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Evaluation of Noise Exposure on Manufacturing Industry During Grinding Work Process for Palm Oil Machinery

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Abstract: The common occupational health hazard in Malaysia is a prolonged noise exceeding 82 decibels (dB), which may cause hearing impairment, headache, and stress. The main factor that may cause a hearing problem is due to not wearing a proper PPE, which are is resulted from a worker's behaviour and a limited language capability in communication at work in which leads to a misunderstanding. Herein, this study was conducted to evaluate the noise exposure in palm oil manufacturing industry. Based on a preliminary study on noise exposure in the selected company in palm oil manufacturing industry, the highly potential area which contribute to excessive noise in the workplace occurred at is the grinding area. Based on the distributed questionnaire during abovementioned preliminary study, most respondents suggested on building a soundproof room at the grinding area as a control measure on reducing the risk of noise exposure. The soundproof room is more and less resemble an exhibition booth, which is made from a wooden board, acoustic foam, fibre drums and cardboard barrels, and a welding strip curtain. The data called as neutral sound was collected before building up soundproof room to find out whether the place was affected by noise from other work processes or not in order to get accurate data when taking noise readings. After completion of the soundproof room, there will be two data collection processes which are data collection before and after the installation of acoustic foam in the soundproof room. Its purpose was to find out how much noise could be reduced by using acoustic foam. In addition, it is also to find out whether the 1 cm thickness of the acoustic foam can affect the rate of noise reduction. After being analysed, the data will be compared to see how much noise can be reduced by using acoustic foam material. Acoustic foam has successfully acted as

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an absorbent material to prevent the noise passing through the soundproof room, as collected data shows there was an 11% total noise reduction after acoustic foam was installed. In conclusion, noise can be reduced by 19% from the implementation of noise risk control i.e. via building a soundproof room in the grinding area. The noise reduction of soundproof rooms can be improved by changing a better sound-absorbing material, such as mineral wool, acoustic cotton batts, and acoustic quilted panels.

Keywords: Soundproof, Noise Exposure, Grinding, Manufacturing Industry, Health Hazard.

1. Introduction

In the context of heavy industry and manufacturing, the distinction between sound and noise is determined by the person and the situation. If the sound is loud and they are exposed for a long time, it can be dangerous to a person's hearing (Canada Ca. 2017) [1]. Many things can cause noise, such as a man's vocal cord, a running engine, a vibrating loudspeaker diaphragm, a working machine tool, and others. Sound or noise has two distinct qualities. It is a combination of frequency and volume. Numerous manufacturing processes, machineries, and equipment's generate a lot of noise which can cause hearing loss (Environmental Protection Department. 2021)[2]. Noise exposure has been linked to physiological and psychological stress reactions in addition to hearing loss. Hearing loss is one of the most visible and clearly quantifiable consequences of excessive noise exposure. Its advancement, on the other hand, is subtle, in that it normally occurs gradually over time, culminating in impairment that can lead to disability before an individual realises what has happened. While the losses appear to be transient at first, they eventually become permanent because of continued exposure. It might be difficult to find a cure for such an effect. Excessive exposure to noise produced by a variety of sources has been linked to hearing loss in numerous studies (Mokhtar et al. 2007) [3]. According to the Malaysian Department of Occupational Safety and Health (DOSH), excessive noise at work caused 91 percent of reported occupational disorders in 2019.Excessive noise is defined as a daily noise exposure level of more than 82 dB(A), a daily personal noise dose of more than fifty percent, a maximum sound pressure level of more than 115 dB(A) at any time, or a peak sound pressure level of more than 140 dB(C) by the Occupational Safety and Health (Noise Exposure) Regulations 2019. If employees are exposed to an excessive noise exceeding the limit specified in sub regulation (1) based on the report referred to sub regulation 4(4), the employer shall take such measures to reduce the excessive noise. Before taking the measure under sub regulation (2), employer shall make an assessment whether it is practicable to reduce such excessive noise by way of engineering control or administrative control. If upon the completion of the assessment made under sub regulation (3) the employer found that it is practicable to reduce such excessive noise by engineering control, the employer shall reduce the excessive noise by use engineering control. If it is not practicable to reduce such excessive noise by engineering control solely, the employer shall reduce the excessive noise by use engineering control together with administration control. If it not practicable to reduce the excessive noise by use engineering control together with administration control, the employer shall reduce the excessive noise by use administration control and if it still not practicable, the employer shall take other effective measures which it shall include personal hearing protector to reduce excessive noise (OSHA, 2019) [4].

