

Industrial Noise Measurement and Noise Contour Mapping: A Case Study in Power Plant, Rayong Province, Thailand

Somboon Chaiprakarn¹ and Taweesak Thongsan^{2*}

¹ Program in Practical Engineering, Faculty of Engineering, Maharakham University

² Department of Electrical Engineering, Faculty of Engineering, Maharakham University

Received March 9, 2024
Accepted March 26, 2024
Published April 30, 2024

***Corresponding author:**

Taweesak Thongsan, Department of Electrical Engineering, Faculty of Engineering, Maharakham University, Maharakham, Thailand

E-mail:

taweesak.th@msu.ac.th

©2024, Chaiprakarn, S and Thongsan, T

This is an Open Access article published under a Creative Commons (CC BY-NC-ND 0.4) license.



ABSTRACT

Introduction: This study aimed to assess the noise level in a working environment and to illustrate noise contour maps to define areas for wearing personal protective equipment in the electricity production process of the power plant in Rayong province.

Methods: The measurement of noise levels was divided into all areas, a total of 1,700 points, using the sound level meter model NL-42EX (Class2) standardized by IEC61672 Type2, ANSI S1.4, JISC1509-1. Then, the results were illustrated to create the noise contour map and define areas for wearing personal protective equipment.

Results: Compared to the standard noise levels that allowed employees to average receive throughout a day's work in 2018 from the Department of Labor Protection and Welfare, 45 points were detected over the standard level at 85 dB(A) (2.5 %) at the areas of machinery works continuously, steam turbines, gas turbines, steam generators, etc. Protective equipment and measures must be implemented for electricity production workers. To prevent hearing impairment, one should initially wear personal protective equipment, which can reduce noise exposure by Ear Muff. The derated NRR is 24 dB(A), and the sound level of the employee when wearing an ear muff is 65.7 dB(A), which is a safe sound level.

Conclusion: Additionally, a hearing conservation program should be implemented to comply with the legislation and reduce risks to employees' hearing performance.

Keywords: Noise Measurement, Noise contour mapping, Power plant

Introduction

Noise is one harmful factor humans must experience in their daily lives and is important for living life because noise is essential for communication between humans, but touching a very loud sound over a long time, especially loud noises from construction work or noise from production processes in industrial plants, causes hearing loss [1] or a reduced ability to hear sounds compared to people with normal hearing [2]. It may cause accidents at work. This is because loud noise causes changes in personal behavior. For example, some people may feel slow to respond to various signals. It also disrupts communication. This causes the operator not to hear the danger signal that is loud enough to cause an accident. Exposure to loud noises that exceed legal standards for an excessively long time may cause a chance of hearing impairment, both temporary and permanent. In addition, noise affects the human ability to perceive high-frequency sounds. That means that audio masking in the workplace causes people to hear sounds but not effectively comprehend what others are

saying during conversations. Interrupted conversations can affect workplace performance [3, 4].

According to the World Health Organization (WHO) estimates, roughly 16 percent of the world's population is deafened due to workplace noise exposure [4, 5]. Noise exposure is the leading cause of preventable hearing loss [4]. In Asia's manufacturing industry, noise-induced hearing loss (NIHL) is one of the most prevalent forms of workplace damage [5]. Prevention is crucial because NIHL is a sedentary disease that cannot be cured [6]. NIHL because noise happens while the noise intensity could be excessive, which results in mechanical harm to the cochlea [7]. The ordinary human ear and frightening system have their maximum quantity to accept and comprehend the sound level [8]. NIOSH suggests an excessive noise limit of 85 dB(A), depending on a time-weighted average of eight hours (8-hr TWA). Noise levels of this magnitude and above are deemed dangerous [9]. The Minister of Labour Protection and Welfare announced the subject of

calculating the sound level felt in the ear when wearing personal safety equipment in 2018 [10].

In this case, the power plant uses noisy machines in its power plant process. Specialized machinery and equipment are gas turbines, steam turbines, and generator issues in processes. If such equipment is not maintained properly, it will generate dangerous noise within the workplace [11]. A secure and healthy place of work is crucial for workers. In current operating conditions, most manufacturing workers do not care about noise exposure, which may show their unwillingness to use hearing protection [12]. Hearing loss due to noise exposure and other physical aberrations can be avoided by reducing noise exposure in the workplace and improving noise-protection protocols. Workers exposed to noise must use proper earplugs or earmuffs [13]. The greatest method to increase the operation's quality while lowering the chance of an accident is to take safety management seriously. Although most risks and hazards can be avoided by employing accessible procedures, accidents can still occur due to a lack of understanding on the part of the personnel. Most accidents in business are caused by unsafe labor and working conditions [14].

