# Irwan Syahrir

## The Analysis and Mapping of Factory Equipment Noise on the Worker's Hearing Power

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# The Analysis and Mapping of Factory Equipment Noise on the Worker's Hearing Power

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**Abstract.** Hearing loss due to noise is a disturbance in the form of a decrease in the function of the sense of hearing due to exposure to noise with excessive noise intensity continuously for a long time. This study will observe the extent of noise disturbance to workers at PTI Company. PTI is one of the largest companies in Indonesia engaged in the cosmetic industry. In the production process using machine tools that can cause noise, resulting in hearing loss for workers. Contour mapping of noise distribution was carried out in 2 Plants, namely Plant Jatake 1 (powder and semisolid production) and Plant Jatake 2 (liquid production), as a danger zone to noise between 85 - 103 dB. The research data shows that there are 4 zones that have a noise level between 86.4 dB-103 dB. This value exceeds the standard set threshold of 85 dB. The determination of the audiometric test respondents in this study used a purposive sampling technique from 1574 respondents. Noise that exceeds the threshold value can cause significant hearing loss. The results of Medical Check Up (MCU) observations on workers in 4 areas whose noise values exceed the threshold indicate that many workers have hearing loss. Factors that can affect the hearing loss of workers, namely: noise value, MCU test results (audiometry test), age of workers, and years of service. The results of this study can be used as a reference for companies to improve and reduce hearing loss problems due to work.

## INTRODUCTION

Over 5% of the world's population or 430 million people require rehabilitation to address their 'disabling' hearing loss (432 million adults and 34 million children). It is estimated that by 2050 over 700 million people or one in every ten people will have disabling hearing loss [1]. Hearing loss has long been recognized as an occupational disease [2–4]. The most severe impact of a noisy work environment is permanent deafness known as noise induced hearing loss(NIHL) [5,6].

The cosmetic industry uses advanced and sophisticated technology in the form of production machines so as to provide convenience in the production process, increase productivity, and work efficiency. This has the potential to have an impact on the environment including: water pollution, air pollution, soil pollution, vibration, and noise. If not managed properly, this environmental pollution can potentially have an impact on human health.

One type of pollution that can potentially interfere with human health is noise. Based on data from the World Health Organization [7] in 2012 there were 5.3% or 360 million people in the world who experienced hearing loss. The definition of noise according to the Regulation of the Minister of Manpower and Transmigration Number 5 of 2018 concerning the threshold value of physical factors and chemical factors in the workplace is all unwanted noise originating from production process tools and/or work tools that are at a certain level can cause hearing loss. Sound in the workplace turns into an occupational hazard when its presence is physically and psychologically disturbing or unwanted [8]. There are many studies that discuss hearing loss due to noise at work, including [3–6]: In Permenaker Number 5 of 2018 , it is stated that the threshold value for noise is 85 dB with an exposure time of 8 hours a dayand 40 hours a week. Operators or field workers who operate production equipment are environmental components that are affected by ambient noise. The main effect of hearing loss is impaired communication, which can adversely affect relationships with family and friends and create difficulties at work [9,10] found that hearing loss can also be caused by fatigue

Noise is one of the environmental pollutants that can cause occupational diseases at PTI, namely the cosmetics industry which employs 1829 workers (cut off 30 April 2021) in the PTI factory area. In the production process that

occurs in machine tools can make noise. The machine tools used in the production process operate 161 hours per week. Based on the results of interviews with members of the SHE (Safety, Health, and Environment) department, PTI has provided ear plugs so that the noise intensity received by workers can be reduced by about 10 dB with an exposure time of 8 hours / shift. However, the low awareness of workers with a value of 75% does not use personal protective equipment in the form of earplugs.

Factors related to noise-induced hearing loss are suspected to be due to a relationship between noise intensity, length of work, years of service and age with noise-induced hearing loss [11,12]. According to [13] , hearing loss is caused by high noise levels, besides that there are other factors that can affect hearing loss in workers such as age, years of service, use of ear protection equipment and a history of ear disease. Noise can cause deafness or damage to the sense of hearing. There are various ways to detect ear disorders, one of which is through audiometric examination. This examination is an examination carried out to check the level of function of a person's hearing by hearing certain sounds, tones, or frequencies. Therefore, it is necessary to measure noise in the workplace which can potentially interfere with the health of workers. This measurement aims to determine how much noise exposure workers have. So that it can be done to prevent the impact of noise on workers.

