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Environmental Ergonomic Analysis: Understanding Noise Effects on Security and Comfort

Dinda Okta Dwiyanti Ridwan Gucci [1], Muhammad Adi Sukma Nalendra [2], Fauziah Fatma Ramadhani [3]

[1,3] Industrial Engineering Department, Faculty Technology Industry, Institute Technology Batam
Jl. Gadjah Mada, Complex Vitka, Tiban Come on, Batam
E-mail: dinda@iteba.ac.id, 2011039@student.iteba.ac.id

[2] Design Communication Visual Department, Faculty Technology Information, Institute Technology Batam
Jl. Gadjah Mada, Complex Vitka, Tiban Come on, Batam
E-mail: adisukma@iteba.ac.id

ABSTRACT

In activities production PT. XYZ has several forms of production processes. It is a grinding process, which has the potential to give rise to noise coming from the tools used during the production process. The continuous noise produced can damage healthy hearing workers. To know the noise level produced during the grinding process on module 04 and module 05 of the Santos project and calculate the recommended time When exposed to noise. Data collection will use a sound level meter to gauge noise. Data calculations using distribution frequency and counting level noise equivalent (Leq) obtain point noise on Dilinta Sembiring and Saiful above the Threshold Limit Value (NAV), namely 86.87 dBA and 85.35 dBA. Calculated exposure time use method NIOSH recommends that Crossed Sembiring can work for 5 hours 19 minutes and Saiful for 7 hours 37 minutes. If No, use PPE when exposed continuously.

Keywords: *Ergonomics Environment, Noise, Grinding, NOISH*

Introduction

Big cities in Indonesia are already experiencing rapid economic development, including industry. However, growth has a positive impact and harms comfort and safety at work. Usually, the potential danger is sourced from environmental work (physical, chemical, biological), buildings and building installations, materials and production processes, and many more. Many other potential factors can become a source of danger at work. If sources of danger are not controlled precisely, it can give rise to accidents and illnesses as a consequence of work. As for one aspect of source danger in the environment, work is a production process, especially in field fabrication.[1], [2], [3], [4]

In every production process activity in the industry, workers are naturally not free from noise from voice machines, equipment work, and voices from other areas of work that can be done to improve performance in work.[5], [6] Noise is the sound that is not desired by the ear. The deafening sound generated sustainably and continuously can damage the eardrum. [7]Excessive noise level mark threshold can result in emergence disturbance hearing good nature temporary nor permanent If exposed a period prolonged without the use of a tool protector ear. There are two types of hearing disturbance: auditory and non-auditory disorders. Auditory disorders are disturbances directed to hearing humans, and non-auditory disorders such as disturbance in communication, threats of danger safety, declining performance work, stress, and fatigue. Fatigue to workers is usually marked by reduced desire for work caused by monotony, intensity, and duration, as well as work, physical, state environment, mental causes, health status and circumstances, and nutrition.[8], [9], [10] Problem noise at PT. XYZ is moving in the field fabrication caused by the equipment used during work and causes sounds that aren't desired.

PT XYZ Batam is a company operating in specialised fabrication for oil and gas. This company owns several production process activities for making modules, including *grinding*. *Grinding* is one of the activities for polishing existing module areas done welding. This process produces high noise from friction in the rotating tool with the iron module. The intensity noise in the PT fabrication area needs to be analysed based on the matter. XYZ Batam to create an environment comfortable and able to prevent potency danger consequence noise caused by tools work. Based on the noise data on module 28, measured previously, the measurement ranges between 86.25 dBA and 89.07 dBA. From value, the no work on module 028 fulfils Noise Threshold Limit Value (NAB) requirements Kep-51/MEN/1999 and SNI No. 16-7063-2004 if work is done for 8 hours. Study This was carried out on modules 004 and 005, which are new modules produced by PT. XYZ, so the noise level needs to be measured for comparison, and the maximum exposure time must be counted to the noise level generated.

Several previous studies bear similarities to this research, each focusing on the impact of environmental factors such as temperature and noise on cardiovascular function or workplace exposure mapping. For instance, [10], [11], [12] studied for analysis of the Effects of Temperature and Noise on the Cardiovascular System and explored similar themes. Similarly, [11], [12], [13] Mapping and Calculating Noise Exposure Levels in the Wood Processing Industry in Siak District, Riau Province. These studies highlight the varied applications of environmental ergonomics, reflecting the unique challenges different industries face.

