OCCUPATIONAL NOISE EXPOSURE ASSESSMENT FOR COAL AND NATURAL GAS POWER PLANT WORKERS

A Project

Presented

to the Faculty of

California State University, Chico

In Partial Fulfillment

of the Requirement for the Degree

Master of Science

in

Environmental Science

Professional Science Master Option

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by

Sean P. Spitzer

Spring 2011

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ACKNOWLEDGMENTS

I thank Dr. John Nishio for his exceptional guidance through the duration of my enrollment in the Professional Science Masters degree program at CSU Chico. Dr. Nishio has the unique ability to treat his students as intellectual equals, which fosters an empowering and engaging learning environment. Many thanks go out to Dr. Randy Senock for his patience and willingness to provide numerous edits and input into the data analysis of the project. I also thank Dr. Karin Hoover who provided gracious and timely input into the statistical analysis portion of this project.

This project was possible due to the guidance of David Crosby, the industrial hygienist who hired and mentored me over the summer months of 2010. Thanks for all your wisdom and your willingness to help me succeed in the corporate environment. Thanks also go out to Amanda Melendez, who shared the duties of the safety internship and equally contributed to the data collection of the project.

Finally, I thank my wife Emily, who unrepentantly encourages me to strive for achievement. Her support keeps me going with one eye always pointed into the future.

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ABBREVIATIONS AND DEFINITIONS

dB (decibel) – A standard measure of sound pressure level. A measurement of zero decibels is equivalent to 0.00002 N m^{-2} in air, which corresponds to the quietest sound at 1000 Hz that is detectable by a typical young human ear (Davis, 2007). Instruments used in the project recorded sound pressure levels in decibels, abbreviated as dB.

dBA – A measurement of decibel level which is weighted to filter sound in the 20-20000 Hz frequency range; the normal range of human hearing.

Dose – A percentage of the OSHA maximum allowable noise exposure, related to a standard 8 h time-weighted average. Calculation: % Dose = $(C_1/T_1 + C_2/T_2 + C_n/T_n)$ x 100 where C is the time exposed at a particular dB level and T is the exposure time allowed at that dB level. For example, an 8 h TWA at 90 dB is equal to 100 % dose by definition. Every 5 dB over 90 dB based on an 8 h TWA doubles the 100 % dose. Inversely, every 5 dB under the 90 dB 8 h TWA results in half of the 100 % dose (Occupational Health and Safety Administration, 1991).

HPD (Hearing Protection Devices) – Personal protective equipment designed to reduce sound pressure levels received by the inner ear. These can be ear plugs, canal caps, or ear muffs; each having its own standard dB reduction rating.

L-Average – The average dB level recorded measurement within a specified timeframe. For run times of exactly 8 h, the L-Average and the TWA are equal.

ABBREVIATIONS AND DEFINITIONS

MSDS – Material Safety Data Sheet – A document that chemical manufacturers provide for their chemical products. The MSDS lists comprehensive knowledge about the chemical and its hazards.

Peak Noise – A measurement (in dBA) of the maximum recorded sound level. OSHA requires PPE to be provided to employees if noise at any duration exceeds 115 dB.

PEL – Permissable Exposure Limit, the maximum OSHA allowed worker exposure set at 90 dB over an 8 h TWA. Employer-provided hearing protection must attenuate employee exposure to at least this level.

OSHA – Occupational Safety and Health Administration (OSHA), a branch of the U.S. Department of Labor. OSHA is the agency in charge of worker safety regulation enforcement in the United States.

SCBA – Self Contained Breathing Apparatus, a respirator which is supplied by a tank of compressed air for breathing during hazardous air quality conditions.

TWA – The Time Weighted Average, measured in dBA, of sound sampled over a typical work shift. An 8 h TWA is equal to the measured dB level average over an 8 h period. For run times of exactly 8 h, the L-Average and the TWA are equal. Calculation: TWA = 16.61 Log_{10} (DOSE/100) + 90 (Occupational Health and Safety Administration, 1991).

ABSTRACT

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Power generating facilities continuously expose many workers to high noise environments. Company-sponsored hearing conservation programs are put into effect in order to minimize detrimental noise exposure to plant workers. As part of the program implemented at a western utility company, 67 employees of various job descriptions at eight different power-generating facilities were measured for noise exposure using a standard 8 hour time-weighted average. In addition, a total of 316 area noise samples were recorded at locations around the various facilities. The measurements were taken over the summer months of 2010. Approximately 6 % of workers received noise exposures that exceeded the Occupational Health & Safety Administration's permissible exposure limit. Maintenance personnel received the highest mean time-weighted average

noise exposure (78.3±5.9 decibels, n = 26). While coal plants measured significantly lower mean area noise levels (80.6±8.9 decibels, n = 2) compared to gas plants (83.4±10.2 decibels, n = 6), workers at coal plants measured significantly higher mean time-weighted average noise exposures (77.8±12.3 decibels, n = 19) than workers at gas plants (69.0±10.0 decibels, n = 48).

CHAPTER I

INTRODUCTION

Economic Impacts

Noise exposure in the occupational setting is becoming an increasingly significant health and safety issue. An estimated 30 million U.S. workers are exposed to hazardous noise levels at the workplace, with compensation settlements estimated to be $242.2 million per year in disability alone (National Institutes for Occupational Safety and Health, 2001). Although hearing loss is irreversible, treatment in the form of hearing aids is available at a substantial cost. Hearing aids can be purchased for an average price of $1986 as of 2007 (Johnson, 2008). Additionally, there is a cost of $300 per year for replacement batteries (National Institutes for Occupational Safety and Health, 2001). Noise, in addition to causing hearing loss, has also been implicated in detrimental impact on human physiological and psychological systems including a multitude of bodily stress responses (Bronzaft, 1996).The liability and rising costs associated with occupational noise has placed increased pressure on numerous industries to alleviate the problem of worker exposure.

Fortunately, hearing loss from occupational noise exposure is 100 % preventable through various control measures. Noise can be simply eliminated from its source through the use of engineering controls. Examples include intrinsically low-noise machine design, as well as containment walls surrounding high-noise machinery. Noise elimination is the preferred and most effective method, although there are many situations in which engineering controls are impractical as they relate to cost and ease of implementation. Worker education is another effective means of mitigating noise exposure, as certain operational procedures can be performed by workers to reduce their overall exposure. Examples include shutting down certain pieces of equipment before entering specific high noise areas in order to perform routine maintenance. The most common and often sole practice of hearing protection is the use of personal hearing protection devices (Tak et al., 2009). Hearing protection devices (HPD's) worn by the workers can provide limited yet vital protection from hazardous noise.

Health Impacts

Hazardous industrial noise can be defined as sound that is superfluous and detrimental to human health. As objects in the environment move, they produce vibrations that have a specific amplitude and frequency often called a sound wave. The human ear is capable of perceiving sound waves in the range of 20 to 20,000 Hz, or vibrations per second (Davis and Murphy, 2007). It does so by using the outer ear to funnel sound waves into the ear canal where three small bones, the ossicles (see Figure 1), are vibrated by the energy of the wave (Evans-Martin, 2005). As the ossicles vibrate, they transmit energy from the air into a liquid medium within the inner ear (Davis and Murphy, 2007). The liquid medium surrounds the cochlea, a snail-like coiled structure that contains numerous hair cells on its lower membrane surface (Evans-Martin, 2005). As the fluid surrounding the cochlea is set into motion by the ossicles, the hair cells actively transform the energy into electro-chemical signals that are sent to the brain via

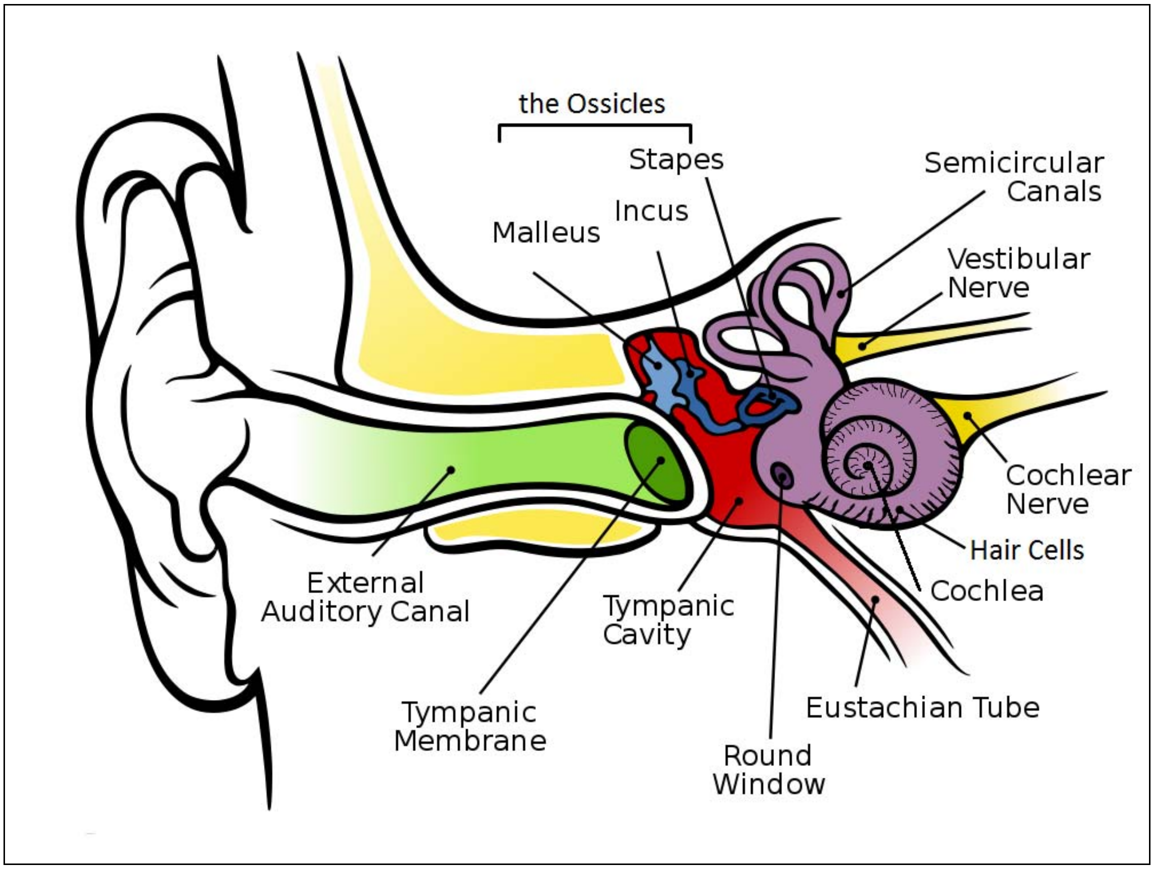

Figure 1. Illustration of the human ear and its parts.

Source: Chittka, L., 2005, Perception space, the final frontier: PLoS Biology, v.3, p. 564-568. Reprinted with Permission.

the acoustical nerve. Each hair cell is responsible for a particular place on the lower cochlear membrane, and each place elicits a particular audible frequency (Davis and Murphy, 2007). Because the membrane is narrower at the base (nearest to the oval window) of the cochlea, and broadens towards the center of the spiral, the frequency of sound waves decreases towards the apex (Faller et al., 2004). High noise levels that damage hair cells will first cause damage to the cells at the base of the lower cochlear membrane, so hearing loss of higher frequency sounds occurs first.