Therefore, noise exposure is necessary to discuss in this research. In addition, it is based on the exposure length that exceeds the National Institute for Occupational Safety and Health (NIOSH) standard, which is 8 hours per day of exposure for a noise level of 85 dB(A). The purpose of this study was to investigate the noise levels that were present in the kernel recovery station during the power plant process. This study also shows the noise contour mapping of the measurement location to figure out how the noise is spread out.

Methodology

Study Design

A cross-sectional study was applied. Data were collected by measuring the process of power plants in all areas in Rayong Province of Thailand, collecting data between July and September 2023.

Tools and Equipment

By using sound level measurements were conducted in all areas. By measuring all 1,700 sound points, approximately an area of 55,500 m² (Grid area 5x5 meter). Using the sound level meter model NL-42 EX (Class 2) standardized. Able to be detected during 25 to 141 dB, standard body IEC 61672 Type 2, ANSI S1.4, JISC 1509-1 and using sound calibrator model NC-74 IEC60942 standardized measure according to the criteria the announcement of the Department of Labor Protection and Welfare, Thailand on criteria and measurement methods and analysis of working conditions regarding levels of heat, light, or noise, including the duration and type of work that must be carried out B.E.2018.

Surfer software program version 12 was conducted by analyzing grid data based on a colored map of noise contours, in which safe, cautious, and dangerous areas were identified, with the last area requiring noise control measures.

Methods

The preliminary site survey was a survey of the working area of the power plant. To collect basic information by walking around and observing the work area in which employees may be exposed to loud noise, the nature of the loud noise, and the duration of exposure and selecting a measurement tool for convenience in recording data and planning measurement points. The researcher prepared a power plant diagram and the accompanying production process. To set the measurement points from the power plant process area. A grid was created to determine the distance from the measurement point by setting a grid of 5x5 meters per channel, as this was an area where no machines could work. A total of 1,700 were measurement points throughout the region.

Noise levels were measured using a sound levels meter. Carry out monitoring of the 5 minutes average (LAeq 5 minutes), maximum sound level (L_{Amax}), and minimum sound level (L_{Amin}) using the Integrated Sound Level Meter, a type 2 sound level standard required by IEC international standards 61672, before measuring, it was calibrated and rechecked for accuracy with a Sound Level Calibrator at a standard sound level of 94.0 dB, work areas that were monitored for sound level were divided to map the sound level lines. (Noise Contour Map) into a size of 5x5 meters.

Collecting the data obtained from each measurement point into the computer program SURFER Software Version 12. After measuring the sound level, the program displayed a map of the noise level in different ranges (Noise Contour Map). The information from all the analyses was then developed into a plan showing the noise levels in the power process, which could then be evaluated to determine measures to reduce and prevent noise levels.

Results

Noise measurement

After measuring 1,700 points, it was found that the noise ranges were 60.1 - 96.7 dB(A). Preparing a noise contour mapping could show the characteristics of the noise distribution in each area and be used for noise management plan development. The information could control the sound level and warning signs to be aware of the danger of noise hazards in each area, whereas a major source of noise, including steam turbine generators (STG), gas turbine generators (GTG), combustion inlet filter houses, the exhaust stack of heat recovery steam generator (HRSG), and cooling tower. This result found the top three of the lowest average

noise, 60.1, 65.2, and 68.4 dB(A), in the non-process area, workshop, and water treatment process, respectively. In contrast, the highest averages, 95.2,

96.1, and 96.7 dB(A), were found at steam turbine generators No.1 and 2 and gas turbine generators, respectively (Table 1).

Table 1 Noise measuring results in the power plant process.

Area	Measurement points	Min. level of noise (dB(A))	Max. level of noise (dB(A))	Results	
				Meet the measurement points (%)	Not meet the measurement points (%)
Power Plant Process	1,700	60.1	96.7	1,655 (97.35)	45 (2.65)

Noise contour mapping

With the information on spatial variations and an understanding of noise distribution in power plant processes, we found that the noise risk zone (NRZ) criteria values on the map correlated with NRZ criteria (Table 2).

Noise measurements were used to create noise contour maps in loud areas of the power plant process area. Maps with information showing the sound levels were created using the software program SURFER Version 12 (Figure 1, 2). Areas in green, light green, blue, purple, and light purple represent noise levels below the Threshold Limit Value (TLV), indicating safe zones, whereas the yellow, orange, and red areas exceed this threshold [17].



