plant (there are only a few speakers in each area), employees who are furthest from the speakers are turning these devices up as high as they go so that people can hear them far away.

Results of the Review of Administrative Controls and HPD Use

The researcher consulted with The Plant's Corporate Industrial Hygiene services group for feedback on how frequent periodic noise monitoring is either recommended or required. It was recommended that a site-wide sound level evaluations be performed with a sound level meter at least every three years. Additionally, it was recommended that noise dosimetry be conducted for all areas included in The Plant's Hearing Conservation Program at least every two years.

Personal protective equipment is considered the least desirable method in the hierarchy of control of hazards and in the case of noise control it is only as effective as the people who wear hearing protective devices and supervision that enforces its use.

The researcher conducted an informal observation to gauge the proper use of hearing protective devices. As identified in Table 4-2, twenty-three employees in The Plant's Hearing Conservation Program were either not wearing their hearing protective devices or were wearing them improperly. When the subjects who were not wearing hearing protective devices were asked why they were not wearing such equipment, the most common answer was that they forgot. Five of the employees mentioned that it was inconvenient because hearing protective devices were not readily available in their department.

Table 4-1

Hearing Protective Device (HPD) - Use Informal Observation Results

Response	Frequency (N=131)	Percentage
Worn Properly	108	82.4%
Worn Incorrectly	14	10.7%
Not worn at all	9	6.9%

A thorough review of The Plant's Hearing Conservation Training given to all employees was conducted. While the training is fairly comprehensive, a review of compliance with OSHA's Hearing Conservation Standard revealed that one deficiency existed in that the training does not address the proper use of hearing protective devices.

One of the employees who experienced a hearing loss was an employee in Building B. Employees included in The Plant's hearing conservation program were selected based on the area to which they are assigned and not necessarily actual noise exposures. The vast majority of this employee's day is spent in an office environment which was measured by a SLM to be less than 70 dBA. Noise dosimetry was conducted on this employee on a worst case scenario. The worst case scenario was a day in which the employee observed two hours of an experiment in Department #6. Noise dosimetry indicated a time weighted average of 68.5 decibels. It is the policy of Company XYZ that employees be included on the SEEL if even one calendar day exposure results in a time weighted average exposure is greater than or equal to 85 dBA.

While the need for hearing protective devices seemed to be clear to employees assigned to hearing conservation areas, employees who periodically were required to perform work in a hearing conservation area did not seem to understand the boundaries of required use of hearing protective devices. There currently is no signage at the entrance to Department # 6. Signage in Department #7 was placed on racking at a height of 4 ½ feet and on occasion was found to be obstructed by pallet storage.

The researcher evaluated The Plants audiogram procedure and found that all employees at The Plant an 8 hour equivalent TWA noise exposure about 85 dbA or higher receive an audiogram at least annually. Baseline audiograms are performed with-in six months of the employee's first exposure at a level greater than and 8 hour TWA of 85 dbA. All audiograms are performed by a qualified outside agency and the results are sent to Company XYZ's Corporate Occupational Medicine Department for review. Annual audiograms are compared to the employee's baseline results to determine if a standard threshold shift (STS) occurrs. A standard threshold shift has occurred if the results of the annual audiogram identify a change in hearing threshold relative the baseline audiogram of an average of 10 dbA or greater at 2000, 3000, 4000 Hz. After review, the results are then communicated to the employee in writing. If a STS is present then the employee is referred to the local clinic for a follow up audiogram at the company's expense. If the follow-up audiogram confirms the STS is present, then The Plant would document the illness on the OSHA 300 log. All audiometric tests and noise exposure records are retained for the length of employment plus 30 years. Employee training records are also retained for length of employment plus 30 years.

Discussion

As indicated in the literature, hazardous noise levels in the workplace can have a variety of harmful effects on the employees. The proper use of hearing protective devices (HPDs) is a large component of The Plant's Hearing Conservation Program. The literature review stressed that HPDs are only effective if used consistently and correctly. The results indicated that twenty-three employees were not wearing their protective devices or were wearing them improperly. Five of these employees stated that the devices were not readily available in their department. The 4 C's state that caring, or appreciating the need for using hearing protection, is important and that convenience will also increase the likelihood that the devices will be worn.

In order to comply with the OSHA standards, hearing conservation training must be conducted. The literature review discusses that hearing protectors are required for employees who have been exposed to noise at an eight-hour TWA of 85 dBA. The training program was found to be deficient in properly training employees how to correctly use HPDs. The training program does not provide initial fitting during training, nor does it provide training on the proper donning and doffing procedures for each HPD provided. Fourteen people were found wearing the devices, but not wearing them correctly, and another 9 were not wearing them at all. The Hearing Conservation Training Program needs to address this issue better in order to comply with the OSHA standard.