Hearing loss can be separated into two types of deafness: conductive and sensorineural. Conductive deafness occurs when the cochlea is impeded from receiving sound waves due to a mechanical impediment. There are many causes of conductive deafness. Examples include blockage by excessive earwax or a torn drum. The most common cause of conductive hearing loss, called otosclerosis, results when the stapes becomes fixed as to halt transmission of sound vibrations (Faller et al., 2004). Sensorineural, or inner ear deafness, is the result of degenerated neurons in the inner ear that can be caused by occupational noise exposure (Evans-Martin, 2005). Hearing loss is a compound factor of both the level and duration of noise to which a worker is exposed (General Electric Company, 2005). Even though humans are born with approximately 16,000 hair cells, up to 50 % of these cells can become damaged or destroyed before any measureable hearing loss is detected (Daniel, 2007). Because many workers are unaware of any impending hearing damage, it is important for companies to monitor their employees routinely for signs of hearing loss.

Regulatory Impacts

Regulatory limits have been placed on permissible sound level exposures in the workplace. The limits are expressed in units of decibels, the most common measurement of sound, abbreviated as dB. Decibel measurements are a ratio of a reference sound pressure level to a reference velocity. Because the range of sound which causes the human auditory response is extremely large, decibels are recorded on a logarithmic scale. For example, a decibel measurement at 90 dB (running the garbage disposal) is not three times as loud as a measurement at 30 dB (a whisper), but rather

$1x10^6$, or one million times louder (Bronzaft, 1996). The threshold of pain lies in the range of 130 to 140 dB, although sound levels this high are not a requisite for the occurrence of hearing damage (Davis and Murphy, 2007).

The Occupational Health and Safety Administration (OSHA) enforces the title 29 of the Code of Federal Regulations upon businesses operating in the U.S. According to CFR 29 1910.95, the guidelines for occupational noise exposure, workers exposed to sound exceeding levels listed in Table 1 will be provided with personal protective

TABLE 1. OSHA PERMISSIBLE NOISE EXPOSURE LEVELS

Permissible Noise Exposures	
Duration per day, (hours)	Sound level dBA slow response
8	90
6	92
4	95
3	97
2	100
1.5	102
1	105
0.5	110
.25 or less	115

Source: Occupational Safety and Health Administration, 1991, Occupational noise exposure (1910.95(b)(2)): http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=9735 (September 2010).

equipment when engineering controls fail to reduce excessive levels (Occupational Health and Safety Administration, 1991). In addition to providing personal HPD's, OSHA regulations require employers to administer a hearing conservation program to employees who are subjected to an 8-h time-weighted average of 85 dBA or greater, where dBA is a measurement of decibels with an "A" weighting value specific to the range of human hearing. The hearing conservation program consists of monitoring employees with calibrated instruments and recording sound pressure measurements, notifying employees of their results, and an annual audiometric test which is compared to baseline data (Occupational Health and Safety Administration, 1991). The present study focused on the occupational noise monitoring of work areas and employee exposure at specific coal and natural gas power plants.

Purpose

The purpose of the project was to provide justification of the ongoing hearing conservation program for the employees of power plants operated by a western utility company. Such a program is required by federal regulations, at significant cost to the company, when workers are subjected to high noise environments.

Scope

The project details the results of a 12-week paid summer internship with a western utility company, working in the Health & Safety Department under the direction of the Industrial Hygienist. A summary of additional internship work performed, that was not directly related to scientific endeavors, is included at the end of the report in order to inform potential interns. The focus of the material presented is centered on obtaining area noise surveys of eight power plants, as well as personal noise dosimetry data from employees working at the facilities. The results of the studies are intended to be informational to utility company management, OSHA enforcement, and those interested in the field of industrial hygiene.

Significance

The project presents new comparisons between the relationship of area noise data and employee dosimetry data within power plants. The relationship between natural gas and coal plants is also analyzed in terms of area noise levels and employee exposure. The data collection and analyses provide revelations pertaining to differences in plant design, plant technology, and the safety culture of plant workers. The specific analyses performed may assist in the development of engineering and administrative controls designed to reduce employee noise exposure.

Limitations

The main limitations in the project included timing, owing to the short-term nature of the internship, as well as equipment availability. While data was collected at each facility over a one-week period, the number of dosimeters was naturally limited and therefore employee dosimetry was only measured once per employee in order to get the widest selection of possible exposures across an individual facility. Due to normal variances in work load, plant operational load, and specific job task, it is possible that some employees would produce significantly different dosimetry results if repeated measurements were made over a longer period of time. Some employees were seen to jokingly shout into the microphones, which could contribute to inaccurate data. Furthermore, some employees reported losing the windscreen for unknown periods of time on the personal dosimeters. These conditions can result in falsely high recorded peak noise levels and possibly elevated dose and TWA levels.

Making accurate conclusions based on the comparisons of employee dosimetry data and area noise data between plants is complicated for a number of reasons. There are considerable differences between plants, in both technology used as well as overall plant design. Coal plants have significantly more equipment in operation than gas plants, such as coal yard equipment, coal conveyer belts, and coal sulfur-reducing equipment. Even some common types of equipment in operation at different plants vary by age as well as manufacturer, leading to inconsistent standards of noise exposure. Determining a specific target for engineering controls across all plants using this data may therefore not be the best approach. A carefully constructed experiment that targets specific equipment and work processes at the plant-specific level is therefore a better approach towards developing effective engineering controls towards noise reduction.

The employee noise dosimetry data collection and the area noise surveys were not the only parts of the hearing conservation program. The annual audiogram test portion of the hearing conservation program was performed by a contracted licensed audiologist, and examination results are not included in the scope of the project. While the annual audiogram data would be valuable in determining correlations of hearing loss and workplace exposure, the information is considered as confidential medical records. The confidentiality of individuals has been maintained in the reproduction of personal dosimetry data in this report.

CHAPTER II

LITERATURE REVIEW

Occupational noise exposure is a subject of much research in the U.S. One recent study has shown that nearly one in six U.S. workers is exposed to high levels of workplace noise, and that one in three of those workers report not using HPD's (Tak et al., 2009). Another study finds that are exposed to occupational noise to a larger extent than females, which puts them at higher risk. A lack of prevention, the authors conclude, is the major cause of occupational noise induced hearing loss (Nelson et al., 2005). These findings suggest continued data collection and education are needed in industries that expose employees to high noise working conditions.

A 1998 study of construction workers in the state of Washington found that approximately 40 % of recorded worker TWA's exceeded the 85 dBA OSHA action level for hearing conservation programs, while 13 % of construction workers exceeded the PEL of 90 dBA. The study showed that differences in worker trade had no significant effect on variances in the levels of noise exposure for the trades analyzed (Neitzel et al., 1999).

The potential for industrial noise exposure is exemplified by employees at power plants. While there are many trades at work within the facilities, power plant operators alone constituted over 35,000 U.S. jobs in 2008 (U.S. Bureau of Labor Statistics, 2009).The very nature of power plant operations requires large amounts of mechanical power, culminating in a high noise environment. According to a 2005publication from General Electric, the two major factors of worker exposure to high noise levels of power generation equipment are the dB level and the duration of exposure. The report also noted that area noise level is the combined effect of noise radiated by all sources, and that buildings containing sound energy result in a buildup of reverberant noise (General Electric Company, 2005).

An example of reverberant noise shows that for two pieces of equipment 2 meters apart and operating at 80 dBA each, the sound level measured 1 meter in between them will be 83 dBA (General Electric Company, 2005). The measurement can be explained by the physical laws of sound pressure levels, given by the equation,

$$\mathrm{SPL_T} = 10 \times \mathrm{Log} \sum_{i=1}^{n} 10^{\left(\frac{SPL_i}{10}\right)}$$

where SPL_T is the total sound pressure level and SPL_i is the i^{th} sound pressure level to be summed (John Hopkins University, 2006). Therefore, even when equipment operation levels do not exceed 80 dBA, the combined effects of multiple units in operation and reverberation buildup can increase measured sound levels over 85 dBA. While the General Electric report contained detailed information on sound collection techniques and equipment operational levels, it failed to provide any employee dosimetry data.

A 1999 study of coal plant workers in Colorado and Texas found 21.7 % of operators, 30.6 % of maintenance, and 3.2 % of plant support employees exceeded the OSHA 50 % dose criteria. The study suggests that plant operations and maintenance personnel received a higher proportion of noise exposure compared to other job classes (Woods, 2001).

While the previous works of occupational noise studies contained many design aspects similar to the project presented here, many failed to provide area noise surveys for the work sites. A more thorough noise data set, complete with employee dosimetry and area noise surveys, will allow comparisons between overall area sound levels and employee exposure. The relationship between the two data sets will allow better assessment of which areas are in need of better engineering controls, as well as the workers at highest risk. The present project attempted to compare data for coal and gas power plant workers, and add to the body of knowledge to be used specifically for management of power plant employees in worker safety education.

CHAPTER III

METHODOLOGY

Noise sampling was performed at specified facilities, that included 2 coal fired power plants and 6 natural gas burning plants. Plant name and testing dates are shown in Table 2. Natural gas fired power plants are given a prefix with the letter G, while coal

TABLE 2. NAMES, SAMPLING DATES, AND TYPES OF THE DIFFERENT PLANTS SUBJECTED TO NOISE MONITORING

Plant	Sampling Date	Type	Plant Size
Plant C1	6/08/2010-6/10/2010	Coal	522 MW
Plant G1	6/15/2010-6/16/2010	Natural Gas	530 MW
Plant C2	6/21/2010-6/24/2010	Coal	557 MW
Plant G2	6/28/2010-6/29/2010	Natural Gas	520 MW
Plant G3	6/30/2010-7/01/2010	Natural Gas	1102 MW
Plant G4	7/06/2010-7/08/2010	Natural Gas	226 MW
Plant G5	7/12/2010-7/13/2010	Natural Gas	1041 MW
Plant G6	8/03/2010-8/04/2010	Natural Gas	1102 MW

plants are denoted with the letter C. All measurements were taken during the months of June, July, and August, 2010. All values are listed as mean decibel level in units of dBA, ± the standard deviation, and sample size (*n*).

Sound level data for the area noise surveys were measured using a **Quest 2900** (Type 2) sound level meter (see Figure 2), which is manufactured to ANSI and IEC requirements. The sound level data for employee monitoring was collected using **Quest Noise Pro** dosimeters (see Figure 3). OSHA requirements CFR 29 1910.95(h)(5)(ii) and

Figure 2. Quest 2900 Sound Level Meter.

CFR 29 1910.95(h)(5)(iii) mandate periodic exhaustive calibration of audiometric instruments. Units were calibrated by the manufacturer in March, 2010 in order to ensure compliance.

After verification of factory calibration, the specific settings of the units were then configured for our purposes as follows. The response time of the unit was set to “slow”, which allows the meter to discard sudden bursts of noise fluctuations (Quest Technologies, 2010). In this regard, taking noise measurements is much less problematic as the instantaneous noise levels measured are spread over a longer period of time. The instruments were given a weighting value of “A”, which is a specific filter applied by the instruments to measure frequencies between 20 Hz and 20 kHz, the range of human hearing. The measurements on the instruments are then recorded in units reported as

Figure 3. Quest Noise Pro Noise Dosimeter.

