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PROPOSED IMPROVEMENT OF OCCUPATIONAL SAFETY HEALTH IN GAMELAN WIRUN PALU GONGSO INDUSTRY USING PARTICIPATORY ERGONOMICS APPROACH

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ABSTRACT

Gamelan Wirun Palu Gongso Industry is one of the businesses in the informal sector that produces several gamelan instruments such as gong, bonang, and kempul that has not paid attention to occupational safety and health (OSH). Based on observations, there are unsafe behaviors and conditions, health problems, and accidents experienced by workers. This study aims to identify hazards in the workplace, determine the highest priority of hazards to be solved, and then provide recommendations for improvement based on the priority. A participatory ergonomic approach is used to solve the problems in this study. ILO-PATRIS Check Sheet is used to identify hazards in the workplace. The Delphi method determines the hazards with the highest priority for improvement. The Delphi method is a group of interaction processes between researchers and a group of experts identified on a particular topic, usually asking a question that allows a communication process to discuss complex problems but does not allow attending in one meeting. The result of the ILO-PATRIS Check Sheet shows 19 sub-aspects in the workplace that need improvements.

Based on the result of the Delphi method, priority for improvement is found in the noise sub-aspect. With the elimination, substitution, engineering control, administrative control, and the use of PPE, proposed improvements will be focused on controlling noise in the workplace.

Keywords: Participatory ergonomics, ILO-PATRIS check sheet, occupational safety and health, delphi method.

INTRODUCTION

Occupational Safety and Health (OSH) is an aspect that must be applied everywhere, one of which is the workplace. There are three reasons for the importance of OSH for workers and companies. That are morality, legislation, and economy (Sunyoto, 2012). The informal industry in Indonesia currently absorbs much labor. Until the end of February 2018, the number of people working in the informal sector was more dominant than the population working in the formal sector, which amounted to 73.98 million people or 58.22% (Statistik, 2018). The increased attention to OSH should offset the high number of people working in the informal sector, but in reality, many informal industries still pay less attention to the OSH aspect. Gamelan Wirun Palu Gongso Industry is one of the businesses in the informal sector that produces several gamelan instruments such as gong, bonang, and kempul. Based on the preliminary observations, conditions that do not heed OSH were obtained. One of the working conditions that potentially harm workers' health is found in the smelting process. During the smelting process, the workers do not wear a dust mask as personal protective equipment, while smoke and dust exposure can cause breathing problems. In addition to smelting, the forging, pemetakan, and finishing processes also have risks for the health and safety of workers. During the forging, pemetakan, and finishing process, noise exposure is caused by forging the gamelan and grinder. The noise level reaches 96 dB for the forging process, 93 dB for the pemetakan process, and 96.2 dB for the finishing process. The workers still do not use hearing protection as their protective equipment. These conditions can lead to hearing loss for the workers.

This study aims to improve OSH conditions in Gamelan Wirun Palu Gongso Industry. This study uses one of the primary methodologies in macro ergonomics, the participatory ergonomics approach (Hendrik and Robertson, 2002). Participatory ergonomics has been defined with several different meanings but complete each other. Participatory ergonomics can be considered a philosophy, approach, strategy, program, or set of tools and techniques (Salvendy and Karwowski, 2021). Participatory ergonomics also has a meaning as the active involvement of workers in ergonomic knowledge and procedures in the workplace and supported by supervisors and managers who aim to improve working conditions and product quality (Nagamachi, 1995). Another definition of participatory ergonomics is practical ergonomics, with worker participation needed in problem-solving (Kuorinka, 1997). A participatory ergonomics approach can increase workers' sense of ownership of ideas or solutions, leading to a significant commitment to implementing changes (Imada and Robertson, 1987). Evaluation of working conditions to identify potential hazards in the workplace is carried out using the International Labor Organization-Participatory Action Training for Informal Sector (ILO-PATRIS) Check Sheet that ILO-IPEC developed to improve OSH condition and the work environment in the informal footwear sector (Markkannen, 2003). After evaluating working conditions, priority hazards will be selected. The Delphi method involves workers and owners and will be used to select potential hazards. The Delphi method is a group of processes that involve interactions between researchers and a group of experts identified on a particular topic, usually through a series of questionnaires (Yousuf, 2007). The next stage is preparing proposed improvements based on potential hazards with the highest priority. Several studies related to participatory ergonomics approaches have been done before. A study aimed to identify and reduce the risk of work-related musculoskeletal disorders experienced by loading finished goods operators (Aznam et al., 2017). Improvement to hazardous work postures on loading of finished goods operators are carried out with ergonomic interventions,