Additionally, the literature indicates areas working 12 hour shifts do not have the same TWA requirements than areas working eight hours shifts. Previously, The Plant took the stance that a TWA of 85 dBA was needed to place an area in to the hearing conservation program. However, the research indicated that for employees working 12 hours shifts the threshold limit should be less. The researcher speculates that the previous EHS person was not aware of the duration of exposure adjustment.

Chapter V: Conclusions and Recommendations

The purpose of this study was to assess the working conditions as well as practices at Company XYZ's The Plant in order to identify opportunities to reduce employee risk for over exposure to occupational noise. The goals of this study included measuring existing noise exposures in The Plant's Building B, identifying specific sources of noise resulting in eight hour Time Weighted Average measurements above 85 dBA, and analyzing The Plant's Hearing Conservation Program. The methodologies utilized in this study consisted of the subject selection process, instrumentation used, data collection, and limitations of the study. Each job description in Building B was sampled for exposure to noise. Additionally, some employees may have been chosen for dosimetry more than once based on the limited number of employees assigned to certain job description in Building B. Some positions are only staffed with one employee per shift. Noise level measurements were taken using dosimeters and a sound level meter in order to ascertain whether or not employee exposures were above government based limits. Data was then compared to historical data and also against the OSHA standard to identify changes in noise level exposures as well as opportunities for improvement.

Conclusions

It is the conclusion of the researcher that the overall Hearing Conservation Program at The Plant meets the majority of requirements set forth in the OSHA Hearing Conservation Standard. However, after careful analysis it is researcher's opinion that The Plant has the opportunity to improve its Hearing Conservations Program to a best practice level in Company XYZ. The goals of the recommendations are to bring The Plant's Hearing Conservation Program from a level of simple compliance to a level that other manufacturing facilities would aspire to. It is the researcher's opinion that if all the recommendations are implemented, that during the next corporate compliance audit The Plant would surpass Company XYZ expectations, and be awarded a "Best Practice" for its Hearing Conservation Program.

Recommendations

- It is recommended that one additional area (Department # 2) be included in The Plant's Hearing Conservation Program. As mentioned in the results section of this study, because Department #2 works 12 hour work shifts, the threshold limit value for a 12 hour shift has been exceeded (see Appendix D). Noise dosimetry reading for this area taken in 2002 indicated Time Weighted Average measurements of 83.9. Department #2 was not included in The Plants Hearing Conservation Program at that point and a review of this document indicated that only areas with a time weighted average exposure above 85 dBA needed to be included in The Plant's Hearing Conservation Program. Since the EHS professional who conducted noise monitoring at that time is no longer employed at The Plant, it is assumed by the researcher that no adjustments were made to account for shifts longer than eight hours, or there were no work shifts at The Plant that were working 12 hours.
- It is recommended that department # 5 be removed from The Plant's Hearing Conservation Program. As previously noted, the mean time weighted average measurements for department # 5 were 75.4 dBA. Because this is well below 85 dBA as a time weighted average, department #5 no longer meets the requirement for inclusion in The Plant's Hearing Conservation Program.

- It is recommended that The Plant consider more frequent noise monitoring and incorporate this recommendation into The Plant's written Hearing Conservation Program. Results of this study revealed that changes in the workplace can, and do, result in changes to employee time weighted average noise exposures. The additions of new equipment as well as the removal of noise sources in the workplace should be reviewed to ensure that current noise management strategies are effective. The Plant has an active Management of Change process, but the form used to during Pre Start-up Safety Review to document hazard reviews does not include a review of noise exposure. It is the recommendation of the researcher that The Plant consider modifying this hazard review to include a review of employee noise exposure.
- It is recommended that The Plant consider implementing a periodic inspection to ensure employees are wearing their hearing protective devices. Based on the results of periodic inspections for Hearing Protective use presented in Table 4-2, it is obvious that there is definitely value in conducting inspections for proper use. This audit should be conducted by first line supervisors.
- It is recommended that additional storage of hearing protective devices be made available in each department or area in The Plants Hearing Conservation Program. It is recommended that The Plant consider revising the hearing conservation training administrated to all employees. While the training is fairly comprehensive, a review for compliance with OSHA's requirements revealed one deficiency existed – the training does not require participants to don and doff Hearing Protective Devices. An additional suggestion is to consider including

plant maps indicating which areas in The Plant are covered by the Hearing Conservation Program.