Source: Quest Technologies, 2011, Quest Noise Pro Noise Dosimeter: Oconomowoc, Wisconsin, Quest Technologies. Reprinted with permission.

dBA, meaning decibels with an “A” weighting value (Quest Technologies, 2010). Prior to use in the field, each instrument was calibrated at the start of the day using a Quest QC-20 sound calibrator (see Figure 4) per OSHA requirement CFR 29 1910.95(h)(5)(i). The calibration was performed by inserting the microphone of the sound level meters into the calibrator, which emits a standard frequency of 114 dB at 1000 Hz. The sound level meters reported the measured sound level up to 1/10 of a decibel, and the calibration data was recorded. After the noise data was received for each day, the units were subjected to

Figure 4. Quest QC-20 Sound Calibrator.

Source: Quest Technologies, 2011, Quest QC-20 Sound Calibrator: Oconomowoc, Wisconsin, Quest Technologies. Reprinted with permission.

a post calibration. OSHA requirement CFR 29 1910.95(h)(5)(i) specifies that field calibrations whose deviations exceed 10 dB require an acoustic calibration prior to use (OSHA, 1991). At no time during the project did any of the instruments measure a ± 1.0 dBA deviation from the calibrated value, which satisfied OSHA requirements.

Employee Dosimetery

The Quest Noise Pro personal noise dosimeters were issued to a variety of power plant employees. A total of 67 employees were subjected to noise monitoring over the study period. The study organizes employees from different facilities into one of six job categories. Specifically, the targeted groups were plant operators, control room operators, maintenance, warehouse personnel, coal yard operators, and electricians. Plant operators are assigned to general plant inspections, while control room operators work solely inside the control room of the plant. The values collected for control room operators reflect a certain baseline in decibel levels, as the rooms typically are sheltered from machinery and are similar in sound levels to a normal office environment. Only two plants sampled were coal-fired plants; therefore, coal yard operators were only measured at two facilities. Warehouse operators were only measured at 4 facilities due to a lack of availability during testing days.

The most commonly reported job description falls into the maintenance category, which includes mechanics, machinists, welders, and plant technicians. At least one individual in the categories of maintenance, assistant operator, and control room operator from each plant provided data. The Plants G2 and G3 were the only two facilities that had no electrical workers available during the time of study for noise dosimetry.

Each employee was given a personal dosimeter at the beginning of their shift, typically around 6:00 am. The units were set to run, and employees were instructed not to tamper with any of the control features. The microphone was affixed to the shirt collar pointed towards the ear to record sound levels perceived by the individual. The dosimeter microphones were also affixed with a windscreen to alleviate any peak noise associated with wind. The dosimeters were run for approximately 8 h while the employees carried out their normal work responsibilities. When the units were collected, employees filled out a short questionnaire to document any work performed and machinery operated throughout the day. The results of the dosimeter measurements, including L-Average, TWA, Dose, peak level, and run time were recorded on the questionnaires. Because of the mathematical relationship between the recorded parameters, the TWA is chosen as the representative metric with which to report and analyze the data set.

Area Noise

A total of 316 area noise measurements were made at the eight different power plants. The sound level meter was taken to multiple locations throughout each power generating facility for data collection, both inside buildings and out on plant grounds. A windscreen was placed on top of the unit in order to protect the microphone from debris, as well as eliminate any false noise peaks associated with windy areas. Data points were recorded while approaching a target area with the unit held out at arm’s length. Areas targeted for data collection included suspected high noise areas near loud equipment, as well as high worker traffic areas. In addition to compiling sound level data for the specific plants, the power output of the plant at the time of data collection was recorded.

Plot plans of the power plants were provided by the company for each facility, and areas sampled for noise were marked with a sequential number on the plot plans. A separate sheet recorded the specific dBA value of the reading for each numbered area on the plot plan, as well as any other comments associated with the reading. The records for each plant can be found in the appendix section of the report; however, the plot plans have been omitted to maintain confidentiality of the utility company.

CHAPTER IV

RESULTS

Employee Dosimetry

Four employees (approximately 6 %) exceeded the OSHA action level of an 8 h TWA in excess of 85 dBA. Of the four employees, two were in the maintenance category and two in the electrical workers category. Three of the four employees were workers at coal-fired power plants. The highest recorded value, 93.8 dBA after 8 h and 13 min run time, came from one of the employees working at the C1 power plant. The employee's noise exposure exceeded the OSHA PEL of 90 dBA over an 8 h TWA. The calculated dose for the employee's exposure was 169.1 %, while the peak noise level reached 112.5 dBA. The employee was classified as a worker in the maintenance category, and unfortunately, the only detail the employee disclosed about job tasks performed that day was the phrase "millwright," to be interpreted as mechanical labor.

The job category scoring the highest mean employee TWA exposure for all plants was the maintenance category (78.3±5.9 dBA, n = 26). The second highest mean employee TWA was the electrical workers category (76.6±9.0 dBA, n = 9), followed by warehouse personnel (76.2±7.4 dBA, n = 4), coal yard workers (75.2±7.7 dBA, n = 4), plant operators (69.8±3.4 dBA, n = 11), and the control room operators (55.1±9.5 dBA, n = 13) (Figure 5).

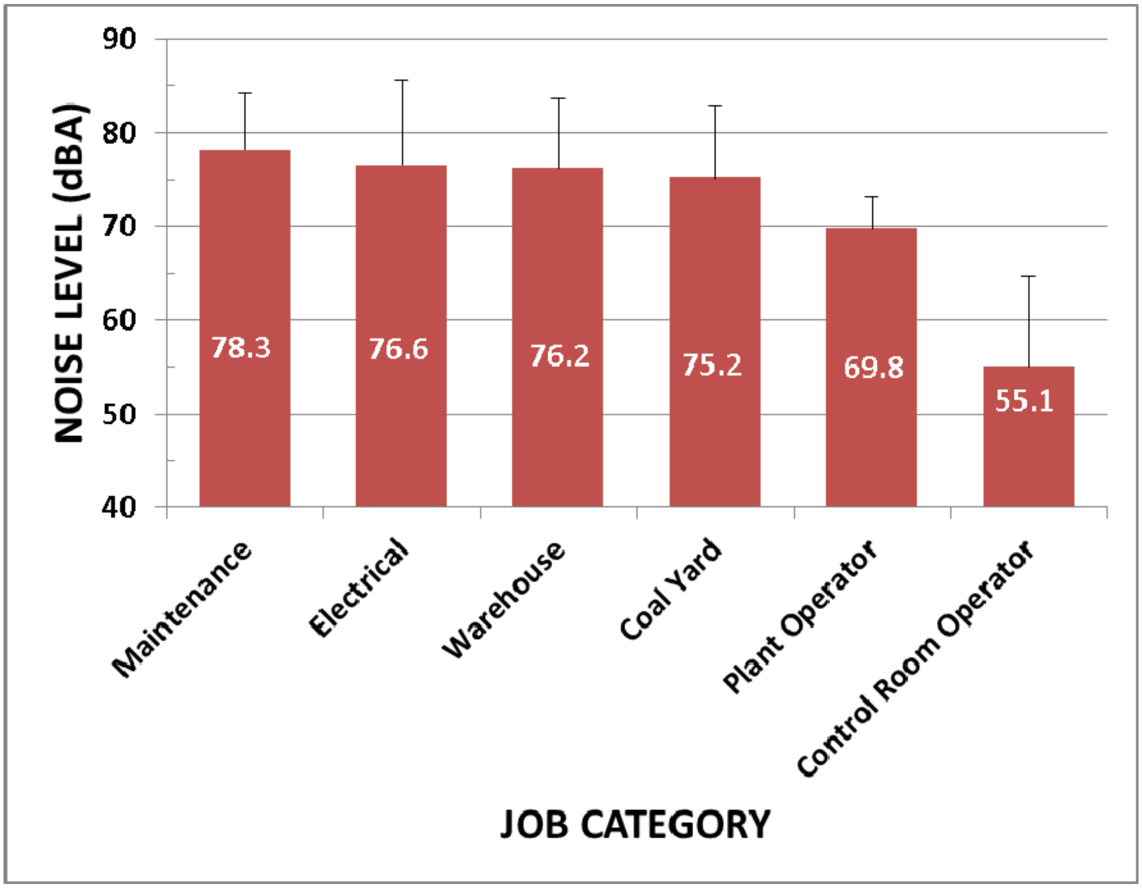

Figure 5. Mean employee TWA exposure by job category. Each bar represents pooled data from all plants. The error bar represents one standard deviation. Maintenance, *n*=26; Electrical, *n* = 9; Warehouse, *n*=4; Coal Yard, *n* = 4; Plant operator, *n*=11; Control Room Operator, *n* =13.

The C2 plant ranked highest on the overall mean employee TWA exposure for all plants (78.1d±7.0 dBA, *n*=13), followed closely by the C1 plant (77.3±20.5 dBA, *n*=6). The G5 gas plant measured the third highest mean employee TWA (72.9±8.6 dBA, *n*=8), followed by G1 (71.4±7.3 dBA, *n*=9), G3 (68.6±10.9 dBA, *n*=7), G6 (67.5±10.5 dBA, *n*=7), and equal values for the G2 and G4 gas plants (66.8±7.3 dBA, *n*=8, and 66.8±14.7 dBA, *n*=9, respectively). The C1 plant had the highest standard deviation of all plants due to its low sample size (n=6), as well as the highest and lowest employee TWA measurements for all plants (93.8 dBA and 36.5 dBA, respectively).