Other relevant studies are [14], [15], [16] and [13] Analysis of Noise Levels to Reduce Noise Exposure, which delved into noise reduction strategies within a specific industrial setting. Effine Lourrinx. [17] studied for analysis of Noise Intensity in the Fabrication Area further exemplifies the diverse applications of environmental ergonomics in addressing workplace challenges. Despite employing similar environmental ergonomics approaches, each study's findings vary due to each company's unique contexts and issues.

These prior studies highlight the complexity of environmental ergonomics and its application in diverse industrial settings. The results of noise measurements in these studies often exceeded acceptable thresholds, emphasising the need for further research and intervention. Each company's distinct circumstances contribute to differing outcomes, underscoring the importance of tailored solutions in addressing workplace environmental factors. This research aims to build upon existing knowledge and insights to develop effective strategies for noise reduction and improve overall occupational health and safety.

Research methods

The Environmental Ergonomics Approach

The environmental ergonomics approach to minimising workplace noise involves various strategies and methods to create a safer and more comfortable work environment for employees. One common approach is ergonomic design, which considers workspace layout, material selection, and the use of noise-reducing equipment. For instance, using sound-absorbing materials or strategically placing work equipment can help minimise generated noise.

Environmental ergonomics studies also entail monitoring and evaluating noise levels in the workplace. Researchers use techniques such as noise mapping, decibel measurements, and sound frequency analysis to identify primary noise sources and understand their impact on comfort and job safety. This approach enables the implementation of appropriate corrective measures, such as isolation or workspace redesign, to reduce noise that could potentially harm workers' health and performance.

A relevant study addressing the environmental ergonomics approach to reducing workplace noise can be found in the journal, for in this study, researchers investigated environmental ergonomics strategies for reducing noise in the workplace. They employed a combination of appropriate workspace design and equipment selection to achieve a quieter work environment that supports employee well-being. This study provides valuable insights into applying environmental ergonomics in the context of noise reduction in the workplace [18], [19], [20], [21].

Furthermore, the journal article offers an important perspective on how ergonomic approaches can aid in noise control within work environments. Jones discusses the significance of employing ergonomic principles to design more friendly, noise-free work environments. This study advocates for adopting holistic ergonomic strategies to address noise issues in the workplace, including design approaches, equipment selection, and regular environmental monitoring [22], [23], [24], [25].

Noise is sound that isn't desired from activities and activities in time; certain ones can disturb the health of people and the comfort of the environment. This matter is one condition that needs to be considered in a physically productive work noise environment, with source noise that varies and changes along walking time. Research methods used in the study: This method of analysis measures and calculates noise so that expected information about the ergonomics environment can be given. Work is physically comfortable and safe for workers, and it becomes material evaluation for PT. XYZ Batam. Study This is a quantitative study Because it takes huge data samples. The following are steps research carried out:

1. **Start**

Research location carried out at PT.XYZ Batam in module 04 and module 05 areas with time study carried out on November 25, 2023. With tool supporter study in the form of:

1) *Sound Level Meter*: to measure level noise during grinding.
2) Meter: for measuring distance measurement noise with source noise.
3) *Noted Book*: for taking notes results measurement noise.
4) *Earplugs* and glasses: Use them as protectors when in the measurement area.

2. **Preliminary studies**

At this stage, this observation prefixes to see problems that occur, along with learning problems through reference-related study.

3. **Data collection**

Data collection methods were carried out in two ways: studies, literature searches, and data collected from secondary research previously related to noise. Then, experiments were made with 5 points measurement with adapt duration shift work 1. Time measurements were conducted at 10.30 WIB, 14.00 WIB, 16.00 WIB, and 17.00 WIB—measurement noise on point employee Work near with source noise. Measurement level noise was done for 10 minutes for every point measurement, recording results every 5 seconds.

4. **Data processing**
   Calculation level noise done with use level noise equivalent (Leq) with formulation as follows:
5. **Analysis and Discussion**
   Data analysis was performed on the experiment results, and calculations studied noise from the correct answer, grouped according to the noise level of each point noise and processed in a statistical way. The discussion was conducted to compare the analysed data results with correct answers for each noise level at the studied point. A comparison is made to examine the connection between the Natara results of the experiment.
6. **Conclusion**
   Conclude how much percentage level noise is at each point and give predictions for forever time exposure noise if the level noise is at the mark recommended threshold.

Results and Discussion

Data collection

a. Noise Data Retrieval

Data retrieval in measurement noise was carried out in module 04 and module 05 on the Santos project, with 5 points of source noise made during the grinding *process*. Procedure measurements made during the study are systematic steps. Procedure measurements were made using tools for protection, self-adaptation, provision, security, and safety—work company. Procedures carried out have considered distance safe recommended, i.e., 30cm from source noise.