Figure 1 Noise Contour Mapping in power plant process



Figure 2 Noise Contour Mapping in power plant process (Spot Map)

Table 2 Noise Risk Zone Classification of Study Area

Intensity of noise in dB(A)	Zones
< 60	Safe
60-65	Tolerable
66-70	Low Risk
71-75	Moderate Risk
76-80	High Risk
>85	Extremely High Risk

Determining areas for wearing hearing protection

The noise level in the electricity production process area is relatively constant throughout the day. To prevent risks to employees who continuously work for 8 hours, the standard value is compared with 8 hours of operation, so the obtained value is compared with the standard value, which is set not to exceed 85 dB(A) in 8 hours. According to setting the noise contour mapping, it was found that the area was safe and has a noise level equal to or less than 85 dB(A), such as the boundary outside the machine enclosure and as for machines that are continuously working, where a sound level measurement result in greater than 85 dB(A). Therefore, in these areas, measures were required to put in place to prevent and reduce noise impacts, such as installing warning signs and hearing protection to prevent impacts on employees' hearing, together with measures to reduce noise levels at the source. Employers must arrange for employees to wear personal protective equipment while working to reduce the sound level that is felt in the ears when wearing personal protective equipment which exceeds the standards set by law.

Calculations using the noise reduction rating (NRR) values listed on the product with the average noise level measurement value throughout the working time were calculated according to the equation below:

$$\text{Protected dB(A)} = \text{Sound Level dB(A)} - [\text{NRRadj} - 7] \quad (1)$$

$$\text{For Earmuff NRRadj} = \text{NRR} \times 0.75 \quad (2)$$

Where, protected dBA is the level of sound felt in the ears when wearing personal protective equipment, Sound Level dBA is the noise level obtained from the measurement was averaged over an 8-hour working time, and NRRadj is the noise reduction value specified on the label must be adjusted according to the nature and type of personal protective equipment. In the case of earmuffs, reduce the noise by 25 percent of the noise reduction value specified on the label or product.

NRR of earmuff identified on label = 32, NRRadj = $32 \times 0.75 = 24$

Calculate the sound level felt in the ears when wearing sound-reducing earmuffs.

$$\text{Protected dB(A)} = \text{Sound Level dB(A)} - \text{NRRadj} - 7$$

$$\text{Protected dB(A)} = 96.7 - 24 - 7 = 65.7$$

In areas where the sound measurement point has a noise level higher than 85 dB(A), personal protection equipment is to be provided with earmuffs. When calculating the level of sound felt in the ears when wearing personal protection equipment, it was found that noise exposure could be reduced from the highest level measured from 90 dB(A) to 59 dB(A), and measures for hearing conservation program should be established in the workplace. Further preventive measures and surveillance should be provided.

Conclusions and Discussions

All noise levels in the power plant process were measured at a total number of 1,700 points. The noise level was found to be in the range between 60.1 - 96.7 decibels (A). Using the Sound Level Meter, model NL-42 EX (Class2), that meets the standards of the standard unit IEC61672 Type2, ANSI S1.4, JISC1509-1 and use the measurement results to create a noise contour mapping and specify areas for wearing personal protective equipment.

The study found that when the measurement results were compared with the standards announced by the Department of Labor Protection and Welfare, Thailand [13,19]. The subject of Noise level standards that employees are allowed to receive on average throughout their daily working hours, B.E. 2018 [19]. It was found that the machinery areas that are continuously operating include steam turbine generators, gas turbine generators, combustion inlet filter houses, the exhaust stack of heat recovery steam generators (HRSG), and cooling towers.

Moreover, the production process area is a closed building on all four sides, so the noise level in the work area is higher than the standard [2, 6]. In addition, it was found that the power plant had provided personal protective equipment such as earmuffs and earplugs [2, 6, 9]. When used to calculate the NRR value, it was found that the type of earmuffs reduces noise when worn while working in noisy areas. The sound level in the ear is 59 dB(A). It is more effective than wearing personal protective equipment such as earplugs to reduce noise with a sound pressure level that can be felt in the ear at 75.5 dB(A). Therefore, measures must be established in the electricity production process to prevent and reduce the noise impact on employees working in the said area [12, 14] to prevent hearing impairment. Initially, personal protective equipment must be specified, including noise-reducing earmuffs and earplugs that can reduce exposure to loud noises, and must carry out measures to preserve hearing to comply with the law [3, 5, 8, 14, 17].

Competing interests

The authors declare that there is no conflict of interest.

Acknowledgements

The author would like to express our gratitude to participants for their cooperation. We also would like to thank my advisor and professor at Faculty of Engineering, Mahasarakham University, and staff of the Power Plant in Rayong Province, Thailand for supporting on this study.