The TWA mean for all employees at coal plants (77.8±12.3 dBA, n=19) is higher when compared to the mean for employees of gas plants (69.0±10.0 dBA, n=48) (Figure 6). To determine the significance of the difference in means between coal and gas

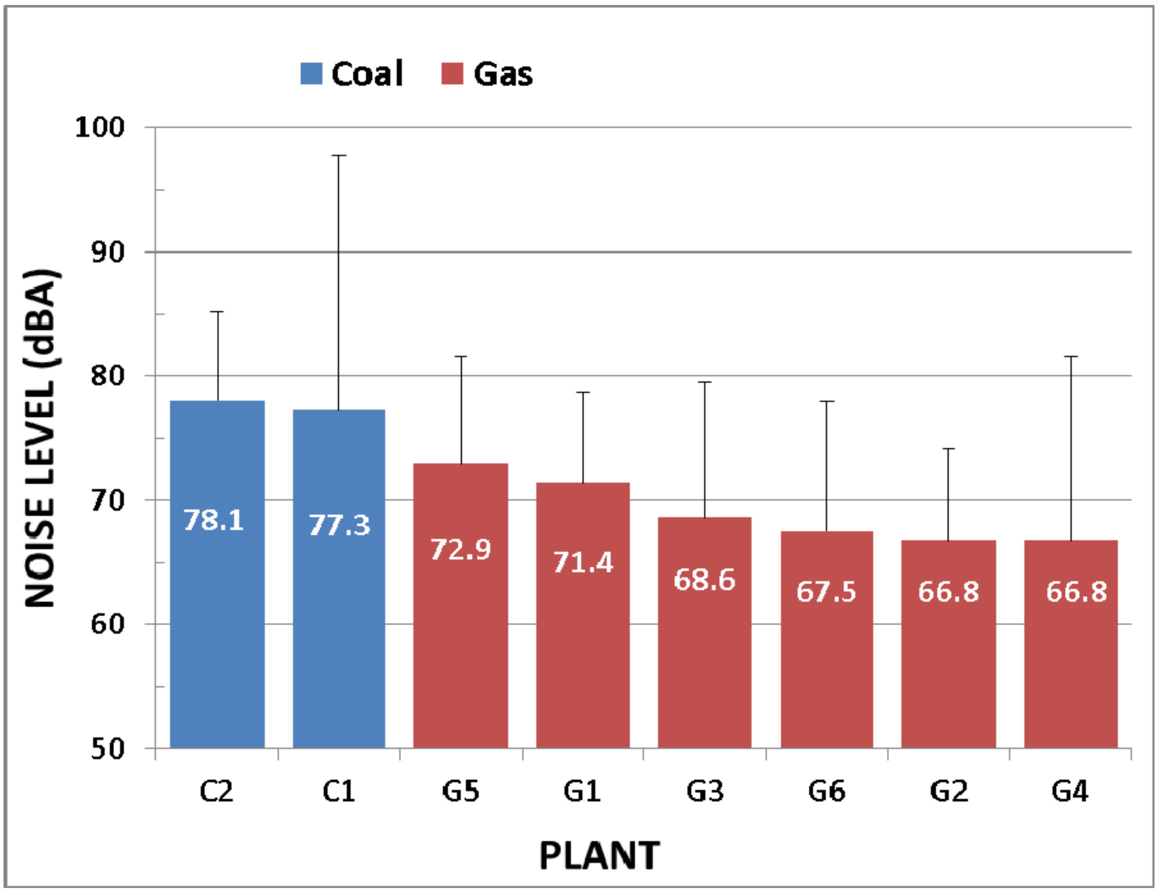

Figure 6. Mean employee TWA exposure level for all pooled job categories at each plant. The error bar represents one standard deviation. C2, *n*=13; C1, *n*=6; G5, *n*=8; G1, *n*=9; G3, *n*=7; G6, *n*=7; G2, *n*=8; G4, *n*=9.

plants, statistical analyses were performed. The data sets were tested for normality using a normal quantile plot. Because the calculated correlation coefficient (0.8525) was less than the critical value (0.9483) at the 0.05 level of significance, the data did not support the claim that the values came from a normal population. A LOG_{10} transformation of the entire data set was performed. The LOG_{10} transformed data appeared reasonably symmetrical and did not have excessive tails; therefore tests based on the assumption of normality were determined to be acceptable. A one-way ANOVA was performed on the LOG_{10} transformed data to analyze the equivalency of means between the coal and gas plant data sets. The results of the ANOVA show that the calculated F statistic (F=6.12) was larger than the critical value (F_{crit}=3.99) at the 0.05 level of significance, resulting in a rejection of the null hypothesis that the means between the two groups are equal. Overall, the TWA for all employees monitored was significantly higher at coal plants than at gas plants (Figure 7).

Area Noise

A total of 316 area noise measurements were taken spanning the eight power generating facilities. The highest recorded sound level reading was 117.0 dBA, measured at the G3 power plant. The lowest recorded value was 53.4 dBA, an indoor measurement of a mobile office space at the C1 plant. The G4 plant recorded the highest mean area noise level (85.9±15.4 dBA, n=23), followed by G5 (85.0±8.5 dBA, n=45), G3 (84.4±11.2 dBA, n=71), C2 (84.2±7.1 dBA, n=29), G2 (82.5±6.0 dBA, n=38), G6 (82.3±9.6 dBA, n=24), G1 (79.5±9.4 dBA, n=33), and the C1 plant (78.6±9.3 dBA, n=53) (Figure 8).

The mean sound level measured across all plants was 82.7±10.0 dBA (n=316), while the averaged mean of the coal plants (80.6±8.9 dBA, n=82) was lower than that of

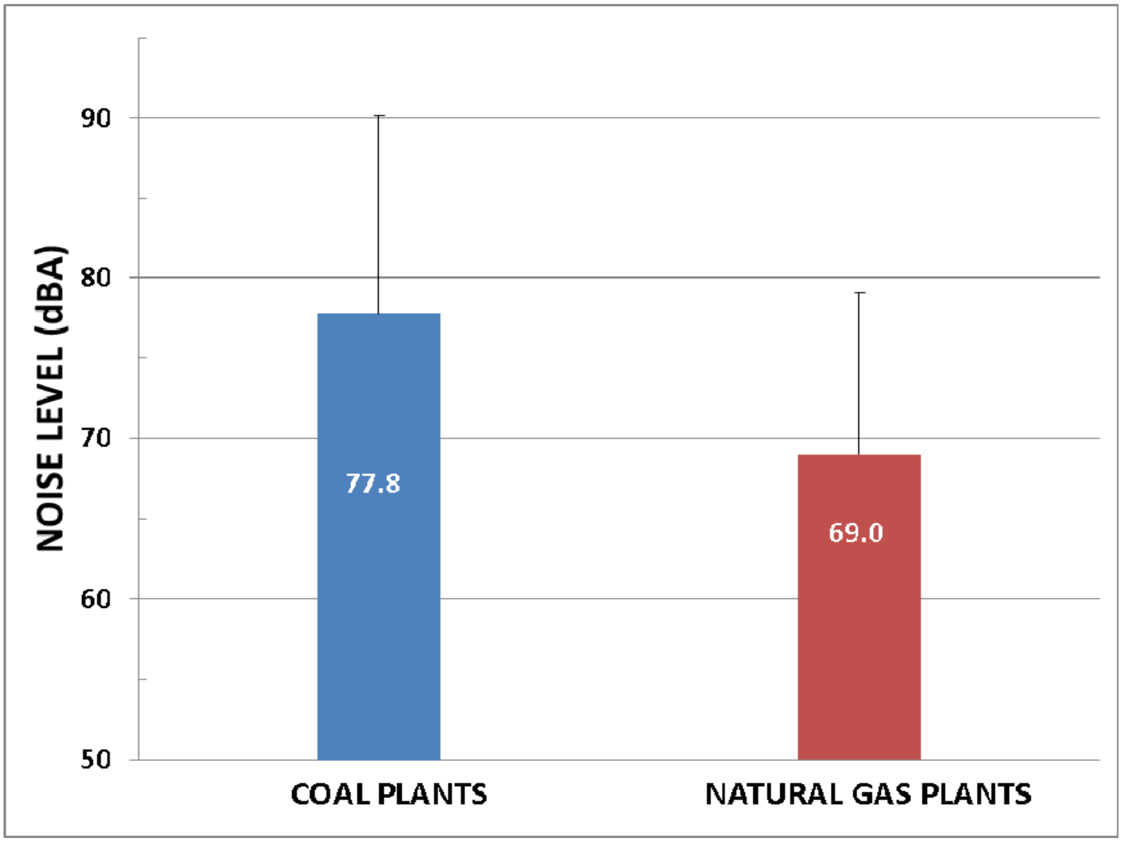

Figure 7. Mean employee TWA exposure for all coal and gas plants. Coal plants, blue; gas plants, red. The error bar represents one standard deviation. Coal Plants, *n*=19; Gas Plant, *n*=48. Statistical analysis showed a significantly higher mean TWA noise exposure level value at coal plants compared to gas plants.

the gas plants (83.4±10.2 dBA, *n*=234). The data sets were tested for normality using a normal quantile plot. Because the calculated correlation coefficient (0.9905) was less than the critical value (0.9953) at the 0.05 level of significance, the data did not support the claim that the values came from a normal population. A LOG_{10} transformation of the entire data set was performed. The LOG_{10} transformed data appeared reasonably symmetrical and did not have excessive tails; therefore, tests based on the assumption of normality were determined to be acceptable. A one-way ANOVA was performed on the LOG_{10} transformed data to analyze the equivalency of means between the coal and gas

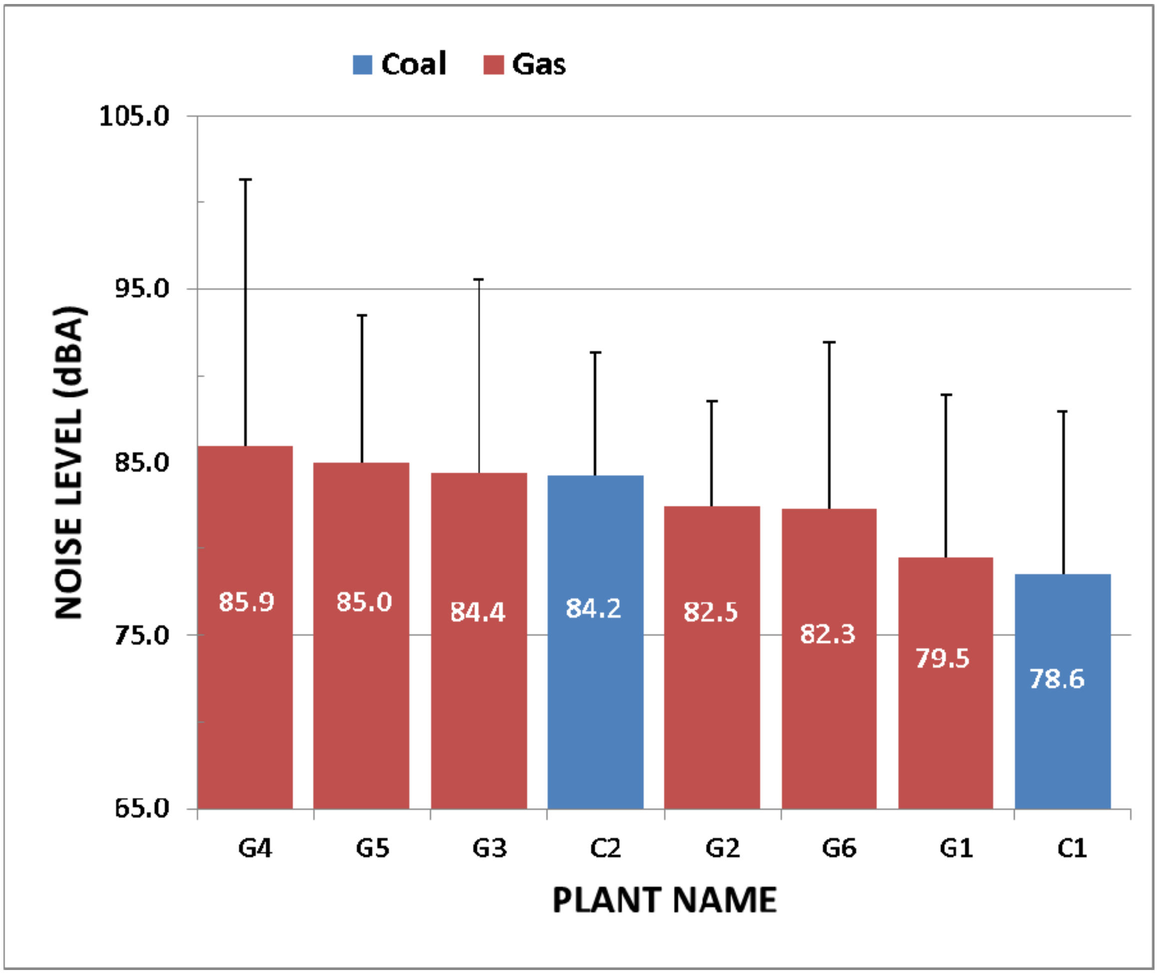

Figure 8. Mean area noise level sorted by facility. The error bar represents one standard deviation. G4, *n*=23; G5, *n*=45; G3, *n*=71; C2, *n*=29; G2, *n*=38; G6, *n*=24; G1, *n*=33; C1, *n*=53.

plant data sets. The results of the ANOVA show that the calculated F statistic (F=4.65) is greater than the critical value (F_{crit}=3.87) at the 0.05 level of significance, resulting in a rejection of the null hypothesis that the means between the two groups are equal. Therefore, the coal plants showed statistically significantly lower area noise levels on average than did the gas plants (Figure 9).