namely participatory ergonomics by focus group discussions and always involve ergonomics teams consisting of management and operator representatives. Another study using a participatory ergonomics approach was also conducted to determine the potential hazards that could cause accidents in the cutting and laminating department at PT Primarindo Asia Infrastructure Tbk (Sukapto et al., 2016). The main problem in that shoe company is developing an OSH management system to improve the safety and health of workers. The participatory ergonomics approach was used in the study as a forum to accommodate the aspirations of all parties carried out by discussion and a direct approach between researchers who act as OSH experts, managers, and employees. A study on participatory ergonomics interventions in the furniture business in Brazil was also conducted (de Macedo Guimarães, 2015). The research aims to improve ergonomic comfort and production results. In this study, workers were involved in the stage of problem identification design and evaluation of solutions. A study of participatory ergonomics in small enterprises that produce crackers was also conducted (Hidayat and Purnomo, 2014). Participatory ergonomics was used in that study to design cracker dryer machines. The participatory ergonomics approach stage included initial interviews to obtain constraint on the production process, group discussions with owners and employees to find solutions, and the design of dryers to implement the results of discussions that had been conducted. Research on methods for evaluating conditions at work using an ergonomics checklist has also been carried out. A previous study used ergonomic checkpoints to evaluate conditions at the printing work station in the Merak Manis batik industry (Suhardi et al., 2016). Another study using ergonomics checkpoints was also conducted to evaluate the working conditions in Yessy's shoe industry (Sidiq, 2016). The ILO-IPEC Footwear Program Team and Markkannen used ILO-PATRIS Check Sheet to evaluate working conditions in the Cibaduyut informal footwear sector industry (Markkannen, 2003).

METHODOLOGY

The participatory ergonomics approach guides the research to obtain optimal employee involvement in improving OSH conditions. The method in this study refers to the framework of the participatory ergonomics approach shown in Figure 1. The sustainability of the participatory ergonomics approach is only temporary at the time of the study. Improving OSH conditions using participatory ergonomics affects not only specific workstations or workgroups but the whole organization. The research began with a literature study and field study. The field study was conducted by observing the workplace to understand the production process flow and the problems in Gamelan Wirun Palu Gongso Industry. Then continued with the problem identification stage, formulating the problem, setting study objectives, determining the benefits of the study, and determining the problem boundaries.

The next step is data collection. The data collection stage is done through interviews and observations. At this stage, the data collected includes the production process sequence, worker's health problems, work accidents, near misses, and assessment of working conditions using the ILO-PATRIS Check Sheet. Based on the participatory ergonomics framework, which is the focus dimension, the assessment of working conditions using the ILO-PATRIS Check Sheet focuses on work equipment, work process, and organization in the workplace. Some workers, as a representative, will be directly involved in a discussion to assess the current working conditions. At this stage, 29 sub-aspects of the workplace were assessed to identify potential hazards in the workplace. After the necessary data are collected, the next step is data processing. Data processing includes a recapitulation of working condition assessment, determining the priority of potential hazards, and preparing proposed improvements based on priorities of potential hazards.