- It is recommended that The Plant consider removing the area manager from the Standardized Employee Eligibility List (SEEL). Based on monitoring results and an interview with the manager it can be safely assumed that his exposure is well under 85 dBA and therefore does not need to have audiometric testing conducted on an annual basis.
- It is recommended that The Plant consider providing better signage which marks the entrances to areas within The Plant covered by hearing conservation and consequently requiring the use of hearing protective devices. While the need for hearing protective devices seemed to be clear to employees assigned to hearing conservation areas, employees who periodically were required to perform work in a hearing conservation area did not seem to understand the boundaries of required use of hearing protective devices. There currently is no signage at the entrance to Department # 6. Signage is Department #7 was placed on racking at a height of 4 ½ feet, although it sometimes gets obstructed by pallet storage.
- It is recommended that The Plant consider reducing occupational noise created as a result of the radio and speaker system. Noise dosimetry indicated an immediate reduction of 2-4 dBA after the radio was turned off. Achieving a 2-4 decibel reduction is very significant in the prevention of occupational hearing loss. The following suggestions to reduce noise created by the radio speakers are offered by the researcher. The first is to discontinue radio transmission at The Plant as this alone will result in a significant reduction in noise levels. Alternately, if it is

determined that radio transmission will continue, additional speakers may be installed in areas currently lacking a speaker, thereby reducing the temptation to turn the speakers up to maximum volume. One other method to prevent excessive noise is to remove the rheostat dials from each speaker and provide one dial to control all of Building B. It is the recommendation of the researcher to limit control of volume to The Plant's supervisory employees.

- It is recommended that The Plant add donning and doffing procedures for hearing protection devices to the site Hearing Conservation Training per 1910.132(f)(1)(iii)

Areas of Further Research

During the course of this, staffing changes occurred in The Plant's Environmental, Health, and Safety Department. Specifically, The Plant has since hired a full time Industrial Hygienist. Although the scope of this study was limited to building B it is the opinion of the researcher that the recommendations of this study be considered for replication in Building A as well. By replicating the methodologies utilized in this study, it is believed that noise protection-based improvements can also be achieved in Building A.

An additional area of research is for The Plant to consider noise reduction engineering projects aimed at reducing employee's exposure to occupational hearing loss. The noise monitoring conducted by the researcher has laid a ground work by identifying areas in which specific projects can be completed. The new area maps highlight areas of high noise, while the dosimetry data provides a long term exposure measurement. These two items coupled together could be use as a baseline noise level for future engineering projects.

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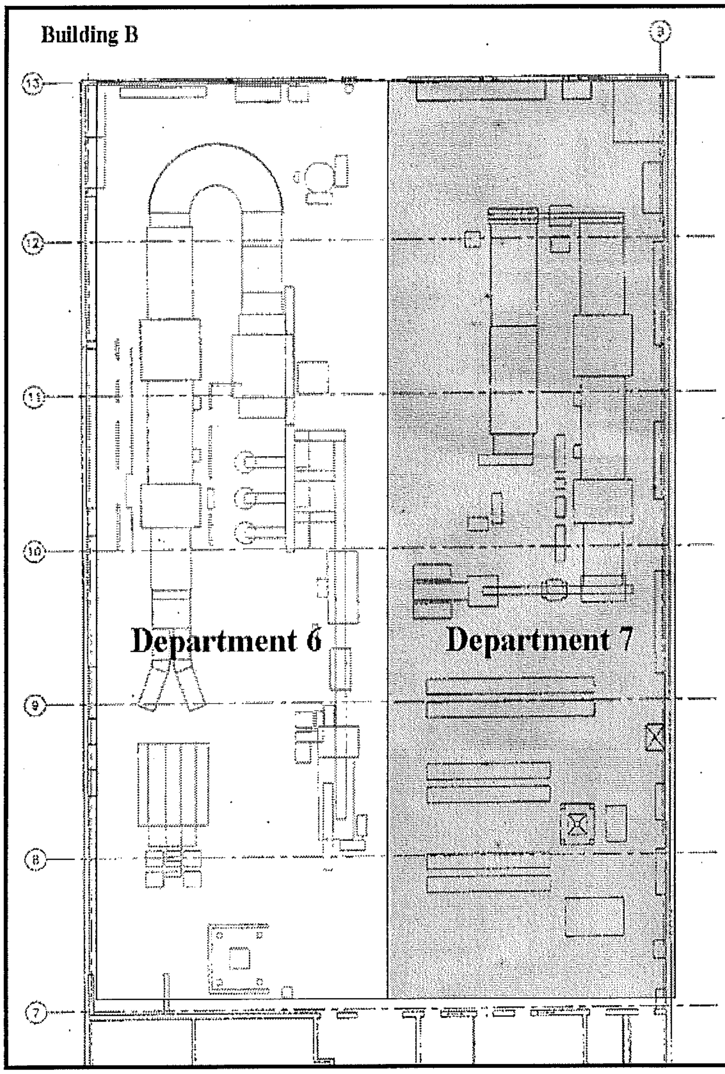
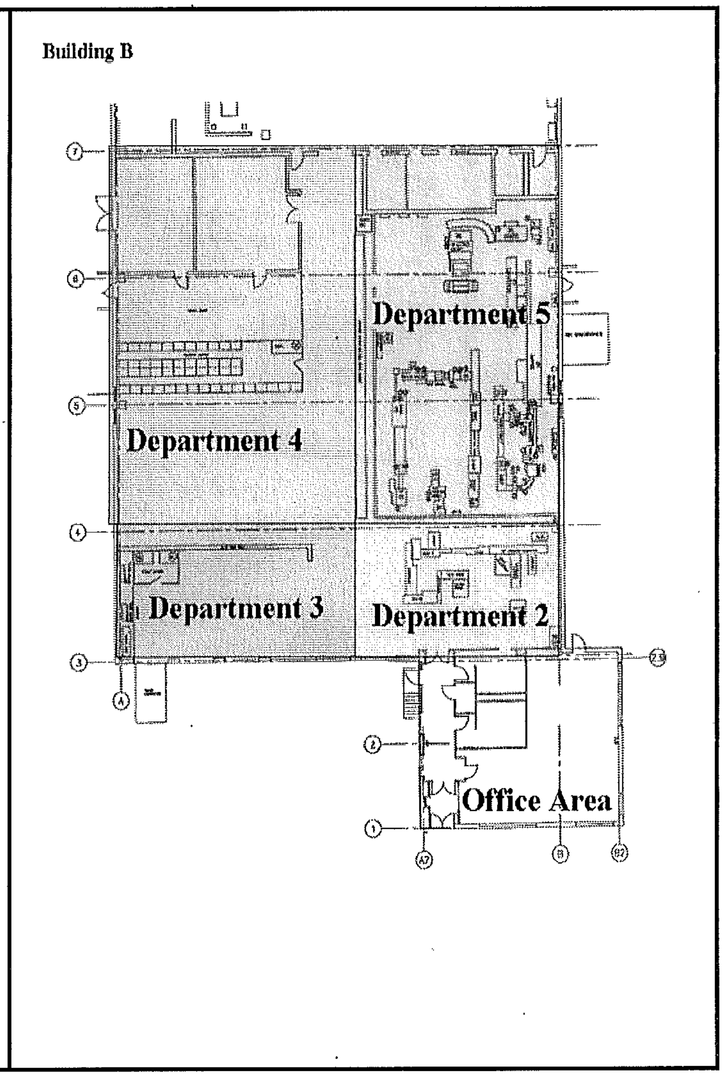
Appendix A: Permissible Noise Exposure (OSHA)