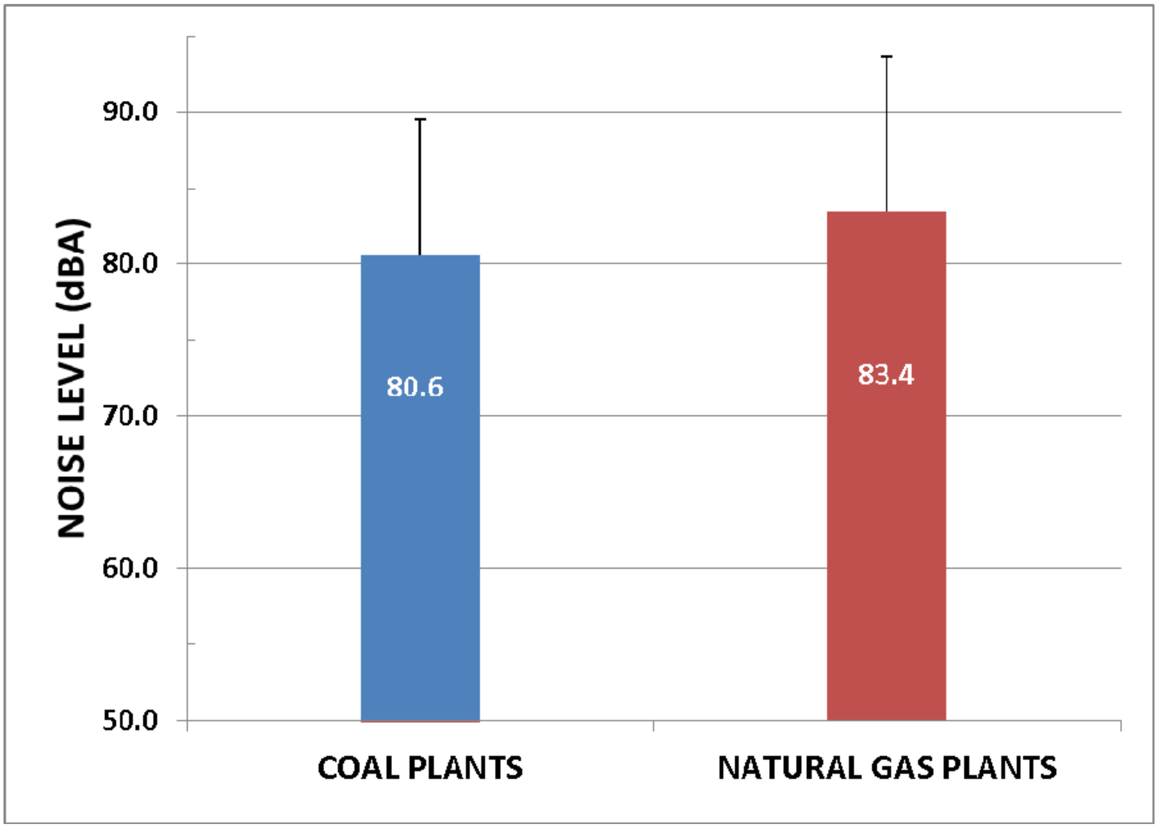

Figure 9. Area noise levels for all coal and gas plants tested. Coal plants, blue; gas plants, red. Values are mean, with error bars representing one standard deviation. Coal Plants, *n*=82; Gas Plants, *n*=234. The mean area noise level was statistically lower at coal plants compared to gas plants.

Combined Comparison of Plant Types

The C1 plant reported the lowest mean area noise value at 78.7 dBA, while it ranked the second highest in mean employee TWA dosimetry at 77.3 dBA (Figure 10). The G4 plant ranked the highest in mean area noise level at 85.9 dBA, and the lowest in mean employee TWA at 66.8 dBA.

While the coal plants had a significantly higher mean employee TWA noise exposure, the gas plants showed significantly higher mean area noise levels (Figure 11).

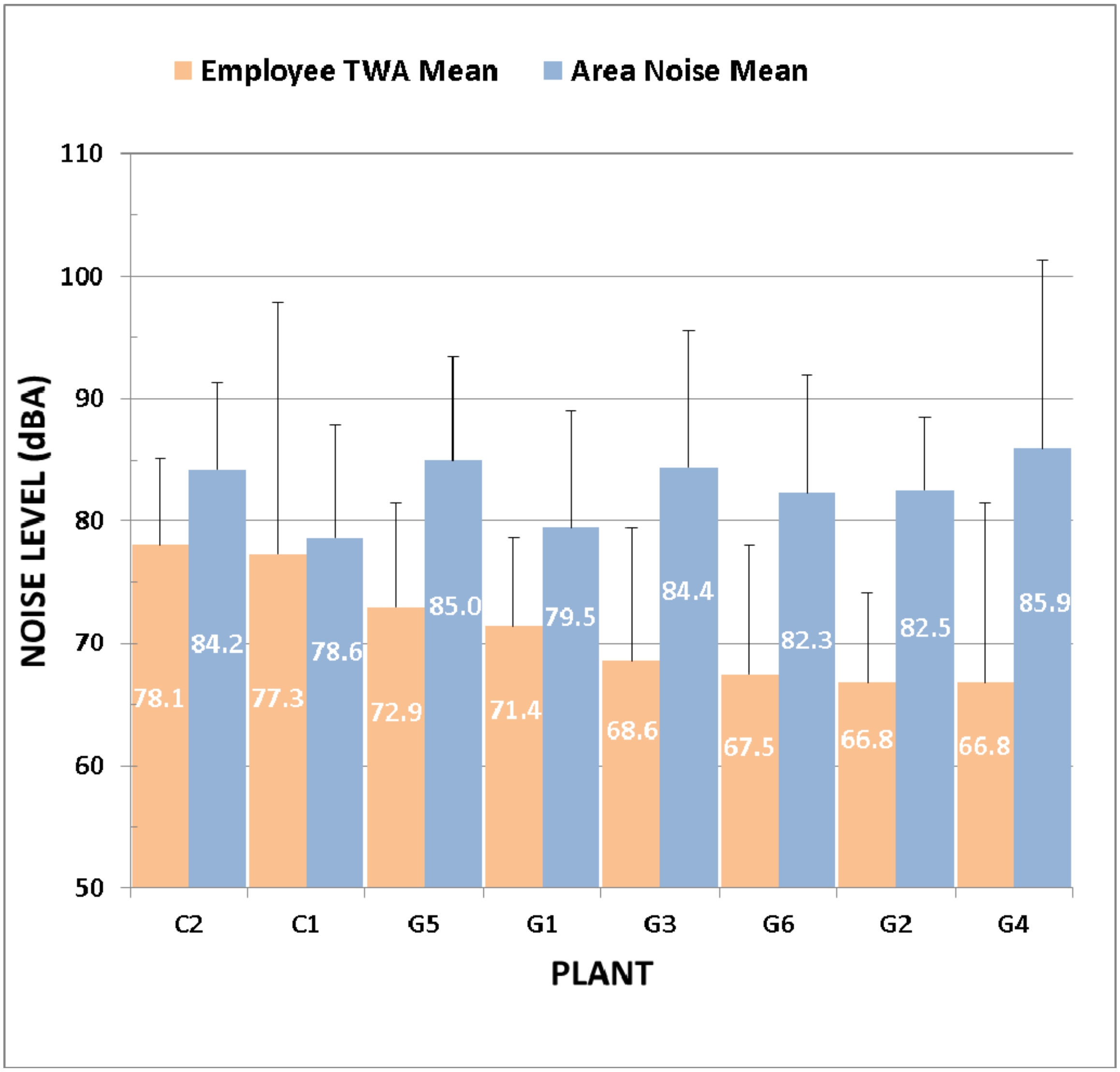

Figure 10. Comparison of mean employee TWA exposure levels to mean area noise levels for each plant. The order of the graph is displayed in descending employee TWA mean by plant. The error bar represents one standard deviation. The following lists for each plant, the sample size for each TWA mean exposure and plant area noise mean, respectively. C2: 13, 29; C1: 6, 53; G5: 8, 45; G1: 9, 33; G3: 7, 71; G6: 7, 24; G2: 8, 38; G4: 9, 23.