In determining the priority of potential hazards, one of the techniques to reach consensus in a group, the Delphi method, is used (Giannarou and Zervas, 2014). An instrument implemented the Delphi method in this study in the form of a Likert questionnaire containing an assessment of the importance of sub-aspects that require improvement according to the assessment of the ILO-PATRIS Check Sheet. Six respondents are five workers, and one owner will be involved in the

Delphi method. The Delphi method in this study was carried out in two rounds, considering the requirement for consensus standard deviations below 1.5 and IQR values below 2.5 (Christie and Barela, 2005; Kittell-Limerick, 2005). The proposed improvement focuses on the potential hazards with the highest average score in the Delphi method. During the preparation of the proposed improvement, an ergonomist is a consultant who provides recommendations and input related to the improvement. The next stage is analyzing and interpreting the data results that have been processed. The last step is concluding the research and suggestions for the company and further research. In this study, a participatory ergonomics approach is used. The framework of participatory ergonomics used in this study can be seen in Fig. 1.

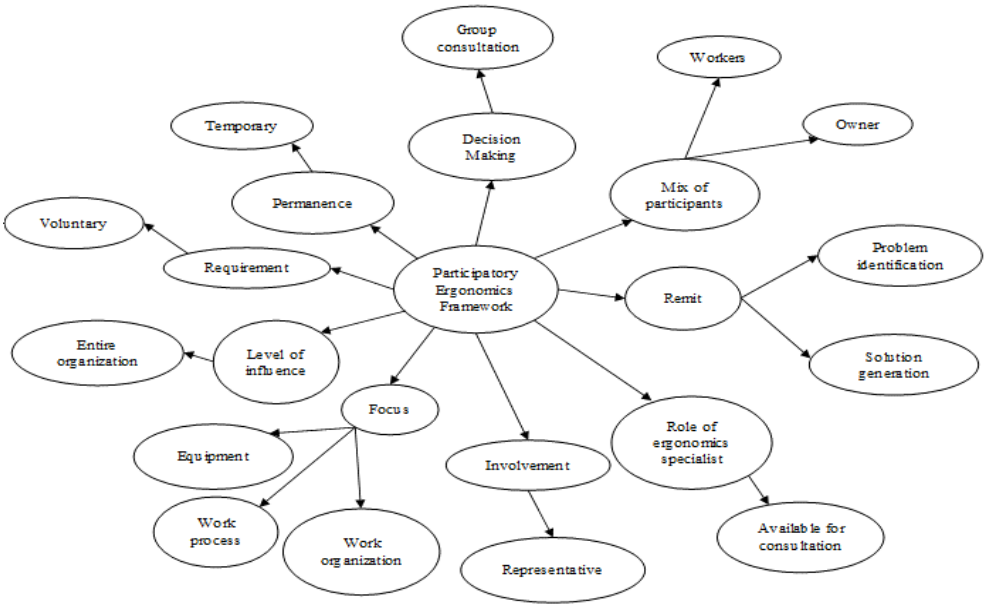

Figure 1. *The Participatory Ergonomics Framework Used in This Study (Haines et al., 2002)*

Figure 1 explains the participatory ergonomics framework used in this study. The participatory ergonomics framework was modified by referring to the dimensions of the ergonomics framework according to Haines et al. (2002). There are nine dimensions of the ergonomics framework and categories for each dimension. The framework is used to guide this research to achieve the expected goals.

RESULT AND DISCUSSION

Gamelan Wirun Palu Gongso Industry produces several types of gamelan, such as kempul, gong, bonang, and kenong. The process production for several types of gamelan is the same, and the difference is in the difficulty level and processing time. The larger the gamelan, the more complex and the more prolonged the required processing time. The sequence of the gamelan production process is shown in Figure 2: a) Material Preparation (lead and copper), b) Smelting, c) Molding, d) Forging, e) Pemetakan, f) Finishing, g) Tuning.