1.1 Problem statement

Heavy machineries, hand tools or equipment's, labour procedures, human factors, and other elements in the manufacturing industry can all generate noise. For long periods of time, many workers are exposed to noise. Employers have provided personal hearing protective equipment (PPE) like earplugs and earmuffs to protect employees from noise hazards. However, some workers do not wear it due to factors of human behaviour and misunderstanding due to limited knowledge of language. It is difficult to keep the workers working in a safe environment if they do not follow the instructions and

also do not understand the instructions given. Therefore, the best approach to controlling noise is to eliminate or reduce the hazard at the source. Attempts should be made to control the noise along its path if it cannot be controlled at its source. As a last resort, the noise control problem may be approached at the receivers or exposed persons.

1.2 Significant of study

This study is significant since excessive noise at the workplace can cause serious consequence if there's no action taken such as noise induced hearing loss. Compared to another area, grinding area is an area that exposed to the high noise levels due to the noise from the hand tools of grinding and large grinding machine. This statement also agreed by the 9 over 10 employees that working in the area during preliminary study was performed. This clearly shows that most of the workers in the area are exposed to high noise levels. This information is reinforced with data taken from the noise risk assessment (NRA) done by Risk Assessor in 2020.

In addition, although all the involved workers had been provided personal protective equipment (PPE) like earplug and earmuff, they still not used it when it should be used and this has been acknowledged by all the involved workers. This show that another control measure needs to apply to avoid workers exposed to the high noise level. So far, engineering control is the best control measure that can be apply in this case because not involved too much cost and can give a safe work environment in the future compare to the substitution since it required more cost to substitute to another high technology machine that not produce too much noise. Furthermore, it is not recommended to change the machine because each workpiece already has its own dimension, measurements, and standard. Elimination as a control measure is a something impossible because grinding is an important process to complete the workpiece.

2. Literature Review

2.1 Introduction of Noise

Noise is defined to as unwanted sound Noise are used interchangeably in acoustics, electronics, and physics, but have different connotation when applied to listeners. In engineering, noise also refers to signals that change over time without meaning, whereas sound refers to meaningful signals. (Fink, D. 2019). Other than that, Noise also defined to all unwanted, unpleasant, annoying or harmful mechanical vibration of a medium, acting through the air on the hearing organ and other element of human body. (Biały, W., Bołoz, Ł., & Sitko, J. 2021). Machine operators, process operators, and maintenance workers are just a few of the job types that industrial plants' noise-emitting machinery exposes. Compressors, pumps, motors, fans, turbines, vents, steam leaks, and control valves are common sources of noise in the manufacturing sector (Oscar Rikhotso, 2019).

2.2 The Effect of Noise

Noise can cause hearing impairment, stress, and noise- induced hearing loss (NIHL) due to long-term exposure of the auditory system to a noisy environment. An early symptom of noise-induced hearing loss, and hearing can gradually recover after people leave a noisy environment. However, if people remain in a noisy environment for a prolonged period of time, their hearing will be permanently impaired. (Ding, T., Yan, A., & Liu, K. 2019). For hearing impairment, it is a silent disorder which may not be detected until the problem become severe (Mulwafu, W., Kuper, H., & Ensink, R. J. H. 2016). For stress category, there are two type of stress that be causes by noise. First is mental stress, it is characterised by elevated stress hormone levels, blood pressure, and heart rate, all of which promote the development of diseases such as stroke, arterial hypertension, ischemic heart disease, and myocardial infarction (Hahad, O., Prochaska, J. H., Daiber, A., & Muenzel, T. 2019). Next is stress job, it was described as "the detrimental physical and emotional responses that arise when the job

requirements do not meet the worker's capabilities, resources, or demands." Many occupational variables can contribute to work-related stress, but exposure to high and low levels of noise is particularly important. Job stress has been linked to a variety of health issues, including cancer, cardiovascular disease, depression, anxiety, and lower job satisfaction. Noise exposure has a significant impact on job satisfaction. Based on the evidence presented above, it is anticipated that noise will have an impact on work-related stress and job satisfaction via mediating noise sensitivity and irritation (Abbasi, M., Yazdanirad, S., Habibi, P., Arabi, S., Fallah Madvari, R., Mehri, A & Ghaljahi, M. 2019).