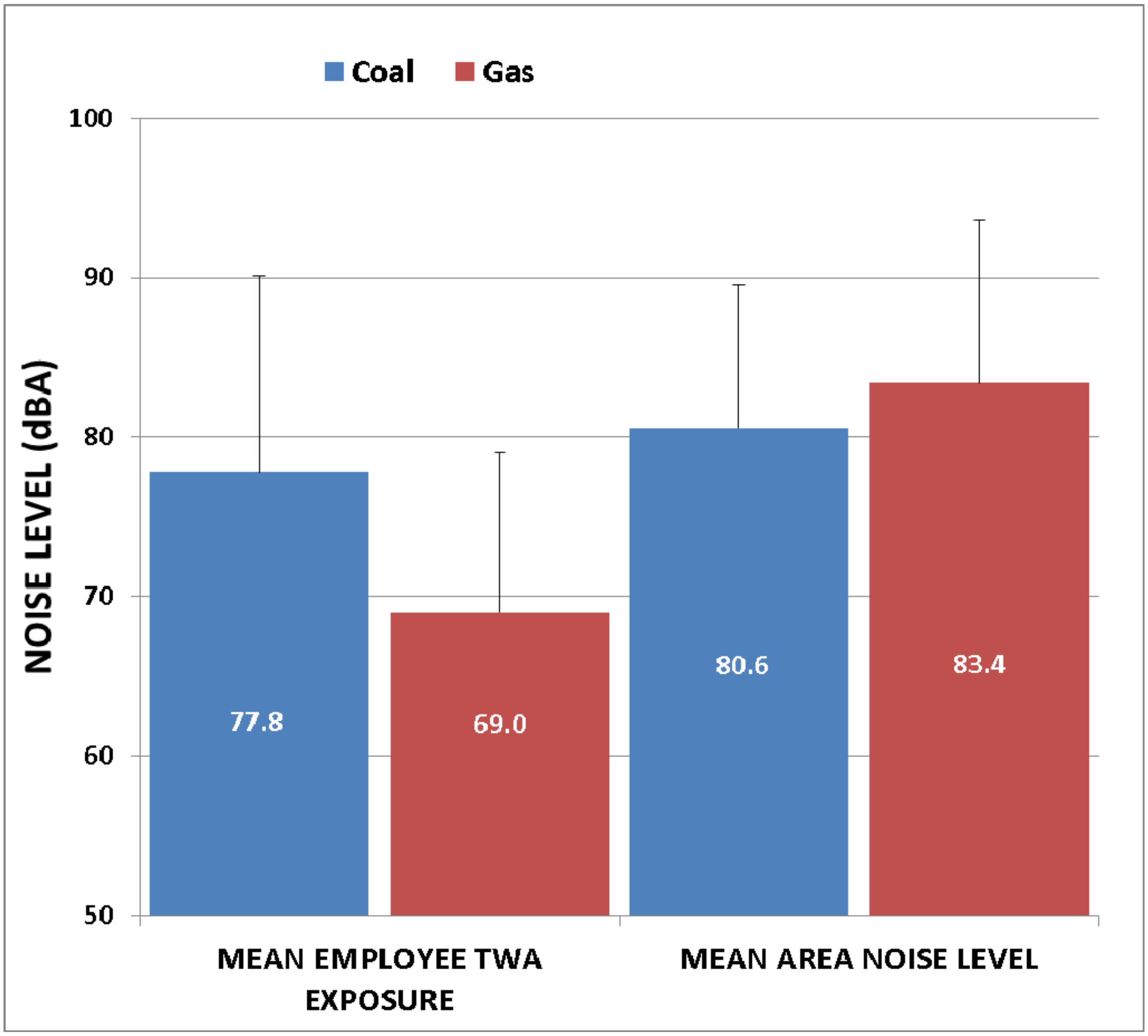

Figure 11. Mean employee TWA levels and mean area noise levels compared by plant type. The error bar represents one standard deviation. Coal Plant TWA, *n*=19; Coal Plant Area Noise, *n*=82; Natural Gas TWA, *n*=48; Natural Gas Area Noise, *n*=234.

CHAPTER V

DISCUSSION

A noise survey was conducted at power plants operated by a western utility company during the summer of 2010. During the summer months, plants typically run at high loads. The plant output, measured in megawatts, has a direct relationship on the amount of equipment in operation, which in turn affects the ambient noise of the facility. While there are numerous variables that factor into the megawatt output of each facility, the sound level data collection period coincides with a medium-to-high power production time period, and is therefore a good representation of sound levels at the facilities.

Maintenance employees were subjected to the greatest TWA workplace noise exposure regardless of plant type (Figure 5), probably because of the increased duration of noise exposure that workers receive during the performance of maintenance activities in the proximity of loud equipment. Noise abatement strategies for maintenance employees should be implemented whenever feasible. The strategies should include maximum HPD use, shutting down or reducing power on equipment near the maintenance employee's work area, or muffling equipment in their work area. Additionally, attention should be paid to the handheld equipment that the workers may employ. Noise containment or dampening structures that house certain equipment may also be considered as a means of minimizing noise exposure of maintenance employees.

Workers at coal plants were subjected to higher TWA exposure than workers at gas plants, regardless of job description (Figure 7). The most intriguing finding of the study was the discrepancy between area noise levels and worker TWA exposure levels for coal and gas plants (Figure 11). Although the coal plant employee dosimetry data showed significantly higher worker noise exposure, the coal plant area noise data showed significantly lower mean noise compared to gas plants.

The findings allow some preliminary speculation to be made. Perhaps the configuration of the coal plants places workers in high noise areas for greater durations of work than gas plants. The engineering controls placed on modern gas plant equipment may account for lower employee dosimetry data, as loud equipment was seen to be contained within localized structures to a greater extent at gas plants than coal facilities. Another possibility is age and health of the workers at the different plant types. A noted observation about the older age of workers at coal plants compared to gas plants may affect the attitude and/or pain threshold of noise exposure. An older worker with a greater degree of hearing loss may tolerate a high noise area for a longer time period, thus achieving a larger TWA exposure level than a younger worker at a gas plant. Finally, the atmosphere of safety and corresponding worker attitude towards perceived risk of hearing loss may vary with respect to gas and coal plant employees. An employee who perceives little health risk in working in high noise areas may tolerate those areas for longer duration, and/or not employ certain engineering controls designed for noise abatement. While these hypotheses are pure speculation, future research in the subject can use these findings as a starting point to design more precise noise experiments.

CHAPTER VI

SUMMARY

In a continuous effort to protect worker safety and health, hearing conservation programs mandated by OSHA are implemented in power generating facilities. The project consisted of the collection of area noise levels and employee dosimetry data at two coal-burning plants and six natural gas plants. Comparisons were made between coal and natural gas plant noise levels and employee dosimetry data. The findings may be used by plant management to implement various controls in order to reduce worker noise exposure.

Conclusions

The project sought to meet compliance with OSHA regulations that require monitoring of industrial noise levels as well as employee exposure. The data collected showed that employee dosimetry and area noise levels exceeded OSHA action levels, providing ample justification for the hearing conservation program implemented for the employees of the power plants. Statistical analyses of the data determined that coal plants produce less noise on average than gas plants, yet coal plant workers received higher time-weighted average dosages of noise. The HPD's offered by the company can significantly lower employee noise exposure below the OSHA PEL, ensuring worker health and safety as well as regulatory compliance. Area noise survey data that contain recorded dBA levels corresponding to locations noted on the plot plans, can be used by Health and Safety personnel to efficiently communicate high noise areas. Posting high noise level warnings as well as HPD dispensaries in or near high noise level areas can be done with greater accuracy in light of these findings. Employee noise dosimetry data can also be used by Health and Safety personnel to effectively communicate workplace hazardous noise to specific plant workers in an effort to ensure employees are protected and informed.

Recommendations

The project made a few noteworthy discoveries that provoke action by management. For specific high noise areas and high noise job tasks, effective hazard communication to mitigate employee noise exposure is recommended. Certain administrative or engineering controls for high noise areas may also be considered.

Additional data collection is needed to supplement the findings of the project. The project was not designed specifically to address the relationship between coal and gas plant noise levels, or compare employee dosimetry between the two plant types. The initial goal of the project was solely to comply to regulatory guidelines. The subsequent data analyses may have a reduced efficacy compared to a project with a research agenda as its primary objective. Future research in the field necessitates a carefully planned noise experiment which satisfies OSHA requirements yet also entertains additional hypotheses.

CHAPTER VII

ADDITIONAL INTERNSHIP PROJECTS

Though the bulk of the scientific work performed during the internship was related to employee noise exposure, a brief summary of other health and safety tasks performed is included in the project. Future students employed within the health and safety industry could benefit from a description of the work assigned to interns in this field. The main duties in addition to noise exposure data collection were the preparation of PPE assessments, the creation of a company-wide online PPE database, and the respirator fit-testing for workers at the various power plants.

PPE assessments are required by OSHA under 29CFR 1910.132(d)(2) (Occupational Safety and Health Administration, 2007). The PPE assessment is necessary whenever workplace hazards are present. Examples include chemical, radiological, mechanical, or environmental hazards which can cause injury to employees. Due to the nature of the power plants, all of these hazards are present in the workplace. The creation of PPE assessments was strategically carried out using all available resources. This included researching Material Safety Data Sheet (MSDS) forms for recommended PPE when handling specific chemicals, as well as extensive interviewing of employees about specific task processes. In addition, careful first-hand observation of hazardous work being performed was also used to fill out PPE assessment forms.

After compiling PPE assessments for each of the plants, similar tasks were grouped together and terminology was standardized in order to prevent duplication between plants. This was done by assessing the location within the plant where the task was being performed, and then assigning common terminology to the task. The results were entered into an Excel spreadsheet, and each column was given filters for ease of searching. Each plant was given its own column, and the tasks were listed as rows. The corresponding PPE assessments for each task were then hyperlinked to the company server from the spreadsheet. Clicking on a particular PPE assessment from the spreadsheet would open a new window within the company network and load the PPE assessment form, all of which were stored on a networked hard drive. The networking was accomplished through cooperation with the company IT department. PPE assessments, as well as the database, were updated in conjunction with the Health and Safety department during weekly meetings. See Appendix B for a sample PPE assessment and Appendix C for the PPE assessment database.

The final major project undertaken as a Health and Safety Intern was the administration of respirator fit testing. According to 29CFR 1910.134(c), OSHA requires employers to implement respiratory protection programs whenever workplace conditions require respiratory use (Occupational Safety and Health Administration, 2008). The industrial environment of large power production facilities and the various concentrated chemicals stored on site necessitate such protection. OSHA regulations require annual fit-testing of employees, which is a time-consuming yet necessary activity of industrial hygienists. Although regulations allow a qualitative test to determine effectiveness of the respirator, such as a smoke irritant sprayed around an individual breathing through the respirator, the company has adopted a policy to administer quantitative tests in the interest of enhanced worker safety. Quantitative respirator fit tests were performed using a PortaCount PRO model 8030 manufactured by TSI Incorporated (see Figure 12).

Figure 12. The PortaCount Pro quantitative respirator fit testing machine. The blue tube takes in ambient air, while the clear tube takes in air from the inside of the respirator. The machine amplifies airborne particles using isopropyl alcohol and counts them in an internal chamber.

The Portacount measures airborne particles during eight separate scenarios within the fit test examination, and assesses a pass/fail grade based on what is called a “fit factor” rating. The fit factor is calculated by the equation:

$$\text{Fit Factor} = \frac{\text{Particle count in ambient air}}{\text{Particle count inside mask}}$$

Particles are not discriminated by chemical composition within the unit. Respirators that cover half of the face require a fit factor of 100 to achieve a passing grade, while full-face and SCBA respirators require a fit factor of 500. Employees who were members of the emergency response teams at each plant were fit tested for all three respirator types.

A key finding from administration of the respiratory tests was that employees who had a clean-shaven face, as well as women who pulled their hair back, passed the test with less complications than those with facial hair or other obstructions. However, employees with facial hair were able to pass the test after some adjustments were made to tighten the straps of the mask. Although the Portacount recorded quantitative information for each of the eight fit tests performed on every employee, resource limitations placed the work burden on reporting only a pass/fail result to managerial personnel. It is important to note that while all employees passed the fit test, it is likely that under emergency conditions, those who had difficulty passing the test would not be fully protected. Additionally, even when not in an emergency situation, comfort factors may result in inadequate protection.

Analysis of the fit factor data, had it been retained, would have been useful in correlating various parameters such as age, weight, and abundance of facial hair to more efficient respirator filtration. The data analysis may have proven useful in encouraging employees to strive for factors that lead toward a higher fit factor, and therefore better respirator protection. A possible future study would be the design of an experiment that attempts to determine correlations between an individual’s personal physical characteristics and score of the fit factor. This would be accomplished through the use of a form that notes personal characteristics as well as a quantitative fit factor for each of the tests administered by the Portacount. More detailed knowledge of respirator fit factors may assist managers in ensuring maximum worker protection is being provided.

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APPENDIX A

The C1 Plant. Table includes plant output at time of area noise measurements, as well as approximate location of dBA readings that correspond to the numbers marked on the plot plan (not shown in order to maintain confidentiality of utility company).