TABLE G-16A

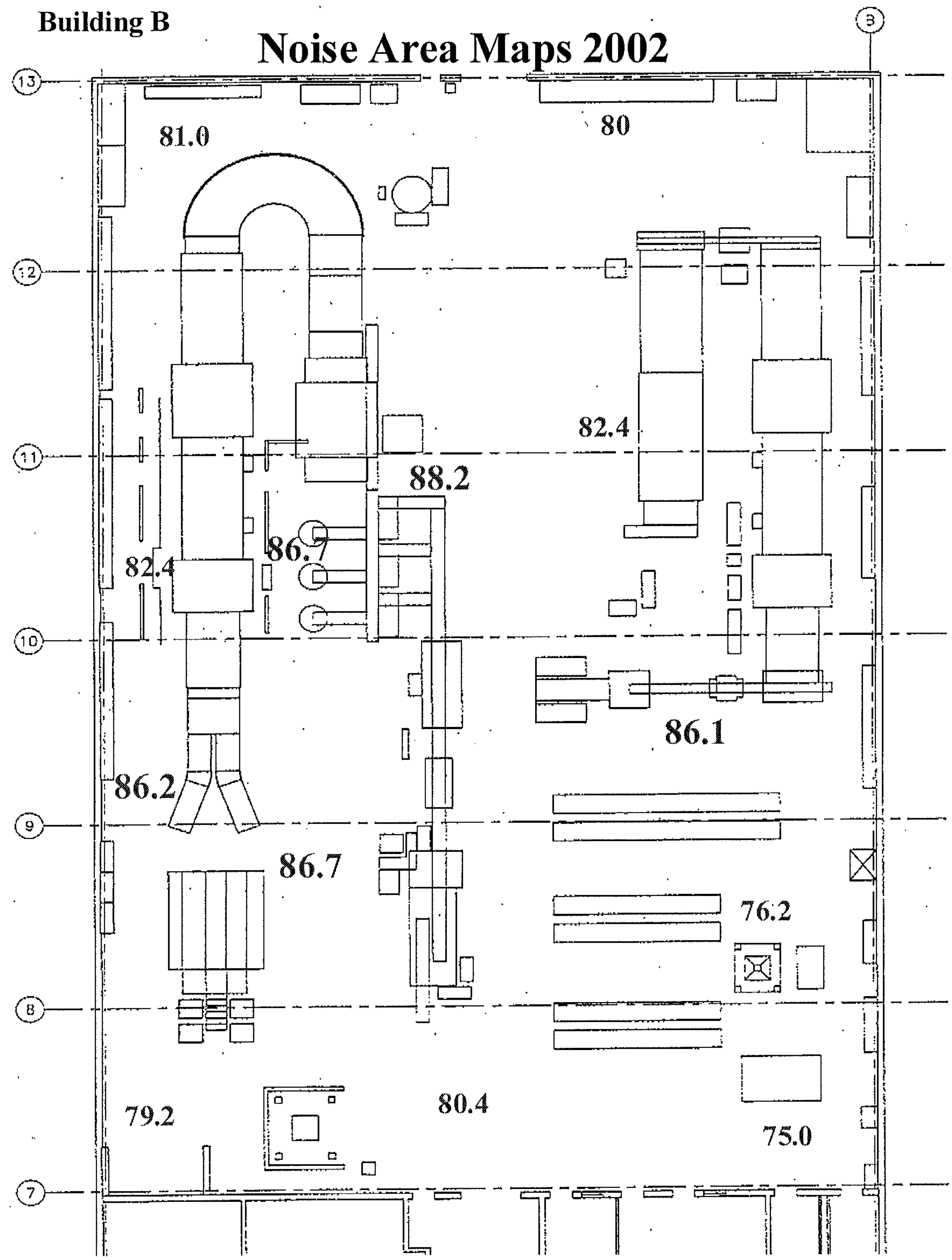
A-weighted sound level, L (decibel)	Reference duration, T (hour)
80	32
81	27.9
82	24.3
83	21.1
84	18.4
85	16
86	13.9
87	12.1
88	10.6
89	9.2
90	8
91	7.0
92	6.1
93	5.3
94	4.6
95	4
96	3.5
97	3.0
98	2.6
99	2.3
100	2
101	1.7
102	1.5
103	1.3
104	1.1
105	1
106	0.87
107	0.76
108	0.66
109	0.57
110	0.5
111	0.44
112	0.38
113	0.33
114	0.29
115	0.25
116	0.22
117	0.19
118	0.16
119	0.14
120	0.125
121	0.11
122	0.095
123	0.082
124	0.072
125	0.063
126	0.054
127	0.047
128	0.041
129	0.036
130	0.031