# RESEARCH METHODS

## Research Time and Place.

It will be held from 20 March 2021 to 20 June 2021 with the research location at PTI Company which is located at Jatake Industrial Estate: Jatake 1 and Jatake 2.

The research method used is descriptive analytic method, which describes the noise facts that occur in the PTI factories located at Plant Jatake 1 and Plant Jatake 2 by measuring the noise level carried out by the main cause, then followed by comparing standards quality standards that have been set in Permenaker Number 5 of 2018. Based on the noise testing at PTI, a flowchart was compiled as a test flow diagram to the data analysis stage and conclusions.

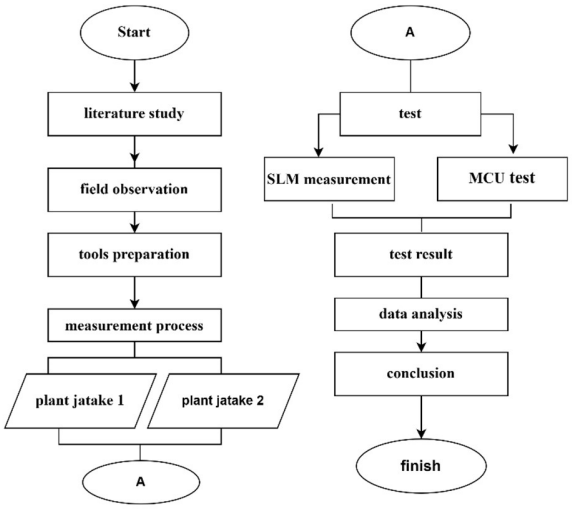


**Figure 1**. Research flow chart

## Research Tools

Several measuring tools are used to support the implementation of this research. The tools used in this research are as follows:

- Sound Level Meter (SLM), serves to measure sound intensity in order to determine the noise level in the work environment. Sound Level Meter which is used to store and process data (data logger). Data can be saved and processed to a computer with a USB cable and the software provided. Besides that, it is easy and

simple to use.
- Timer/Stopwatch as a tool to measure the time required in testing using a Sound Level Meter (SLM).
- Area Layout in PTI Factory : Jatake 1 and Jatake 2.
- Stationery, serves to record and report measurement results. The writing tools used are books, pens and/or pencils.
- The meter is used to measure the distance from the measuring point to the location of the machine.
- Medical Check Up results data from doctors in collaboration with PTI.

### Data collection technique

This research was conducted by referring to the data collected during the observation. Data collection techniques carried out by researchers include:
- Literature study, namely by reviewing the literature in the form of books, previous reports, research, and relevant journals.
- Documentation, namely the observation method by documenting research in the form of photos of activities.
- Direct measurement, which is to obtain primary data regarding noise levels and hearing power.

## RESULTS AND DISCUSSION

### Current Noise Measurement

Noise measurements using the sampling point method were carried out at Plant Jatake 1 (Decorative Factory Production and Engineering) in the Upstream Powder, Upstream Semisolid, Downstream Powder, Downstream Semisolid areas, and Plant Jatake 2 (Liquid Factory Production and Engineering) areas in Upstream Liquid and Downstream Liquid. Measurement data was collected on March 20 - June 20, 2021, where every day 2 measurement periods were carried out, namely 08.00 AM - 12.00 AM (1st period) and 13.00 PM - 16.00 PM (2nd period). Then each period is taken 10-20 times. Measurements were made at several sampling points which indicated the presence of noise hazards and human activities. Noise level measurements were carried out using a Sound Level Meter (SLM).