	C1	**Output = 507 MW**
Number	**dB reading**	**Approximate Location**
1	53.4	Construction Office
2	68.6	Construction Office
3	66.4	Conference Room
4	70.6	Fire Pump House
5	75.0	Fire Pump House
6	83.0	FPWA
7	73.7	Fire Pump House
8	72.4	FPWB
9	75.7	FPWB
10	71.8	Storage Area
11	69.1	Storage Area
12	79.3	Storage Area
13	76.2	Storage Area
14	80.5	Unit 1 Stack
15	81.2	Unit 1 Stack
16	82.2	Unit 1 Baghouse
17	91.7	Unit 1 Baghouse
18	91.5	Unit 1 Baghouse
19	90.0	Unit I 8aghouse
20	83.1	Unit 1 Stack
21	84.3	Unit L Stack
22	86.1	Unit L Baghouse
23	77.4	Fly Ash Silo
24	70.9	Settling Tank
25	74.2	Transfer Tower B (not running)
26	72.1	Transfer Tower B
27	73.3	Transfer Tower B
28	71.9	Transfer Tower B
29	71.1	Settl ing Tank

	C1	Output = 507 MW
Number	**dB reading**	**Approximate Location**
30	80.3	Unit 2 Stack
31	82.4	Unit 2 Stack
32	79.4	Unit 2 Baghouse
33	78.6	Unit 2 Baghouse
34	87.6	Primary Fans
35	96.6	Primary Fans
36	96.2	Pri mary Fans
37	93.0	Primary Fans
38	97.9	Primary Fans
39	95.9	Primary Fans
40	84.8	Primary Fans
41	83.1	Unit 2
42	73.2	Unit 2 Baghouse
43	85.0	Unit 2 Baghouse
44	83.8	Unit 2 Stack
45	84.0	Unit 2 Stack
46	65.0	Crusher House (not running)
47	65.0	Crusher House
48	64.5	Crusher House
49	75.2	Cooling Tower
50	74.0	Cooling Tower
51	75.0	Cooling Tower
52	77.5	Chlorine Building
53	73.7	Clarifier #2

The G1 Plant. Table includes plant output at time of area noise measurements, as well as approximate location of dBA readings that correspond to the numbers marked on the plot plan (not shown in order to maintain confidentiality of utility company).

	G1	**Output = 318 MW**
Number	**dB reading**	**Approximate Location**
1	53.7	Administration Office
2	74.5	Unit 1
3	72.0	Unit 1
4	72.3	Unit 1
5	75.2	Unit 1
6	73.5	Unit 1
7	83.5	Unit 1
8	65.2	Unit 1
9	77.2	Unit 1
10	74.1	Unit 2
11	88.2	Unit 1
12	79.1	Unit 2
13	82.0	Unit 1
14	78.3	Unit 2
15	81.7	Unit 1
16	73.1	Unit 1
17	74.3	Unit 2
18	82.8	Unit 2
19	80.4	Unit 2
20	82.1	Unit 2
21	80.9	Unit 3
22	85.3	Unit 2
23	86.7	Unit 2
24	70.4	Unit 2
25	92.6	Unit 3
26	92.8	Unit 3
27	89.2	Cooling Tower
28	71.4	Cooling Tower
29	68.8	Chemical Storage
30	76.5	Cooling Tower
31	95.1	Unit 3
32	94.5	Unit 1
33	96.7	Unit 1

The C2 Plant. Table includes plant output at time of area noise measurements, as well as approximate location of dBA readings that correspond to the numbers marked on the plot plan (not shown in order to maintain confidentiality of utility company).

	C2	**Output = 318 MW**
Number	**dB reading**	**Approximate Location**
1	69.6	Administration Office
2	73.9	Unit 4 Turbine
3	77.8	Unit 4 Chemical
4	77.4	CTBO Tank
5	82.6	Unit 4 Cooling
6	74.8	Water Treatment
7	89.0	Unit 4 Millbay
8	89.4	Unit 4 Baghouse
9	86.6	Unit 4 Baghouse
10	86.7	Unit 4 Baghouse
11	81.2	Unit 4 Baghouse
12	88.2	Coal Yard
13	77.8	Chemical Storage
14	84.8	Ash Pump
15	84.5	Unit 1,2,3 Maintenance Shop
16	83.4	Unit 1 Stack
17	98.1	Unit 1 Boiler
18	81.5	Unit 1 Cooling Tower
19	78.1	Unit 2 Cooling Tower
20	81.6	Unit 3 Cooling Tower
21	79.3	Unit 1,2,3 Turbine Room
22	79.0	Unit 1,2,3 Turbine Room
23	83.8	Unit 1,2,3 Turbine Room
24	85.7	Unit 3 Boiler Room
25	93.0	Unit 1 Boiler Room
26	100.6	Coal Lab
27	88.6	Unit 4 Boiler Room
28	94.2	Unit 4 Boiler Room
29	89.4	Unit 4 Turbine Room

The G2 Plant. Table includes plant output at time of area noise measurements, as well as approximate location of dBA readings that correspond to the numbers marked on the plot plan (not shown in order to maintain confidentiality of utility company).

	G2	**Output = 502 MW**
Number	**dB reading**	**Approximate Location**
1	67.9	Administration Office
2	72.3	Turbine Gas Supply
3	80.2	Turbine Gas Supply
4	88.9	HRSG Unit B
5	82.0	HRSG Unit B
6	74.8	HRSG Unit B
7	74.1	Cems Building
8	80.3	HRSG Unit B
9	90.8	HRSG Unit B
10	93.9	HRSG Unit B
11	76.4	UPS Batteries
12	81.7	#3 HYD
13	81.9	HRSG Unit A
14	80.1	HRSG Unit A
15	83.8	Cems Building
16	74.0	Ammonia Tank
17	79.6	HRSG Unit A
18	89.9	HRSG Unit A
19	86.0	HRSG Unit A
20	89.0	Combustion Turbine A
21	82.6	Combustion Turbine A
22	87.2	Steam Turbine
23	83.5	Steam Turbine
24	82.0	AUX Cooling
25	86.1	COR
26	96.1	COR
27	80.2	COR
28	81.9	COR
29	78.0	COR

	G2	Output = 502 MW
Number	**dB reading**	**Approximate Location**
30	81.0	Lube Oil
31	80.1	Chemical Feed
32	86.0	Chemical Feed
33	82.8	Steam Turbine
34	87.6	Steam Turbine
35	83.4	Steam Turbine
36	81.5	PIV-4
37	90.7	Steam Turbine
38	75.5	Steam Turbine

The G3 Plant. Table includes plant output at time of area noise measurements, as well as approximate location of dBA readings that correspond to the numbers marked on the plot plan (not shown in order to maintain confidentiality of utility company).

	G3	**Output = 593 MW**
Number	**dB reading**	**Approximate Location**
1	81.1	Water Treatment
2	70.0	Fire Pump
3	100.1	Electric Pump
4	106.5	Diesel Pump
5	75.2	Diesel Pump
6	68.3	Fin Fans
7	87.2	Fin Fans (on)
8	82.7	Fin Fans inside
9	83.9	Unit 3 Chiller
10	86.4	Unit 3 Chiller
11	93.7	Unit 3 Chiller
12	82.6	Unit 3 Chiller
13	80.4	Electrical PDC- 10
14	105.5	7-12PR
15	77.8	7-12PR
16	75.5	Chemical Injection
17	94.4	Heat Pump
18	94.4	Boiler Feed Pump
19	88.3	Boiler Feed Pump
20	98.3	Lube Oil Room
21	82.0	GTG 1
22	88.8	GTG 1
23	88.2	GTG 1
24	79.1	GTG 1
25	92.5	Gas Module
26	104.3	Gas Module
27	80.8	Electrical Unit
28	85.8	Unit 1
29	107.6	Unit 1

	G3	Output = 593 MW
Number	**dB reading**	**Approximate Location**
30	78.5	Unit 1
31	117.0	Load Component
32	110.0	Turbine Component
33	82.2	HRSG
34	92.7	Boiler Feed Pump
35	63.4	PDC 1B
36	88.0	HP Valves
37	92.3	HP Valves
38	84.3	HP Valves
39	83.0	Steam Lube Oil
40	90.3	Steam Enclosure
41	100.8	Steam Enclosure
42	85.3	Steam Enclosure
43	88.2	Crew Pumps
44	74.2	Crew Pumps
45	75.8	NH3 Pump
46	84.7	Water Pump
47	82.2	Water Pump
48	91.5	Condensate Pump
49	77.0	Air Injector
50	74.9	Lube Oil Storage
51	78.4	CCW Pump
52	86.2	Heat Valve
53	65.1	H2 Skid
54	66.2	Switchyard Building
55	73.0	Gas Yard
56	68.1	Lime Silo
57	76.4	ACC Ground Level
58	71.6	ACC Top Floor
59	75.5	ACC Top Floor
60	83.9	ACC Top Floor
61	87.1	HRSG Ground Level
62	73.8	HRSG Top Floor
63	83.8	HRSG Top Floor
64	76.4	HRSG Stack Level

	G3	**Output = 593 MW**
Number	**dB reading**	**Approximate Location**
65	84.1	WE & SOC Fans
66	89.2	WE & SOC Fans
67	72.9	Chiller Tower
68	80.5	Chiller Tower
69	65.3	GT Inlet Filter Compressor
70	86.6	Mezzanine
71	90.6	Gas Turbine Exhaust Blower

The G4 Plant. Table 4 includes plant output at time of area noise measurements, as well as approximate location of dBA readings that correspond to the numbers marked on the plot plan (not shown in order to maintain confidentiality of utility company).

	G4	**Output = 27 MW**
Number	**dB reading**	**Approximate Location**
1	61.3	Administration Office
2	66.4	Unit 1
3	72.6	Unit 2
4	66.1	Inside Unit 2 (lube oil room)
5	82.8	Unit 1
6	57.8	Unit 2
7	87.8	Unit 2
8	78.5	Steam Vent
9	87.1	Unit 2
10	95.6	Unit 2
11	114.1	Engine Fan Unit 2
12	96.3	Unit 1
13	114.4	Engine Fan Unit 1
14	82.8	Unit 1
15	78.1	Drums
16	71.4	Water Treatment (1)
17	94.5	Unit 2 Second Floor
18	90.2	Unit 2 Turbine
19	92.7	Unit 1 Turbine
20	99.3	Unit 1 ins ide
21	93.0	Unit 1 inside
22	104.7	Unit 2 inside
23	88.3	Unit 2 inside

The G5 Plant. Table includes plant output at time of area noise measurements, as well as approximate location of dBA readings that correspond to the numbers marked on the plot plan (not shown in order to maintain confidentiality of utility company).