References

- [1] Rattanak A. Situation of hearing loss from exposure to loud noise in occupations in Thailand and abroad. *Journal of Public Health Research*. 2017; 10 (1): 1-10.
- [2] Bunprom P, Chaiyanan S, Phungkat Y, Sirijaroonwong U. The measurement of sound levels in the washing department at a jeans dyeing factory in Samut Sakhon Province, Thailand. *Journal of Kanchanaburi Rajbhat University*. 2020; 9(2), 316-27.
- [3] Workplace Health and Safety. Managing noise and preventing hearing loss at work. Available from: <https://www.worksafe.qld.gov.au/safety-and-prevention/hazards/hazardous-exposures/noise>.
- [4] National Occupational Research Agenda. Hearing loss. Available from: <http://www.cdc.gov/noish/nr-hear.html>
- [5] National Institute for Occupational Safety and Health. Preventing occupational hearing loss: a practical guide. Available from: <http://www.cdc.gov/niosh/docs-96-110/pdfs>
- [6] Bunprom P, Chaiyanan S, Phungkat U, Sirijaroonwong U. The noise contour map in bleaching and dyeing process to determine the standard of hearing conservation program of a factory in Samut Sakhon Province, Thailand. *Journal of Public Health*. 2022; 17(2), 1-11.
- [7] Sari MA, Adnan A, Munir D, Eyanoer PC. The correlation of smoking and noise induced hearing loss on workers at a palm oil factory X in Medan-Indonesia. *Bali Medical Journal*. 2017; 6(3), 637-40.
- [8] Balazikova M, Andrejiová M, Wysoczanska B. Methodology for Risk Assessment of Noise Effects at Workplace. *MM Science Journal*. 2019; (05):3426-30.
- [9] Juwana W, Adnan A, Haryuna TS. Noise induced hearing loss in begerpang palm oil mill workers. *An International Journal of Otorhinolaryngology Clinics*. 2018; 10(2): 56-60.
- [10] Situngkir D, Ayu IM, Sipahutar L. Respondent's characteristic and noise intensity as predicting factors of noise induced hearing loss. *The Indonesian Journal of Occupational Safety and Health*. 2020; 9(3): 239-47.
- [11] Subramaniam M, Hassan M Z, Sadali MF, Ibrahim I, Daud MY, Aziz S, et al. Evaluation and analysis of noise pollution in the manufacturing industry. *Journal of Physics: Conference Series*. 2019; 1150 (1): 012019
- [12] Zaw AK, Myat AM, Thandar M, Htun YM, Aung TH, Tun M, et al. Assessment of noise exposure and hearing loss among workers in textile mill (Thamine), Myanmar: a cross-sectional study. *Safety and Health at Work*. 2020; 11(2): 199-206.
- [13] Announcement from the Department of Labour Protection and Welfare Regarding calculating the sound level felt in the ear when wearing personal safety equipment B.E.2561 (A.D.2018). The Royal of Thai Government Gazette of The Kingdom of Thailand 2018:135 (Pt 33 ng): 9-10.
- [14] Hassanvand D, Zare S, Ghotbi-Ravandi MR. Noise assessment and sound map projection using surfer and noise at work tools in a tire manufacturing complex in Iran, 2018. *Journal of Occupational Health and Epidemiology*. 2019; 8(2): 109-17.
- [15] Cahyadi B, Timang GA. Mapping of noise levels made by drilling machines on project x using contour zone method. *Materials Science and Engineering*. 2019; 528(1): 012066.
- [16] Li X, Dong Q, Wang B, Song H, Wang S, Zhu B. The influence of occupational noise exposure on cardiovascular and hearing conditions among industrial workers. *Scientific Reports*. 2019; 9(1): 11524.
- [17] Panjaitan N, Panggabean UN. Analysis noise level in production the palm oil: a case study. *Journal Teknik Industri*. 2022; 23(2): 121-32.
- [18] Hasrul N, Ngadiman A, Mansur R, Sirat R, Mohd MF. Safety and risk evaluation using HIRARC model at palm oil mill. *Int J Innov Technol Explor Eng*. 2019; 8(11): 790-7.
- [19] Announcement of the Department of Labour Protection and Welfare on criteria and measurement methods and analysis of working conditions regarding levels of heat, light, or noise, including the duration and type of work that must be carried out B.E.2561 (A.D.2018). The Royal of Thai Government Gazette of The Kingdom of Thailand 2018:135 (Pt 57 ng): 11-16.
- [20] Panjaitan N, Panggabean UN. Analysis noise level in production the palm oil: a case study. *Jurnal Teknik Industri*. 2022; 23(2): 121-32.