2.3 Equipment to measure Noise

The equipment to measure noise. There are two type of equipment that measure noise which is dosimeter and sound level meter (SLM). A noise dosimeter is a device that measures noise exposure over time and reports the cumulative dose. Accurate noise dosimetry is difficult caused by a variety of issues, including the wide range of noise kinds and situations encountered, as well as the demands that this variability places on dosimeters and their use (Smalt, C. J., Lacirignola, J., Davis, S. K., Calamia, P. T., & Collins, P. P.2017). The Sound Level Meter (SLM) is an instrument that may be used to measure the noise level for a short period of time. For better performance, a noise level measurement that can show the result immediately on the computer is necessary. This would make it easier for the user to see and measure the noise (Lapono, L. A. S., & Pingak, R. K.2018).

2.4 Act, Regulation, ICOP and Guideline

The Factory and Machinery (Noise Exposure) Regulations 1989, which have been in operation for 30 years, were gazetted under the Occupational Safety & Health Act (OSHA) 1994 as OSH (Noise Exposure) Regulations 2019 on 1st March 2019. It accompanied by an ICOP on the management of workplace noise, a legally-bonded document to serve as a reference for industries to comply with the regulation’s requirements. The primary role of the regulation and ICOP is to reduce the occurrence of occupational noise-related hearing disorders, especially NIHL. As the new noise regulation was promulgated under the OSHA 1994, the major advantage is that all ten sectors covered under the OSHA 1994 will be applicable to this regulation as well. Thus, the protection of the working population against hazardous noise is being widely expanded under this regulation. The noise is related to the Guidelines on Management of Occupational Noise Related Hearing Disorders, where are the purpose of these Guidelines is to assist Occupational Health Doctors (OHDs) in managing occupational noise-related hearing disorders following the Occupational Safety and Health (Noise Exposure) Regulations 2019 and the Industry Code of Practice for Management of Occupational Noise Exposure and Hearing Conservation 2019.

2.5 Noise Control Measure

The noise control measure was divided into five categories which is eliminate, substitution, engineering control, administration control and PPE. Elimination suggests that the procedure or task should be changed in order to partially or entirely get rid of the risk. Focusing on elimination to completely remove the threat can help reduce catastrophic workplace accidents or casualties. As a result, this is regarded as the best risk-control method currently in use, and it should always be investigated following the identification of a risk (Ömer Söner, 2022). On the other side, substitution is the process of swapping out a conventional chemical or technique for a less dangerous one. Therefore, substitution necessitates a wider viewpoint in order to be aware of potential less risky alternatives. If the use of dangerous drugs cannot be avoided during the substitution process, it might be thought about eliminating the activity altogether. Engineering controls may be one of the practical and efficient methods for eliminating the risk or lessening the possibility of the danger of exposure if elimination or substitution are truly impossible to achieve owing to technical limitations (Ömer Söner, 2022). In engineering control, one of the measures for controlling noise is to control it at its source, where the noise is generated. The worker can modify or replace gear bearings, bumpers, or blades to reduce or eliminate the impact of aerodynamically generated noise or resonance effects. Administrative controls are any arrangements or procedures that limit the daily noise exposure of employees by control of the

work or production schedule. Examples of administrative methods include shortening the length of time an employee is exposed to excessive noise by job rotation and scheduling machine operating times to reduce the number of employees exposed to noise. The ear protection was use to ensure that the exposed employees are adequately protected from excessive noise. Employees who are exposed to excessive noise should be provided with suitable hearing protectors. The hearing protectors serve to protect the employees against excessive noise during the interim period before the noise is successfully reduced through engineering control measures, or when engineering or administrative measures are not feasible.

2.6. Example of noise in other Industry

The construction industry is a major source of noise pollution because the noise produced is continuous and a mixture of different types of sound. There are lots of factors that contribute to the noise pollution at a construction site. Noises from machinery or handwork construction such as piling, welding, knocking, hammering, or even material transportation. Different level of noises to and from the construction site within certain period depends on the type or stage of job occurring at the site. Different jobs use different equipment or instruments to perform the work. Hence, this shows that noise pollution at construction sites is mixed with different types of noise. In the construction industry, workers are normally forced to perform their tasks in bad working conditions such as long time period under the sun, exposure to high levels of sound intensity, and exposure to dust and chemicals all-days long. Furthermore, long periods of working time combined with poor working conditions and noise pollution cause workers' stress levels to rise. Stress is the main factor causing cardiovascular diseases, and one of the factors that cause stress is unwanted noise or noise pollution. (Feng, C. Y., Noh, N. I. F. M., & Al Mansob, R. 2020).