Appendix B: Department layout of Building B

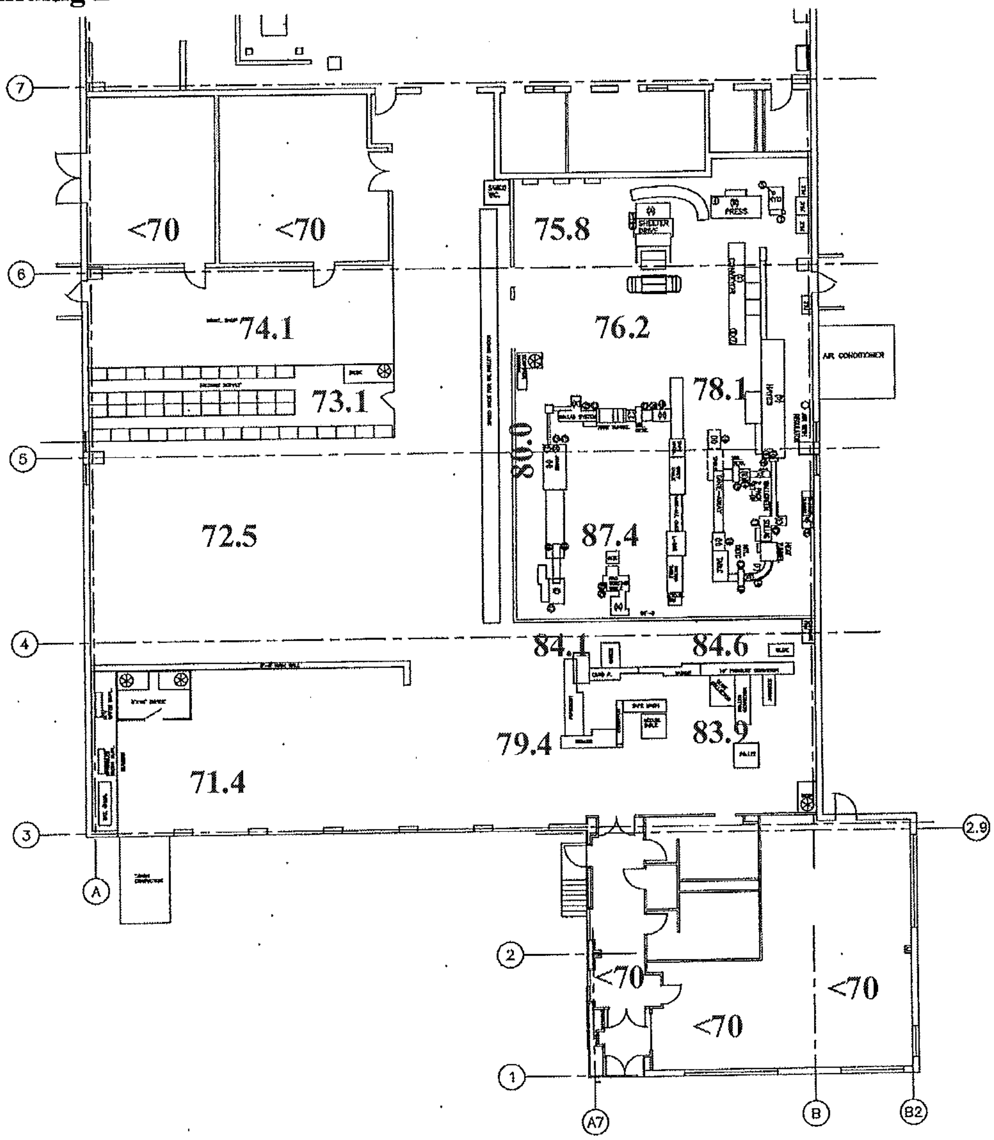




Appendix C: Building B Area Noise Maps (2002)



Building B