Figure 1. Measurement process level noise during the grinding

Every measurement must represent every work shift. A representative each time in data collection is as follows:

1. L1 can be taken at 07.00, representing 06.00 – 09.00
2. L2 can be taken at 10.00, representing 09.00 – 14.00
3. L3 can be taken at 15.00, representing 14.00 – 17.00
4. L4 can be taken at 20.00, representing 17.00 – 22.00
5. L5 can be taken at 23.00, representing 22.00 – 24.00
6. L6 can be taken at 01.00, representing 24.00 – 03.00
7. L7 can be taken at 04.00, representing 03.00 – 06.00

Table 1. NAB noise KEP-51/MEN/1999

Duration of Contact in a Day	Noise Limit Maximum
16 hours	82 dBA
8 hours	85 dBA
4 hours	88 dBA
2 hours	91 dBA
1 hour	94 dBA
30 minutes	97 dBA
15 minutes	100 dBA
7.5 minutes	103 dBA
3.75 minutes	106 dBA

1.88 minutes	109 dBA
0.94 minutes	112 dBA
28.12 seconds	115 dBA
14.06 seconds	118 dBA
7.03 seconds	121 dBA
3.52 seconds	124 dBA
1.76 seconds	127 dBA
0.88 seconds	130 dBA
0.44 seconds	133 dBA
0.22 seconds	136 dBA
0.11 seconds	139 dBA
No can	140 dBA

b. Noise Level

Level data noise on each operator and each time measurement on November 25, 2023, is more representative and represented by levels noise equivalent. Example calculation as follows:

Table 2. Noise Level Data Crossed Sembiring at 10.30 WIB

79	92	92	93	93	82	79	83	87	88
79	87	79	83	79	88	84	92	92	85
91	86	85	85	86	80	81	86	91	81
92	80	86	81	79	81	93	93	86	92
92	81	89	88	79	92	94	85	94	79
94	88	94	89	91	89	85	84	92	84
84	84	93	94	92	92	91	79	91	86
89	82	85	80	80	87	92	87	79	81
90	94	84	89	82	92	85	88	91	89
90	81	90	93	83	85	82	82	94	83
83	80	94	85	88	84	94	93	88	88
84	85	83	83	80	90	90	91	90	92

Data processing

There are 120 noise data taken. One *grinding* operator measured for 10 minutes and recording was done every 5 seconds. The data above is taken 1 of 4 times on the same day, namely at 10.30 WIB. The data will be processed using distribution frequency with the formula as follows:

1. Distribution Frequency

Example noise data calculation Crossed Sembiring taken at 10.30:

Calculation amount class =1 + 3.3 x log *n*

1 + 3.3 x log 120 = ***7.8613*** = 8

$$\text{Interval} = \frac{nilai\ maks - nilai\ min}{jumlah\ kelas} = \frac{94-79}{7.8613} = 1.90808 = 2$$

From the results calculation, one can group distribution frequency noise as follows:

Table 3. Distribution Frequency Noise Crossed Sembiring

No	Noisy Intervals		Middle Value	Frequency
1	79	81	80	23
2	82	84	83	20
3	85	87	86	20
4	88	90	89	20
5	91	93	92	28
6	94	96	95	9

2. Noise Level Calculation Equivalent (*Leq*)

From the calculation of the results, distribution frequency is known as mark center and frequency emergence noise from each noisy interval; then,

$$Leq_{\text{avg 8 hours}} = 10\ log\ \frac{\Sigma T_{n\ x\ 10^{0.1\ x\ Leq\ (n)}}}{\Sigma T_n}$$

$$Leq = 10 \log \frac{1}{120} (23 . 10^{0,1\ x\ 80} + 20 . 10^{0,1\ x\ 83} + 20 . 10^{0,1\ x\ 86} \dots\dots\dots\dots\dots\dots + 9 . 10^{0,1\ x\ 95})$$

$$= \mathbf{89.34}$$

Calculations were made for each operator, and measurement level noise was taken at each time. As for recapitulation calculation, Leq carried out on each operator is as follows:

Table 4. Level noise equivalent on November 25, 2023

point operator measurement	level noise equivalent (dBA)			
	time			
	10:30	14:00	16:00	17:00
crossed sembiring	89.34	79.46	79.17	89.57
Yustopan	84.70	82.48	85.25	85.83
risky	83.70	80.61	83.23	87.67
Saiful	86.79	83.78	81.67	86.85
khairul	85.05	81.39	81.40	84.71

Fluctuation level noise on every point measurement can be seen in Figure 2.