There are numerous work environments in the transportation sector where employees must complete tasks requiring a high level of concentration and attention while being exposed to noise levels that are higher than those considered to be acceptable for office workers performing similar demanding tasks but below those that pose a risk of damage. In the presence of constant noise produced by their vehicle's engine or engines, pilots, bus, truck, and train drivers must all make safety-critical choices and operate technological equipment (Marion Burgess, 2017). Transportation causes noise pollution, particularly in urban areas where there is an overabundance of moving cars and trains. The health of living things is harmed by noises, which are produced by all kinds of transportation despite the emphasis on road travel. Another effect of transportation that is detrimental to human health and tangible objects is vibration. Both the noise pollution and the traffic from moving cars may have an influence. To lessen the impacts of vibration, mitigation measures may be adopted (D'Agosto, 2019)

3. Materials and Methods

3.1 Materials and Apparatus

The materials to make the soundproof room is consisted of partition, wooden board, acoustic foam, funnel, and welding strip curtain. The noise level was collected using the Proskit MT-4618 sound level meter.

3.2 Methods

Soundproof room working process

Figure 1: Installation of the Exhibition Partition Booth Part

First step is installing the exhibition partition booth part. Based on Figure 1, the exhibition partition booth is one of the items that will be used to build a soundproof room. The dimension of exhibition booth is 2.5m height, 3m length and 3m weight. The components used in the exhibition partition booth are wooden panels and iron frame. Wooden panels are used as walls that will be installed with acoustic foam. The iron frame is used to strengthen the structure of the exhibition booth, such as the frame and connector, so that it can stand firmly and stably.

Figure 2: Installation of Wooden Board as a Roof of Soundproof Room

Second step is installing the wooden board as a roof for soundproof room. This wooden board will be cut based on the predetermined measurements, which are length 3m, height 0.14m, and thickness 0.025m. The number of boards used to make the roof of the soundproof room is 21 pieces. This board will be installed on the exhibition partition booth by using self-drilling screws with sizes of 2 inches and 3 inches.

Figure 3: The Installation Process of Acoustic

Third step is installing the acoustic foam. In this process, acoustic foam with 50cm height, 100cm length and 1cm thickness is installed on the walls and roof to increase sound absorption so that the amount of sound that comes out of the board or exhibition booth will decrease. The amount of acoustic foam used in this process is 60 pieces. The time taken to install acoustic foam on exhibition booth is two weeks.

Figure 4: The Installation of the Funnel

Next step is installing the funnel. This funnel is made to remove and prevent iron dust and sparks from spreading. The materials used to make this funnel are a fibre drum and a cupboard barrel. This item is made of a layer of paper. It has strong durability and heat resistance. The size of the fibre drum used is 590 mm length, 570 mm diameter, and 2 mm thickness, while the measurements for the barrel cupboard used are 700 mm long and 400 mm wide. Following that, it will put on the jig as shows at figure 5 bellow. The jig was custom made to be a stand for the funnel. It has wheels to make it easy to move around. The jig was 1000 mm long, 730mm height and weight 620mm

Figure 5: The Customize jig

Figure 6: The Installation of Welding Strip Curtain

Last step is installing the welding strip curtain. The welding strip curtain is made of polyvinyl chloride (PVC) with measurements 1800mm length and 500mm width. Welding strip curtain used because it has high heat resistance and provides protection against UV rays. It is also durable and is not easily torn by sparks and metal spatters produced during the grinding processes. Before the curtain is installed, a rail will be attached to the wooden board by using 2-inch self-drilling screws and a drilling handling tool.

3.3 Equations

In this study, the average formula is used to calculate the noise reading. Noise reading will be taken using a sound level meter (SLM). After the noise reading has been collected, it will be calculated using the average formula to get the total noise reading from the collected data. Below is the calculation process for the average method:

$$\boldsymbol{Average} = \frac{\sum_{i=1}^{n} \boldsymbol{X_i}}{\boldsymbol{n}}$$