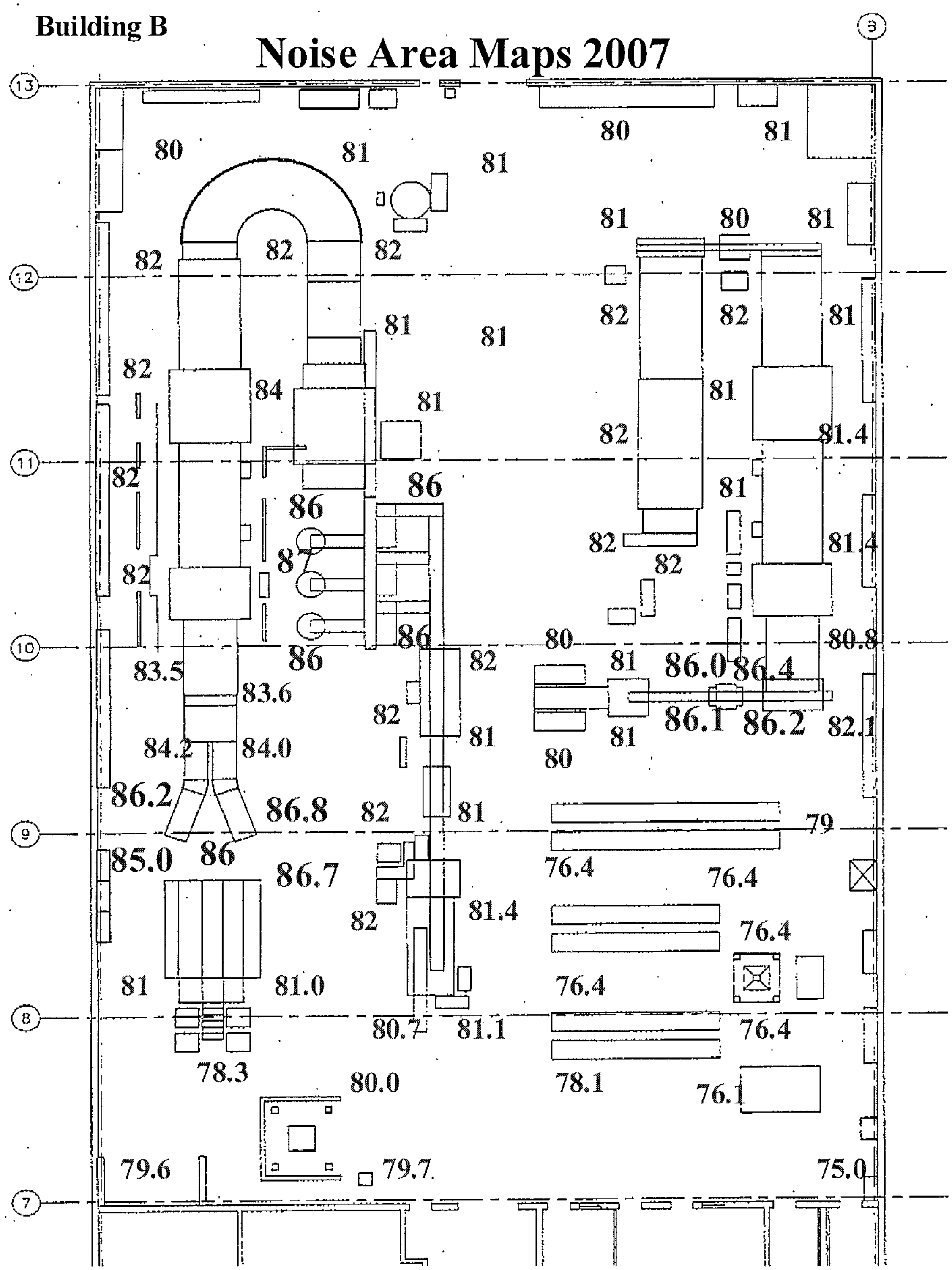
<70
<70
75.8
74.1
76.2
73.1
78.1
80.0
72.5
87.4
84.1
84.6
79.4
83.9
71.4
<70
<70
<70
AIR CONDITIONER
7
6
5
4
3
2
1
2.9
A
A7
B
B2