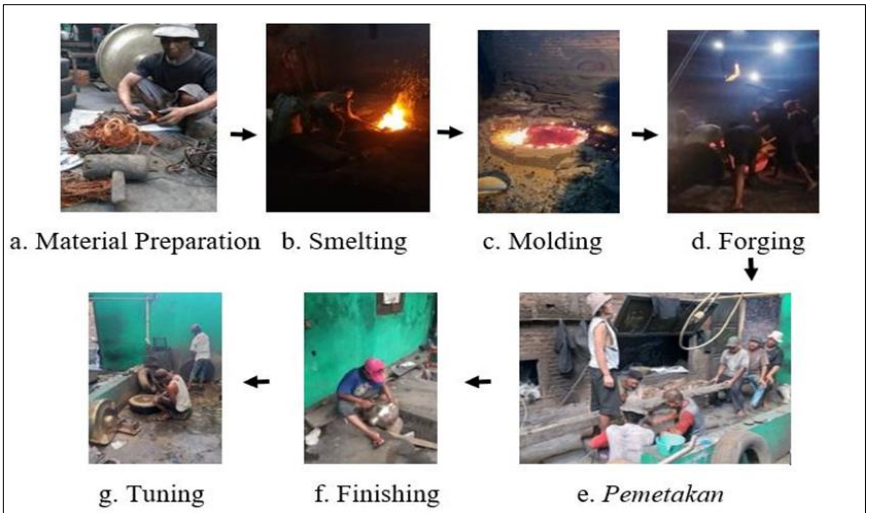

Figure 2. *Gamelan Production Process*

Table 1.

Floating-point operations necessary to classify a sample

Health Problems	Worker Frequency	Percentage (%)
Pain in the waist	7	87.5
Pain in the back	7	87.5
Pain in the shoulder	7	87.5
Pain in the arm	1	12.5
Headache	3	37.5
Cough	3	37.5
Blown	2	25
Hearing loss	6	75
Eye irritation	7	87.5

In addition to health complaints, eight workers' interviews were conducted to obtain data on work accidents and near misses that workers had experienced during the past year working in Gamelan Wirun Palu Gongso Industry. Data about work accidents and near misses can be seen in Table 2.

Table 2.

Work Accidents and Near Miss Experienced By Workers

Work Accidents / Near miss	**Worker Frequency**	**Percentage (%)**
Blistered skin exposed by sparks	6	75
Fall or almost fall at the workplace	3	37.5
Struck down by working tools	1	12.5
Injured due to working tools	5	62.5
Swollen elbow (hit by hammer)	3	37.5
Shocked by electricity	1	12.5

Working conditions are assessed using the ILO-PATRIS Check Sheet by observing, documenting, and discussing with several workers, then determining the scores for each sub-aspect. Sub-aspects that require significant improvement will be given a score of 0. Sub-aspects that require minor improvement will be given a score of 1. At the same time, sub-aspects that do not require improvement (satisfactory) will be given a score of 2. This assessment of working conditions will

generate several sub-aspects that need improvement (sub- aspects with scores of 0 and 1) because they can harm the health and safety of workers. Recapitulation of working condition assessment using ILO-PATRIS Check Sheet can be seen in Table 3.

Table 3.

Recapitulation of Working Condition Assessment

Monitoring Item	Maximum Number of Scores (Number of Sub Aspects x 2)	Total Score	Percentage of Accomplishment
Physical Environment	10	2	20%
Premises	16	6	38%
Welfare Facilities	8	7	88%
Ergonomics	8	4	50%
Equipment	2	1	50%
Work Organization	6	6	100%
Personal Protective Equipment	2	0	0%
Daily Management	6	4	67%

Based on the assessment of working conditions using the ILO-PATRIS Check Sheet, 19 sub-aspects have a score below 2 (0 and 1), which means that these sub-aspects require both major and minor improvements. Delphi method will determine the most priority sub-aspects to be improved. In Delphi method round 1, six respondents were given a summary of the assessment of working conditions using the ILO-PATRIS Check Sheet as the consideration to fill the Delphi questionnaire. Then participants were asked to fill out the Likert questionnaire with a score scale of 1 to 5. Score 1 means very unimportant, score two means not important, score three means less important, score four means necessary, and score 5 means very important. The questionnaire used in the Delphi method in this study can be seen in Table 4.

Table 4.