$\sum_{i=1}^{n} \boldsymbol{X_i} = \boldsymbol{X_1} + \boldsymbol{X_2} + \boldsymbol{X_3} \ldots\ldots + \boldsymbol{X_n}$

n = total number of terms

4. Results and Discussion

In this section, all the data analysed will be shown through graphs and tables. The first thing to do is to know the noise level in the grinding area. Data will be collected in that area by using a sound level metre (SLM). The second thing is to measure the noise level (neutral sound) at the project site. Its purpose was to find out whether the place was affected by noise from other work processes or not in order to get accurate data when taking noise readings. The third point is that after the process of building a soundproof room, there will be two data collection processes which are data collection before and after the installation of acoustic foam in the soundproof room. Its purpose was to find out how much noise could be reduced by using acoustic foam. In addition, it was also to find out whether the thickness of the acoustic foam also affected the rate of noise reduction. After being analysed, the data will be compared to see how much noise can be reduced by using acoustic foam material. After that, the noise reduction data will be compared with the excessive noise data in the grinding area to see how much noise was reduced after the soundproof room was installed.

4.1 Excessive noise in grinding area

Before the soundproof room is built, some data needs to be collected in the grinding area to find out the level of excessive noise in the area.

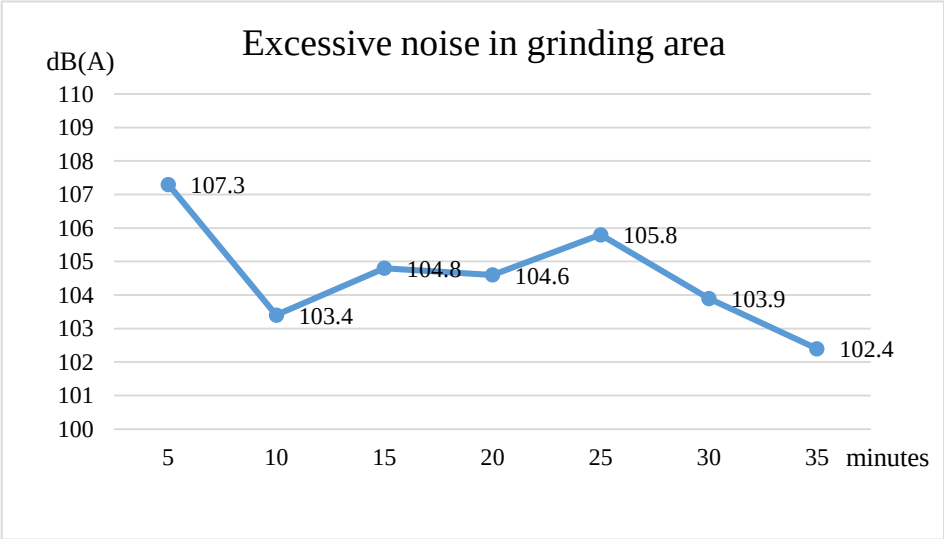
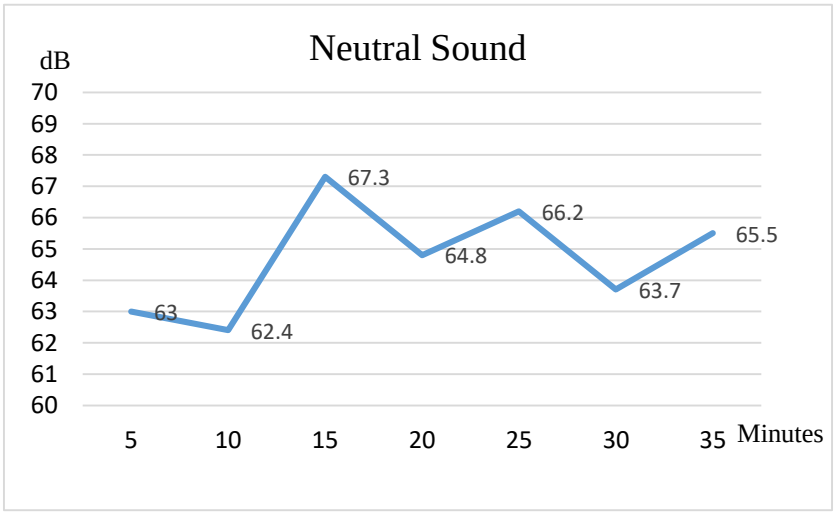


Figure 7: The noise reading data of excessive noise in grinding area

Based on Figure 7, The total of noise reading was 7 and the time taken for taking one reading was 5 min. On the 5th minute, the noise reading was the highest at 107.3 dB (A) while on the 35th minute, the noise reading was the lowest at 102.5 dB (A). The noise in the grinding area is already exceeding the daily noise exposure limit which is 85 dB(A). Therefore, control measures should be taken to reduce excessive noise in the grinding area.