Appendix D: Table of Dosimetry Data for Building B

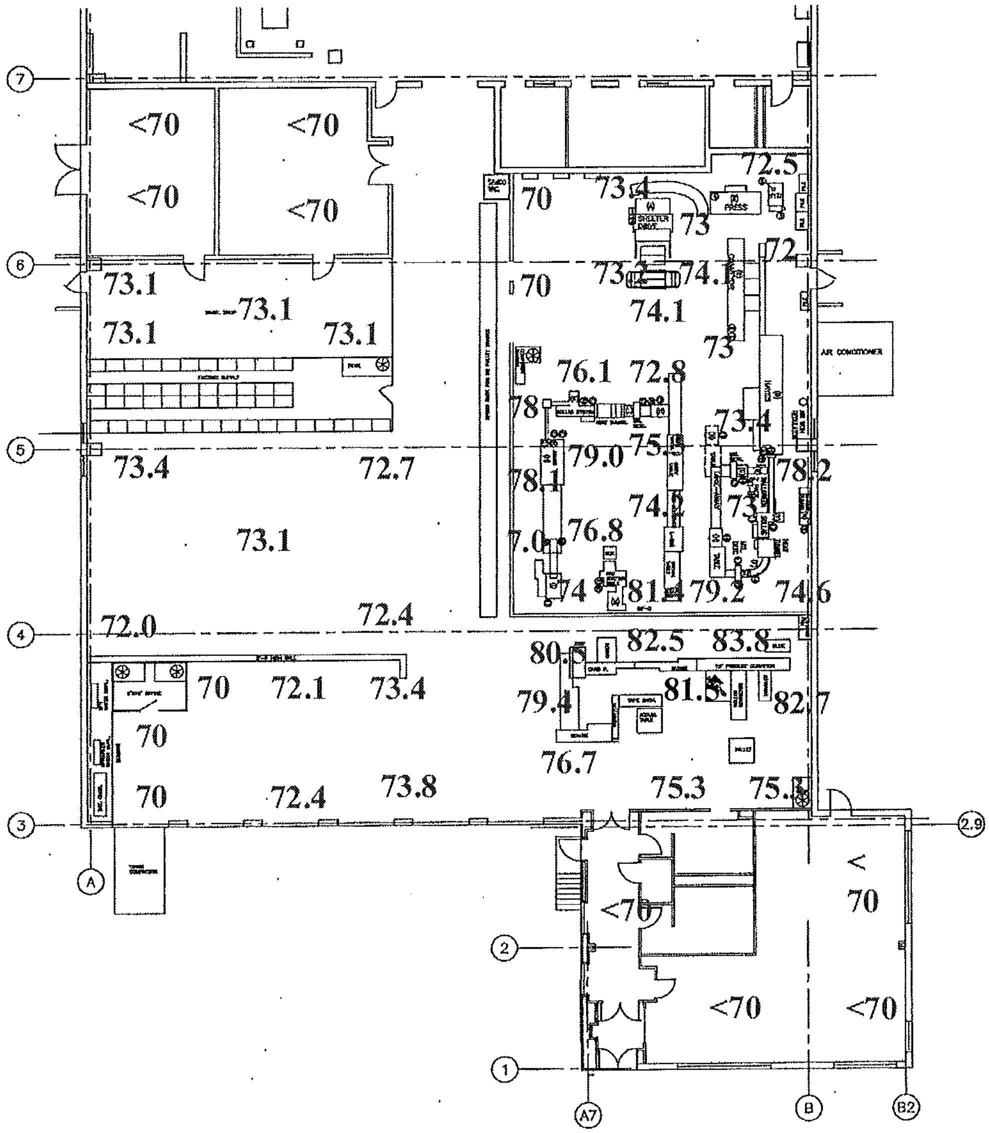
Sample		Dept.	Date	Job Title	Shift	Shift Duration	Sample time	TWA	comments
PDC-07-	2	1	1/25/07	Department Mgr.	am	8	8:06	68.5	radio on
PDC-07-	6	2	11/6/07	Operator	day	12	10:55	88.6	radio on
PDC-07-	19	2	4/9/07	Operator	pm	12	6:27	87.4	radio on
PDC-07-	15	2	2/20/07	Operator	am	12	8:11	87.1	radio on
PDC-07-	12	2	2/15/07	Operator	pm	12	9:13	86.6	radio on
PDC-07-	17	2	2/20/07	Operator	day	12	10:50	86.3	radio on
PDC-07-	8	2	2/20/07	Mix Person	pm	12	10:45	86.1	radio on
PDC-07-	9	2	2/15/07	Operator	mid	12	9:03	85.9	radio on
PDC-07-	10	2	2/16/07	Operator	am	8	9:03	84.1	radio off
PDC-07-	22	2	6/13/07	Operator	am	8	5:40	83.9	radio off
PDC-07-	24	2	7/18/07	Operator	am	12	7:00	83.8	radio off
PDC-07-	4	2	2/13/07	Process Technician	day	12	10:45	83.4	radio off
PDC-07-	11	2	2/16/07	Mix Person	am	12	6:40	82.9	radio off
PDC-07-	14	2	2/16/07	Operator	pm	12	11:53	82.9	radio off
PDC-07-	5	2	2/13/07	Operator	mid	12	10:50	82.8	radio off
PDC-07-	1	3	11/6/06	Receiving Operator	day	8	8:01	67.6	radio on
PDC-07-	42	3	5/30/07	Shipping Operator	day	8	8:00	62.1	radio off
PDC-07-	3	3	1/30/07	Receiving Operator	mid	8	7:30	60.3	radio off
PDC-07-	27	3	7/18/07	Shipping Operator	pm	8	6:16	57.0	radio off
PDC-07-	20	4	4/9/07	Maintenance Tech	pm	8	6:42	78.2	radio on
PDC-07-	28	4	9/27/07	Maintenance Tech	day	8	6:12	76.2	radio on
PDC-07-	26	4	9/27/07	Maintenance Tech	pm	8	6:18	73.3	radio on
PDC-07-	43	5	5/31/07	Operator	am	8	8:01	77.1	radio on
PDC-07-	47	5	6/4/07	Operator	am	8	8:00	76.9	radio on
PDC-07-	54	5	6/12/07	Operator	am	8	8:00	76.9	radio on
PDC-07-	23	5	11/17/07	Operator	am	8	7:00	76.9	radio on
PDC-07-	49	5	6/6/07	Operator	mid	8	8:04	76.8	radio on
PDC-07-	53	5	6/13/07	Operator	pm	8	8:00	74.9	radio off