### Data Analyst of Area Measurement in Jatake 1 and Jatake 2

The results of noise measurement on Jatake 1 and Jatake 2 can be written the level of noise in the following,

1. Plant J1, floor 1 decorative area, room of powder mixing and kompak 11 : 93 db
2. Plant J1, floor 2 decorative, machine room press and intermediate materials : 103 db
3. Plant J2, upstream liquid, area mix cream, liquid, thick,& gel 1 : 88 db
4. Plant J2, Utility Area of J2, WWTP (Waste WaterTreatment Plant) : 86,4 db

From the result of noise level measurement , it can be concluded that these 4 areas must be given extra attention and solutions. So that these 4 areas do not cause ongoing occupational diseases for workers in those areas. Before determining the solutionto these 4 areas, continuous analysis is needed such as comparison diagrams with standard threshold values and processing of medical check up results.

### Comparison with Standard

In addition to calculating the noise level, the noise level is also compared with the standards set from the permissible Threshold Value within 8 hours per day, which is below 85 dB according to the Minister of Manpower Regulation Number 5 of 2018 [14]. The fluctuations in the noise level at each measurement point can be seen in the image below.

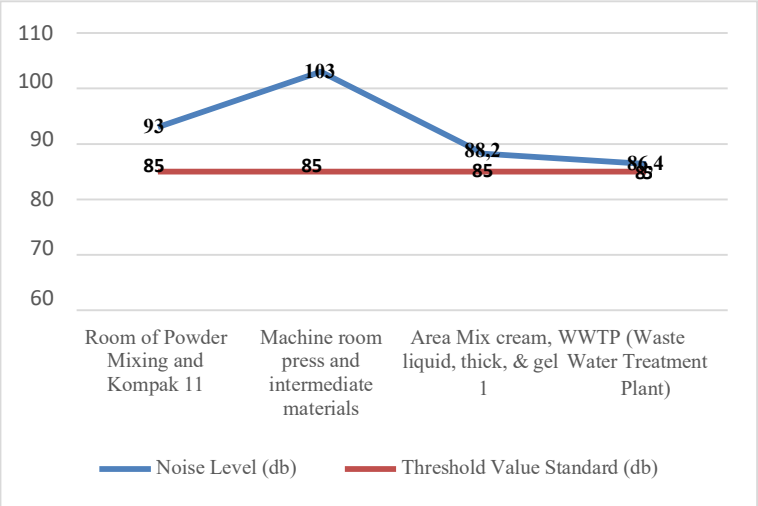


**Figure 2.** Comparison of Noise Levels with Standard Threshold Values

Figure 2 above shows the highest threshold value in the area of the press machine room and intermediate materials. From a total of 88 rooms that have been tested for noise values, there are only 4 engine area rooms that have values exceeding the threshold. This means that 4 of the 88 rooms, only 4.5% received a value exceeding the standard. Subsequently, a medical examination of the workers in the area was carried out. The purpose of the medical check-up is to find out what percentage of people have been exposed to occupational diseases, especially hearing loss in that area.

## Processing of Medical Check Up Results

Medical Check Up (MCU) examinations were carried out on all factory employees as many as 1,574 respondents. These respondents, only 1,080 respondents worked in the areas. There were four department location observed, namely decorative 1, decorative 2, liquid 1 and liquid 2. The number of workers in each department in sequence are 296, 240, 520 and 24 workers. The purpose of the observation is to determine the number of hearing disorders in workers. The evaluation results show that the number of workers who experience hearing loss are 85, 10, 175 and 0 workers, respectively. The results of the health examination showed that 25% of workers who take part in the medical check-up (period 01 February 2021 to 01 July 2021) are experiencing occupational diseases in the form of hearing loss. The hearing loss mentioned is mild hearing loss, meaning that no one has severe hearing loss (according to the doctor's analysis). However, the health of each personnel's body is also different, therefore this cannot be underestimated. There must befurther anticipatory steps to reduce occupational diseases due to noise and can reduce the number of hearing loss in the following years

## Analysis Through Root Cause Analyse

In this study, a fishbone chart will be used to analyze the cause and effect of the problem in order to find out the factors that affect the quality that we are studying [15]. The cause and effect diagram (Fishbone Chart) depicts lines and symbols that show the relationship between cause and effect that occurs in the intensity of noise that can cause. Occupational Diseases at PTI. So that it can find out the consequences of a subsequent problem, and the results of thisroot cause can be taken a corrective action.