4.2 Neutral sound

The sound data were taken to find out whether the place was affected by noise from other work processes or not in order to get accurate data when taking noise readings.



4.1 The Data Comparison Between Before and After the Installation of Acoustic Foam on The Exhibition Partition Booth

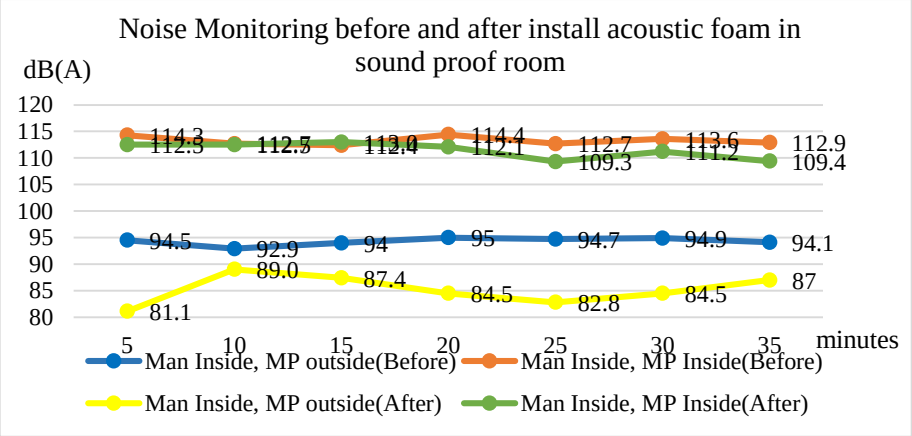


Figure 3.1: The Noise Readings Before and After The Installation of Acoustic Foam on an Exhibition Partition Booth

Based on Figure 3.1 shows the noise readings before and after the installation of acoustic foam. The purpose of combining these readings into one graph is to compare and contrast before and after the installation of acoustic foam. For the man inside, MP inside category shows that the noise reading after the installation of acoustic foam is identical, which is around 109.3 dB(A)-112.5 dB(A), with a total difference of 1 dB-4 dB in the noise reading. This shows that even though acoustic foam has been installed, the noise reading in the soundproof room is still high compared to the noise reading before installation. For the man inside, MP outside category shows that the noise reading after the installation of acoustic foam is decrease, which is around 81 dB(A)-89 dB(A), with a total difference of 4 dB-13 dB in the noise reading. The total noise reduction is 11%. This shows that after the acoustic foam is installed, the noise that passes through the soundproof room is decreasing because there is an absorbent material that prevents the noise from leaving the soundproof room.

3.2 The Data Comparison Between Before and After the Installation of Soundproof Room

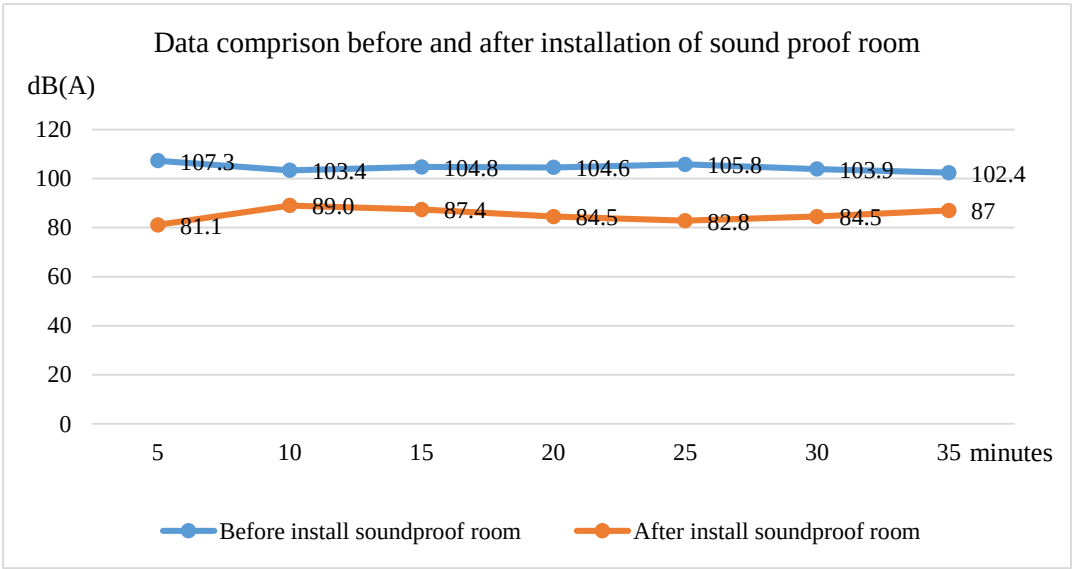


Figure 3.2: The Noise Readings Before and After the Installation of Soundproof Room