	G5	**Output = 562 MW**
Number	**dB reading**	**Approximate Location**
1	70.6	Administration Office
2	66.5	Warehouse
3	73.5	Unit 8 Stack
4	70.4	Combustion turbine unit 8
5	83.2	Combustion turbine unit 8
6	83.1	Combustion turbine unit 8
7	91.0	Combustion turbine unit 8
8	80.8	Combustion turbine unit 8
9	86.4	Combustion turbine unit 8
10	84.0	Combustion turbine unit 8
11	88.3	Unit 8
12	93.1	Unit 8 Pump
13	81.0	Unit 8 Pump
14	83.4	Unit 8 Pump
15	83.0	Steam Turbine
16	86.5	Steam Turbine
17	84.5	Steam Turbine
18	85.4	Steam Turbine
19	75.3	Steam Turbine
20	76.7	Cooling Tower
21	84.7	Cooling Tower
22	79.4	Cooling Tower
23	80.3	Cooling Tower
24	87.4	Unit 3 Stack
25	96.4	Unit 3
26	112.6	Unit 3
27	92.3	Unit 3
28	92.4	Pinion
29	86.9	Pinion

	G5	**Output = 562 MW**
Number	**dB reading**	**Approximate Location**
30	96.0	Unit 3 inside
31	92.8	Unit 3 inside
32	95.5	Unit 3 inside
33	91.9	Unit 3 inside
34	93.2	Unit 3 inside
35	73.3	Unit 3 behind
36	80.5	Unit 3
37	87.1	Unit 3
38	70.4	Unit 4 inside
39	81.1	Pinion
40	84.6	Pinion
41	87.3	Pinion
42	85.7	Pinion inside
43	93.6	Pinion inside
44	86.1	Pinion inside
45	85.5	Pinion inside

The G6 Plant. Table includes plant output at time of area noise measurements, as well as approximate location of dBA readings that correspond to the numbers marked on the plot plan (not shown in order to maintain confidentiality of utility company).

	G6	**Output = 357 MW**
Number	**dBA reading**	**Approximate Location**
1	75.6	Control Room
2	95.8	Unit 8
3	82.2	Unit 8
4	90.2	Unit 8
5	81.8	Unit 8
6	83.6	Unit 7
7	91.1	Unit 7
8	77.5	Unit 7
9	82.7	Unit 7
10	87.1	Unit 6
11	89.4	Unit 6
12	82.4	Unit 6
13	85.1	Unit 6
14	90.4	Unit 5
15	83.4	Unit 5
16	88.0	Unit 6
17	77.6	Unit 5
18	63.0	Unit 4
19	71.8	Peakers 15-18
20	61.7	Peakers 11-14
21	63.4	Peakers 19-22
22	85.6	RCC
23	96.1	RCC
24	90.4	RCC

APPENDIX B

A completed PPE Assessment Form for Bulk Chemical Transfers – Truck to Tank Offloading

PPE ASSESSMENT

TASK DESCRIPTION: Bulk Chemical Transfer – Truck to Tank offloading **FORM NUMBER:** PPE-004

FACILITY: ☒C2 ☒G7 ☒G6 ☒G5 ☒G4 ☒G3 ☒ G2 ☒ G1 ☒C1 ☐______

LOCATION: Various **REVISION DATE:** 7/21/2010

CHECK BODY PARTS THAT MAY BE IMPACTED BY THE FOLLOWING HAZARDS:	HEAD	EYE & FACE	EARS/HEARING	HAND	FOOT	BODY	RESPIRATORY	OTHER
ARC FLASH/FIRE SOURCE/DESCRIPTION: Click here to enter text.								
ELECTRICAL CONTACT/SHOCK SOURCE/DESCRIPTION: Click here to enter text.								
FLYING PARTICLES SOURCE/DESCRIPTION: Click here to enter text.								
LIGHT RADIATION SOURCES SOURCE/DESCRIPTION: Click here to enter text.								
CHEMICAL EXPOSURE SOURCE/DESCRIPTION: *Various Concentrated Chemicals*	X	X		X	X	X	X	
MOLTEN METALS SOURCE/DESCRIPTION: Click here to enter text.								
IMPACT /BUMP SOURCE/DESCRIPTION: Click here to enter text.								
FALLING OBJECTS SOURCE/DESCRIPTION: *Chemical connection hose*	X	X		X	X	X		
ROLLING OBJECTS SOURCE/DESCRIPTION: Click here to enter text.								
WALKING SURFACE SOURCE/DESCRIPTION: Click here to enter text.								
PUNCTURE HAZARDS SOURCE/DESCRIPTION: Click here to enter text.								
ABRASION/ LACERATION HAZARDS SOURCE/DESCRIPTION: Click here to enter text.								
TEMPERATURE EXTREMES SOURCE/DESCRIPTION: Click here to enter text.								
OTHER (LIST) SOURCE/DESCRIPTION: Click here to enter text.								

INDICATE PPE TO MINIMIZE EXPOSURE TO THE ABOVE HAZARDS:

HEAD/EYES/EARS/FACE	HAND	FOOT	BODY	RESPIRATORY	OTHER
☒HARD HAT	☐LO VOLT GLOVES	☒STURDY SHOES	☐FR SHIRT	☐DUST MASK	☐HARNESS
☒SAFETY GLASSES	☐HI VOLT GLOVES	☐SAFETY TOE SHOES	☐FR PANTS	☐1/2 MASK	☐
☐GOGGLES	☐LEATHER GLOVES	☐METATARSAL PROT	☐CHEMICAL SUIT	☐FULL FACE	☐
☐ARC FACESHIELD	☐CHEM GLOVES	☐EH SHOES	☐CHEMICAL APRON	☐PAPR	☐
☐STD FACESHIELD	☐ CHEM GLOVES W/SLEEVE	☐PR SHOES	☐FR JACKET	☐ SCBA	☐
☐EARPLUGS	☐ OTHER	☐CHEMICAL BOOTS	☐FR SUIT		☐
☐FR HOOD			☐WELDING PROTECT		☐
☐WELDER HOOD/GOGGLE			☐NATURAL FIBER SHIRT		
			☐NATURAL FIBER PANTS		

SPECIFIC COMMENTS : Recommended PPE includes: Faceshield, chemical gloves, chemical boots, and a full chemical suit. Respirator must be immediately available.

KEY
EH = ELECTRICAL HAZARD
PR = PUNCTURE RESISTANT

STURDY SHOE = HIGH TOP LEATHER SHOE
SAFETY TOE SHOE = ANSI CLASS I/C CLASS 75
WELDING PROTECT = WELDING JACKET, SLEEVES, ETC.

APPENDIX C

The Complete PPE Assessment Database. This spreadsheet links to actual PPE Assessment

LOCATION/ SYSTEM	TASK TITLE	FORM NUMBER	ALTERNATE NAME	G6	G4	G7	G1	G3	C2	G2	G5	C1
VARIOUS	**GENERAL PLANT ACCESS**	PPE-001	Walking the plant grounds	X	X	X	X	X	X	X	X	X
VARIOUS	**BULK CHEMICAL HANDLING**	PPE-002	Bulk Storage changeout	X	X	X	X	X	X	X	X	X
VARIOUS	**HIGH VOLTAGE BREAKER DISCONNECT - 480**	PPE-003	480 rack in/rack out	X	X	X	X	X	X	X	X	X
VARIOUS	**HIGH VOLTAGE BREAKER DISCONNECT - 4160, 7200**	PPE-004	4160, 7200 rack in/rack out	X	X	X	X	X	X	X	X	X
VARIOUS	**TRUCK TO TANK CHEMICAL TRANSFER**	PPE-005	Bulk Chemical Transfer, Chemical Offloading	X	X	X	X	X	X	X	X	X
AMMONIA SKID			Ammonia Tank Storage Area	X			X	X		X	X	X
	Ammonia filter changeout	PPE-006		X			X	X		X	X	X
AUXILLARY FLOOR			TURBINE BASEMENT, Unit Basement	X	X		X	X	X	X	X	X
	EHC System maintenance	PPE-007	Motor, Pump, Reservoir Fluid changeout	X	X		X	X	X	X	X	X
BATTERY ROOM				X	X	X	X	X	X	X	X	X
	Battery Maintenance	PPE-008		X	X	X	X	X	X	X	X	X
BOILER			BOILER ROOM					X				X
	Boiler Slag shooting	PPE-009						X				X
BOILER FEED PUMP				X	X		X	X	X	X	X	X
	Lube Oil Filter changeout	PPE-010		X	X		X	X	X	X	X	X
BOTTOM HOPPER								X				X
	Bottom Ash rodding	PPE-011						X				X
	Pulverizer Startup	PPE-012						X				X
CCW			CCW Pumps, CCW LOCATION	X	X		X	X	X	X	X	X
	Gear Oil changeout	PPE-013		X	X		X	X	X	X	X	X
CEMS SHACK				X	X	X	X	X	X	X	X	X
	Compressed gas Cylinder changeout	PPE-014		X	X	X	X	X	X	X	X	X

LOCATION/ SYSTEM	TASK TITLE	FORM NUMBER	ALTERNATE NAME	G6	G4	G7	G1	G3	C2	G2	G5	C1
COAL YARD									X			X
	Coal unloading	PPE-015							X			X
COOLING TOWER				X		X	X	X	X	X	X	X
	Gearbox maintenance	PPE-016		X		X	X	X	X	X	X	X
FEEDER DECK									X			X
	Coal Sampling	PPE-017	Coal sample pulling						X			X
FIRE PUMP BUILDING			ELECTRIC/DIESEL FIRE PUMP HOUSE	X	X		X	X		X	X	X
	Fire flush	PPE-018		X	X		X	X		X	X	X
HRSG				X		X	X		X	X	X	
	Internals inspection	PPE-019		X		X	X		X	X	X	
HRSG DRUMS				X		X	X		X	X	X	
	Vent operation	PPE-020		X		X	X		X	X	X	
INSTRUMENT & ELECTRICAL SHOP			I&E Shop, I&C Electrical Shop			X			X		X	X
	Grinding	PPE-021			X	X			X		X	X
LABORATORY			SAMPLE BUILDING, SAMPLE SHACK, Water Treatment Lab	X	X	X	X	X	X	X	X	X
	Coal Fineness test	PPE-022							X			X
	Chlorine Leak Repair	PPE-023	Valve check at Bleach Pumps	X	X	X	X	X	X	X	X	X
	Oxygen analyzer maintenance	PPE-024	Oxygen probe			X						X
	pH probe maintenance	PPE-025		X	X	X	X	X	X	X	X	X
	Reagent preparation	PPE-026	Reagent changeout	X	X	X	X	X	X	X	X	X
	Sodium analyzer maintenance	PPE-027			X	X					X	X
	Silica analyzer maintenance	PPE-028			X	X					X	X
	Titration	PPE-029	Water Chemistry analysis	X		X	X	X	X	X	X	X

LOCATION/ SYSTEM	TASK TITLE	FORM NUMBER	ALTERNATE NAME	G6	G4	G7	G1	G3	C2	G2	G5	C1
MACHINE SHOP				X	X	X	X	X	X	X	X	X
	Machining	PPE-030		X	X	X	X	X	X	X	X	X
PUMP HOUSE								X				X
	Sodium Hypochlorite mixing	PPE-031						X				X
PONDS			Holding ponds	X	X		X	X	X	X	X	X
	Potassium Permanganate addition	PPE-032	Biological Control, $KMnO_4$ chemical treatment	X			X	X	X	X	X	X
SCRUBBERS			Scrub house					X				X
	Scrubber Equipment maintenance	PPE-033						X				X
SEAL OIL SKID				X			X	X	X	X	X	
	Hydrogen purge/fill	PPE-034		X		X	X	X	X	X	X	X
TURBINE DECK				X	X	X	X	X	X	X	X	X
	Generator brush changeout	PPE-035		X	X	X	X	X	X	X	X	X
WELD SHOP			Welding shop	X	X	X	X	X	X	X	X	X
	Welding	PPE-036		X	X	X	X	X	X	X	X	X