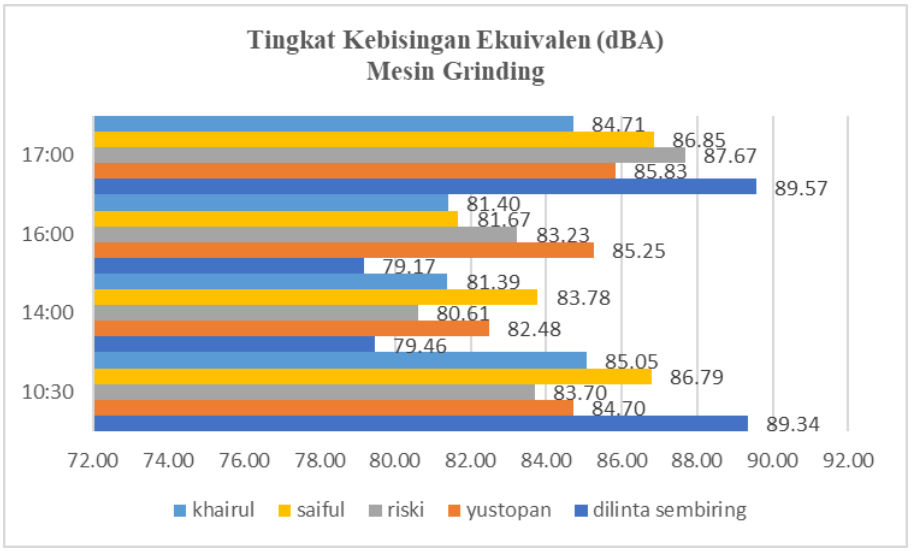

Figure 2. Daytime Noise Levels

Figure 2 shows that operators Dilinta Sembiring and Saiful experienced noise on mark threshold (NAB) KEP-51/MEN/1999 and SNI No. 7063-16-2004. From the graph on Crossed Sembiring, Saiful experienced fluctuating noise so that at the time of measurement, times 10.30 and 17.00 exceeded the mark threshold (NAB) appropriate from the Minister of State for the Environment life provisions.

3. Calculation of Noise Levels During the Day

Calculation level representative noise _ time Afternoon days are also earned using the formula level noise equivalent at 10.30 WIB, 14.00 WIB, 16.00 WIB, 17.00 WIB. Example calculation Leq on time Afternoon as following:

$Leq_{10.30} = 89.34$
$Leq_{14.00} = 79.46$
$Leq_{16.00} = 79.17$
$Leq_{17.00} = 89.57$

$$Ls = 10\ log\ \frac{1}{16}(T_1 10^{0.1\ x\ L1} + T_2 10^{0.1\ xL2} + T_3 10^{0.1\ x\ L3} + T_4 10^{0.1\ x\ L4}) \textbf{(5)}$$

Note: $T_1 = 3$, $T_2 = 5$, $T_3 = 3$, $T_4 = 5$

So,

$$Ls = 10\ log\ \frac{1}{16}(3\ .\ 10^{0.1\ x\ 89.34} + 5\ .\ 10^{0.1\ x 79.46} + 3\ .\ 10^{0.1\ x\ 79.17} + 5\ .\ 10^{0.1\ x\ 89.57})$$

$= 86.87$

Following recapitulation level noise at times Afternoon of 5 *grinding operators:*

Table 5. Noise Levels During the Day

Point Operator Measurement	Ls (dBA)	NAV (dBA)	Reduction (dBA)
Crossed Sembiring	86.87	85	1.87
Yustopan	84.67	85	0
Risky	84.80	85	0
Saiful	85.35	85	0.35
Khairul	83.45	85	0

After doing the calculation level noise equivalent at noonday, also done calculation high level, the noise will be reduced to the Threshold Limit Value (NAB) by the decision of the Minister of State for the Environment Live no.48 of 1996. Changes in level noise on every point measurement can see in Figure 3.