Determination of the cause of the problem is carried out through discussions with the SHE team coordinator at PTI. The SHE ((*Safety, Health, and Environment*) team includes several factors related to the root cause of noise such as human factors, methods, machines, and environment.

After identifying the causes of noise at PTI, an analysis of corrective actions is carried out as a solution to reduce noise exposure that can cause Occupational Diseases. The method used to analyze the problem of noise disturbance

at the factory location is the 5W+1H method [16]. 5W+1H is a method used to find out the problems that occur in detail through several questions, namely: what, who, where, when, why and how. The method is presented in the form of a table as arranged as follows:

1. How
   To find out how the incidence of hearing loss due to noise is experienced by workers, an analysis is arranged according to Table 1.

**TABLE 1.** Analysis of 5W+1H Noise factor

| Factor | Analysis (How) |
|---|---|
| Man | See the unsafe action of every person working in that area |
| Material | Gather tools/supporting information about what is related to the problem |
| Machine | See the machine's work procedure if there is a discrepancy |
| Environment | Seeing the work area environment including the building and the room whether it is adequate or not |
| Method | Seeing the work procedures carried out by personnel related to discrepancies in the way personnel work |

2. Why
   From the fishbone diagram, it is obtained that the cause of noise in a certain area exceeds the standard Threshold Value (85 dB). The following are the causes of Occupational Diseases related to noise:
   a. Lack of knowledge of operators in work procedures
   b. Less careful in behaving safely at work
   c. In one room affected by noise
   d. The working procedure of the machine makes noise
   e. The distance between the operator and the machine is too close
   f. Do not use PPE when working in noisy areas
3. What
   From the fishbone diagram, the roots of the problems obtained can be obtained:

**TABLE 2.** Root Cause

| Possible Root Cause | Discussion | Root Cause? |
|---|---|---|
| There is no standardwork procedure | Make standard work procedures equipped withrules for the use of personal protective equipment in accordance with each work area. | Go |
| There is no standard lead time in every activity | The standard work lead time is in the process of making raw materials. | One Shoot |
| No noise cancelingdevice | Procurement of Personal Protective Equipment (PPE) in the work place that has an excess abovethe standard (85 dB). | Go |
| No noise standard on themachine | The noise standard is stipulated in the Regulation of the Minister of ManpowerNumber 5 of 2018, which is with a noisestandard below 85 dB. | One Shoot |
| Limited/narrow workarea | The work area is limited, it can only be repairedby reducing the tools that enter the area. So the tools in the area are only raw material processing machines. | One Shoot |
| There is no standard PPE sign | Procurement of signage as a rule to remind workers or visitors who will enter the area. | Go |

4. Who

   From the problem of threshold value that exceeds the standard limit, it can cause effects of Occupational Diseases in the workplace, such as hearing loss. Personnel that may be exposed are personnel who work in that part of the area with a duration of 8 working days per day.

5. Where

   The priority locations to improve the noise value are Factory Production Powder (Jatake 1), FactoryProduction Semisolid (Jatake 1), Factory Production Liquid (Jatake 2), and Engineering and Infrastructure Central (Jatake 2).

6. When

   Based on the problem of noise values that exceed the standard, it is necessary to re-evaluate work procedures, especially in that area. The evaluation was carried out in May 2021.

## Implementation of Repairing

Finding problems in the field becomes the basis for finding solutions in order to correct the shortcomings of procedures while working. To improve the findings of the problem in this study is to meet the required standards as follows:

- Standard work procedures are equipped with rules for the use of Personal Protective Equipment) PPE.

  In work processes that have high risk, it is mandatory to use PPE before starting work and during work. The following is an example of a Work Instruction in a high risk noise area that has been equipped with the use of appropriate PPE. The picture above is a Work Instruction in the WWTP area which has high risk of noise. The use of PPE is Major obligation before doing work, so the stages of using PPE are very important to support sustainability.