PDC-07-	36	5	5/16/07	Operator	pm	8	7:47	73.8	radio off
PDC-07-	32	5	5/10/07	Operator	am	8	3:15	72.9	radio off
PDC-07-	44	5	5/30/07	Operator	mid	8	8:00	72.5	radio off
PDC-07-	30	6	9/27/07	Operator	am	8	10:25	88.8	radio on
PDC-07-	31	6	9/27/07	Operator	am	8	10:24	87.8	radio on
PDC-07-	18	6	2/20/07	Process Technician	pm	8	7:13	87.8	radio on
PDC-07-	29	6	7/17/07	Operator	am	8	10:23	87.8	radio on
PDC-07-	21	6	9/27/08	Operator	am	8	5:40	87.8	radio on
PDC-07-	16	6	2/20/07	Operator	am	8	11:09	87.6	radio on
PDC-07-	13	6	2/15/07	Operator	mid	8	10:03	87.1	radio on
PDC-07-	50	6	6/5/07	Operator	mid	8	8:00	84.4	radio off
PDC-07-	57	6	6/21/07	Operator	am	8	8:00	84.2	radio off
PDC-07-	39	6	5/18/07	Operator	am	8	9:00	83.9	radio off
PDC-07-	51	6	6/5/07	Operator	pm	8	8:00	83.7	radio off
PDC-07-	33	6	5/14/07	Operator	pm	8	8:00	83.2	radio off
PDC-07-	7	6	2/13/07	Operator	am	8	10:45	82.9	radio off
PDC-07-	46	6	6/1/07	Operator	am	8	8:00	82.7	radio off
PDC-07-	45	6	6/1/07	Operator	am	8	8:00	80.7	radio off
PDC-07-	37	7	5/17/07	Operator	am	8	8:00	88.1	radio on
PDC-07-	34	7	5/15/07	Operator	am	8	8:00	87.4	radio on
PDC-07-	52	7	6/8/07	Operator	am	8	8:00	87.0	radio on
PDC-07-	40	7	5/21/07	Operator	mid	8	9:00	85.3	radio on
PDC-07-	55	7	6/13/07	Operator	am	8	8:00	85.2	radio off
PDC-07-	25	7	6/13/07	Operator	am	8	7:00	85.1	radio off
PDC-07-	48	7	6/5/07	Operator	pm	8	8:00	84.7	radio off
PDC-07-	35	7	5/15/07	Operator	pm	8	7:30	84.5	radio off
PDC-07-	56	7	6/13/07	Operator	am	8	8:00	84.5	radio off
PDC-07-	41	7	5/30/07	Operator	am	8	8:00	84.4	radio off
PDC-07-	38	7	5/18/07	Operator	am	8	7:30	84.1	radio off

Appendix E: Building B Area Noise Maps (2007)



Building B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