The purpose of this data comparison is to see the effectiveness of the soundproof room in reducing noise in the grinding area. Based on the graph above, the noise reading before the installation of the soundproof room was high, ranging from 102.4 dB (A) to 107.3 dB (A). Meanwhile, the noise reading after the installation of the soundproof room ranges from 81 dB (A) to 89 dB (A). Hence, the total difference between before and after the installation of the soundproof room is from 14 dB to 26 dB. The total noise reduction is 19%. This shows that the control measures taken can reduce the excessive noise in the grinding area.

5. Conclusion

In conclusion, soundproof rooms are feasible because they can reduce excessive noise in the grinding area. This has been proven by studies using acoustic foam as an absorbent material that can reduce noise by 14dB to 26dB (11%). While for the amount of noise reduction after installing a soundproof room is around 14 dB to 26 dB (19%). In addition, workers still need to wear hearing protection to protect themselves from other noise hazards. For the improvement of soundproof rooms in the future, you can use a better sound-absorbing materials such as acoustic mineral wool, acoustic cotton batts, and acoustic quilted panels, depending on the suitability of the workplace or develop new sound-absorbing materials that can increase the percentage of noise reduction with the help of advanced technology in the future.

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References

[1] Indrayani, S. A. (2020). Measurement and Evaluation of Sound Intensity at The. *Journal of Physics: Conference Series*, 4. Canada Ca. (2017). Noise – Basic Information: OSH Answer. https://www.ccohs.ca/oshanswers/phys_agents/noise_basic.html

[2] Environmental Protection Department. (2021). What is noise? https://www.epd.gov.hk/epd/noise_education/young/eng_young_html/m1/m1.html

[3] Mokhtar, M., Kamaruddin, S., Khan, Z. A., & Mallick, Z. (2007). A study on the effects of noise on industrial workers in Malaysia. *Jurnal Teknologi*, 17â-30. https://www.researchgate.net/publication/228501650_A_Study_On_The_Effects_Of_Noise_On_Industrial_Workers_In_Malaysia

[4] DOSH. (2019). Occupational Safety and Health (Noise Exposure) Regulation 2019. https://www.dosh.gov.my/index.php/legislation/eregulations/regulations-under-occupational-safety-and-health-act-1994-act-514/3174-00-occupational-safety-and-health-noise-exposure-2019/file

[5] DOSH. (2021). Guidelines on Management of Occupational Noise-Related Hearing Disorder. https://www.dosh.gov.my/index.php/legislation/guidelines/occupational-health-1/4095-guidelines-on-management-of-occupational-noise-related-hearing-disorders/file

[6] Fink, D. (2019, December). A new definition of noise: noise is unwanted and/or harmful sound. Noise is the new 'secondhand smoke'. In *Proceedings of Meetings on Acoustics 178ASA* (Vol. 39, No. 1, p. 050002). Acoustical Society of America.

[7] Biały, W., Bołoz, Ł., & Sitko, J. (2021). Mechanical processing of hard coal as a source of noise pollution. Case study in Poland. *Energies*, *14*(5), 1332.

[8] Claudio Guarnaccia, N. E. (2013). Noise Sources Analysis in a WoodManufacturing Company. *INTERNATIONAL JOURNAL OF MECHANICS*, 39.

[9] Oscar Rikhotso, J. L. (2019). Noise Sources and Control, and Exposure Groups inChemical Manufacturing Plants. *applied sciences*, 1.

[10] Staseva, E., Kvitkina, M., Litvinov, A., & Kobzeva, N. (2020). The effect of noise on the human body, in particular, on cardiovascular diseases. In *E3S Web of Conferences* (Vol. 164, p. 01028). EDP Sciences.

[11] Ding, T., Yan, A., & Liu, K. (2019). What is noise-induced hearing loss?. *British Journal of Hospital Medicine*, *80*(9), 525-529.