- Procurement of Personal Protective Equipment (PPE)

  Personal protective equipment, commonly referred to as "PPE", is equipment worn to minimize exposure to hazards that cause serious workplace injuries and illnesses [17] . Procurement of Personal Protective Equipment used by PTI is Ear Plug and Ear Muff. Here are the differences and their classification:

  1. Ear Plug
     Ear plug is a personal protective device that is used by inserting it on the outside of the ear canal. Basedon the material, some ear plugs are made of foam/foam/sponge, and some are made of rubber (rubber).
  2. Ear Muffs
     Slightly different from ear plugs, Ear muffs have a larger model like a headset that is usually used tolisten to music, so indirectly the ability to muffle the Earmuff is better than ear plugs.

**WORK INSTRUCTION**
**WASTEWATER TREATMENT PLANT (WWTP)**

| PTI | | | | |
|---|---|---|---|---|
| | Number of Document | | Version | |
| | Effective Date | | Next Review Date | |

3. Job Instruction Description

3.1 Preparation Phase

| No | Procedure | | Standart | Checkpoint | Duration (minute) |
|---|---|---|---|---|---|
| 1 |  | Must use standard personal protective equipment (safety helmet, latex gloves and safety shoes) before entering the utility area, for public areas also use the same safety equipment. | Worker using PPE | Ensure cleanliness and proper use of PPE | |

**Figure 3.** WWTP Work Instructions

- Procurement of Signage for Personal Protective Equipment (PPE)

The SHE (Safety, Health, and Environment) department realizes that companies must deliver OHS communications effectively to create a safe work environment [18]. Safety signs play an important role in achievingthis goal. The visual media is useful for:

1. Remind workers of potential hazards and how to avoid hazards in the work area.
2. Give directions to the location where the emergency equipment is stored.
3. Assist workers or other building occupants during the evacuation process in an emergency.
4. Plus points during OHS audit, helping companies to get ISO, OHSAS, etc. certifications.
5. Examples of the use of signage (Occupational Health and Safety signs) in the PTI environment:

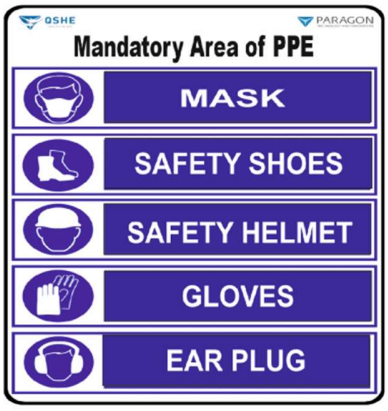


**Figure 4.** PPE Signage

# CONCLUSIONS AND RECOMMENDATIONS

## Conclusions

Based on the results of data processing, analysis, and discussion of the results of research that has been carriedout on the noise level of the Jatake 1 and Jatake 2 Plant areas, it can be concluded as follows:

- Noise measurements in 10 areas at PTI Company obtained results with noise intensity of 46.8 dBA - 103 dBA.
- Noise value in PTI Company at Plant area Jatake 1 and Jatake 2 is colored green which indicates real exposure < 60 dB, yellow color indicates real exposure 70 dB - 85 dB, and red color indicates real exposure > 85 dB.These colors are assumed to be for zoning conditions, green and yellow as safe zones, red as danger zones. The safe zone in the Plant Jatake 1 and Jatake 2 areas has 84 points and the danger zone has 4 points.
- MCU tests on 1574 employees showed as many as 25% had hearing loss and all worked in 4 danger zone points where the noise value exceeded the standard threshold value.

In the future research, it is necessary to conduct research that looks at the effect of hearing loss on work results. And what is the company's strategy to reduce noise caused by engine noise in the room.

## Recommendations

Before installing a new machine, make sure the high risk is equipped with an Occupational Health and Safety Management System. As with this case, it is ensured that the machine is equipped with noise standards that meet the latest government threshold value standards. If this cannot be done, then It can modify the machine by making a silencer cover for the noise source. Make sure all machines are below the preset threshold value.

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