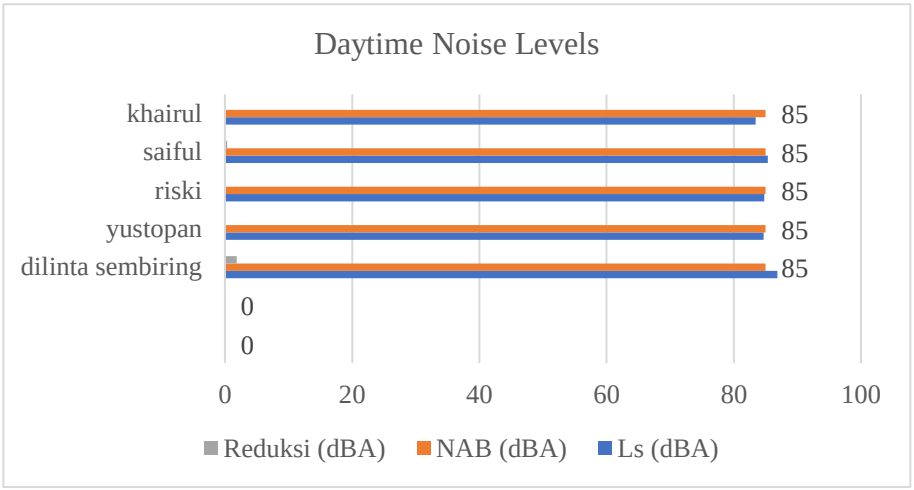

Figure 3. Daytime Noise Levels

From the picture obtained, the *grinding* operators Named Dilinta Sembiring and Saiful experienced level noise on mark threshold (NAB) kep-51/MEN/1999 and SNI 16-7063-2004. From the graph, the level of noise-exposed to Dilinta Sembiring's mark is 86.87 dBA. da Saiful has a mark of 85.35 dBA. With so, the period location from noise Crossed Sembiring and Saiful are located in the condition. They are not safe.

4. Analysis of Allowable Operator Working Time with Use Formula *NOISH*

For every point measurement's level, the noise varies, so in each point, the own time work/exposure different maximums. _ Based on the minister's decision, power work number kep-51/MEN/1999, concerning maximum limits of exposure noise in the work area, the obtained level limits different noise. Use the formula as follows:

Example calculation time work on level noise crossed sembiring

$$T = \frac{480}{2^{(L-85)/3}}$$

$$T = \frac{480}{2^{(L-85)/3}}$$

$$T = \frac{480}{2^{(86,87-85)/3}} = 311 \text{ minutes} = 5.19 \text{ hours}$$

Noise resulting from using tools from a machine grinder piles up loud sounds in a way that keeps going continuously. On point noise processing *grinding* Crossed Sembiring, it is known that calculation distribution frequency generates class intervals equal to 2 with amount class < 8, with frequency appearance noise in the interval 91-93 dBA 28 times. Then, a calculation of the level noise equivalent to the *grinding process* Crossed Sembiring and known own level noise on mark threshold (NAB) on representation time 10.30 WIB and 17.00 WIB is 89.34 dBA and 89.57 dBA, which is Enough dangerous If noise Keep going continuously appear without use silencer voice.

Calculation time permitted work using the worker NOISH method, which only allowed exposed noise in a row for a maximum of 5 hours 19 minutes if there was no use of PPE or effort subtraction noise. On point: This own mark is the highest exposed noise and was identified as unsafe if done during regular working hours, namely eight working hours. Following is the recapitulation calculation time permitted work When exposed to noise at 5 points:

Table 6. Recapitulation time permitted work use method NOISH

Point Operator Measurement	Ls (dBA)	NAV (dBA)	T (Hour)
Crossed Sembiring	86.87	85.00	5.19
Yustopan	84.67	85.00	8.63
Risky	84.80	85.00	8.38
Saiful	85.35	85.00	7.37
Khairul	83.45	85.00	11.45

From the table above, it is known that time permitted work _ after with use method *NOISH* For Crossed Sembiring and Saiful only for 5 hours 19 minutes and 7 hours 37 minutes If exposed without wearing PPE. This is very dangerous if the grinding operator is exposed to noise in a way that keeps going continuously.

Conclusion

The noise level in area module 04 and module 05 at PT XYZ only partially fulfils standard noise according to Kep-51/MEN/1999, namely 85 dBA if work is done for 8 hours. The calculation results in level noise equivalent show that Named worker diligent Sembiring and Saiful have level noise crosses the Threshold Limit Value (NAV), i.e., 86.87 dBA and 85.35 dBA. Yustopan, Riski, and Khairul have a noise level of 84.67 dBA, 84.80 dBA, and 83.45 dBA. But still, one must wear PPE to avoid damage from continuously hearing the consequences of occupation. From the results, the measurement level noise made and the recommended time work according to calculation *NOISH* is different at each point. The two points with the highest noise level also have time for work, which is allowed differently. Crossed Sembiring obtained time for the most extended work, around 5 hours 19 minutes, and Saiful earned the longest, around 7 hours 37 minutes. With This, module 028 and module 004-005 have levels of the same noise above the Threshold Value. This matter needs attention, especially from the *grinding* operator. Always use Personal Protective Equipment (PPE) in the form of *earplugs* or silencer voice to reduce disturbance hearing.

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