[12] Mirza, R., Kirchner, D. B., Dobie, R. A., Crawford, J., & ACOEM Task Force on Occupational Hearing Loss. (2018). Occupational noise-induced hearing loss. *Journal of occupational and environmental medicine*, *60*(9), e498-e501.

[13] Mulwafu, W., Kuper, H., & Ensink, R. J. H. (2016). Prevalence and causes of hearing impairment in Africa. *Tropical medicine & international health*, *21*(2), 158-165.

[14] Hahad, O., Prochaska, J. H., Daiber, A., & Muenzel, T. (2019). Environmental noise-induced effects on stress hormones, oxidative stress, and vascular dysfunction: key factors in the relationship between cerebrocardiovascular and psychological disorders. *Oxidative Medicine and Cellular Longevity*, *2019*.

[15] Abbasi, M., Yazdanirad, S., Habibi, P., Arabi, S., Fallah Madvari, R., Mehri, A., ... & Ghaljahi, M. (2019). Relationship among noise exposure, sensitivity, and noise annoyance with job satisfaction and job stress in a textile industry. *Noise & Vibration Worldwide*, *50*(6), 195-201.

[16] Smalt, C. J., Lacirignola, J., Davis, S. K., Calamia, P. T., & Collins, P. P. (2017). Noise dosimetry for tactical environments. *Hearing research*, *349*, 42-54.

[17] Ryherd, S., Kleiner, M., Waye, K. P., & Ryherd, E. E. (2012). Influence of a wearer's voice on noise dosimeter measurements. *The Journal of the Acoustical Society of America*, *131*(2), 1183-1193.

[18] Lapono, L. A. S., & Pingak, R. K. (2018). Rancang Bangun Sound Level Meter Menggunakan Sensor Suara Berbasis Arduino Uno. *Jurnal ILMU DASAR*, *19*(2), 111-116

[19] Enda Murphy, E. A. (2016). Testing the accuracy of smartphones and sound level meter applicationsfor measuring environmental noise. *Applied Acoustic*, 1-20.

[20] Satherely, E., & Mclaren, S. J. (2015). Evaluation of occupational workplace noise levels in an enclosed workshop at Kiwi Rail. *New Zealand Acoustic*, *29*, 2

[21] Warrington, D. N., & McLoughlin, J. R. (2005). Evaluation of occupational noise exposure-advantages and disadvantages of noise dosimetry versus sampling using a sound level meter. *Proceedings of ACOUSTICS: Paper presented at Australian Acoustic Society. Acoust Aust*, 345-349.

[22] DOSH. (2019). Occupational Safety and health. Safety and Health Officer Regulation 1997. Part II Registration of a safety and health officer, Regulation 6 (1)(a)(b) and (c), 128.

[23] DOSH, (2019). Industry Code of Practice For Management of Occupational Noise Exposure and Hearing Conservation. Page 2.

[24] DOSH, (2021) GUIDELINES ON MANAGEMENT OF OCCUPATIONAL NOISE-RELATED HEARING DISORDERS. Page 4.

[25] Neil J. Sehgal, D. K. (2021). Applying the Hierarchy of Controls: What Occupational Safety Can Teach us About Safely Navigating the Next Phase of the Global COVID-19 Pandemic. *Frontiers in Public Health*.

[26] Ömer Söner, C. K. (2022). Using the hierarchy of controls to improve maritime safety: Case of hot work on. *Dergipark*, 88.

[27] Dosh. (2005, April). Guidelines for control of occupational noise 2005. Engineering Control, 6 – 7.

[28] Feng, C. Y., Noh, N. I. F. M., & Al Mansob, R. (2020). Study on the factors and effects of noise pollution at construction site in Klang Valley. *Journal of Advanced Research in Applied Sciences and Engineering Technology*, *20*(1), 18-26.

[29] D'Agosto, M. d. (2019). Noise pollution, vibration, visual intrusion, and emission of solid and liquid waste. *Transportation, Energy Use and Environmental Impacts*.

[30] Marianna Jacyna, M. W. (2017). Noise and environmental pollution from transport:decisive problems in developing ecologically efficient transport systems. *Journal of Vibroengineering*, 5641.

[31] Marion Burgess, B. R. (2017). Effects of noise for workers in the transportation industry. *the journal of the acoustical society of america*, 1.

[34] Indrayani, S. A. (2020). Measurement and Evaluation of Sound Intensity at The. *Journal of Physics: Conference Series*, 4.