Likert Questionnaire Used in Delphi Method

No	Aspects in Gamelan Wirun Palu Gongso Industry That Need Improvement	Score				
1	Dust	**1**	**2**	**3**	**4**	**5**
2	Chemicals	**1**	**2**	**3**	**4**	**5**
3	Noise	**1**	**2**	**3**	**4**	**5**
4	Temperature	**1**	**2**	**3**	**4**	**5**
5	Lighting	**1**	**2**	**3**	**4**	**5**
6	Fire prevention	**1**	**2**	**3**	**4**	**5**
7	Material storage and handling	**1**	**2**	**3**	**4**	**5**
8	Housekeeping/general order cleanliness	**1**	**2**	**3**	**4**	**5**
9	Waste disposal	**1**	**2**	**3**	**4**	**5**
10	Walls	**1**	**2**	**3**	**4**	**5**
11	Floor/stairs	**1**	**2**	**3**	**4**	**5**
12	Drinking water	**1**	**2**	**3**	**4**	**5**
13	Hazardous postures	**1**	**2**	**3**	**4**	**5**
14	Seat	**1**	**2**	**3**	**4**	**5**
15	Working surfaces	**1**	**2**	**3**	**4**	**5**
16	Working tools or machines	**1**	**2**	**3**	**4**	**5**

17	Shoes, gloves, masks, glasses, etc	**1**	**2**	**3**	**4**	**5**
18	First aid	**1**	**2**	**3**	**4**	**5**
19	Delegation of safety responsibilities to workers	**1**	**2**	**3**	**4**	**5**

After all, respondents have filled out the questionnaire, the value of IQR and standard deviations will be calculated to determine the consensus. The following is an example of standard deviation calculation:

$$Std\ Dev = \sqrt{\frac{\sum(xi - \bar{x})^2}{n-1}} \quad (1)$$

$$Std\ Dev = \sqrt{\frac{0{,}11 + 0{,}11 + 0{,}44 + 0{,}11 + 0{,}44 + 0{,}11}{6-1}}$$

$$Std\ Dev = 0.52$$

The following is an example of IQR calculation :

$$IQR = Q3 - Q1 \quad (2)$$

$$IQR = 5 - 4$$

$$IQR = 1$$

The result of the Delphi round 1 is shown in Table 5. It can be seen that four sub-aspects have not reached a consensus. Those are chemical, temperature, seating, and first aid facilities.

Table 5.

Delphi Round I Data Processing Result

Sub Aspects	Respondent						Average	Std. Dev	Q1	Q2	Q3	IQR	Evaluation	
	1	2	3	4	5	6							Std. Dev	IQR
Dust	4	4	5	4	5	4	4.33	0.52	4	4	5	1	con	con
Chemicals	4	3	5	2	5	1	3.33	1.63	2	4	5	3	div	div
Noise	3	4	4	4	3	4	3.67	0.52	3	4	4	1	con	con
Temperature	1	2	3	1	5	1	2.17	1.60	1	2	3	2	div	con
Lighting	1	3	3	1	4	3	2.50	1.22	1	3	3	2	con	con
Fire prevention	2	2	3	3	3	1	2.33	0.82	2	3	3	1	con	con
Material storage and handling	2	4	3	3	5	2	3.17	1.17	2	3	4	2	con	con
Housekeeping/cleanliness	3	4	4	5	3	4	3.83	0.75	3	4	4	1	con	con
Waste disposal	1	2	3	3	3	2	2.33	0.82	2	3	3	1	con	con

Walls	2	2	2	2	1	3	2.00	0.63	2	2	2	0	con	con
Floor/Stairs	3	3	5	4	3	3	3.50	0.84	3	3	4	1	con	con
Drinking water	2	3	3	5	4	2	3.17	1.17	2	3	4	2	con	con
Hazardous postures	2	2	3	2	3	2	2.33	0.52	2	2	3	1	con	con
Seat	3	1	4	1	5	2	2.67	1.63	1	3	4	3	div	div
Working surfaces	1	4	2	2	3	1	2.17	1.17	1	2	3	2	con	con
Working tools or machines	2	5	3	4	3	2	3.17	1.17	2	3	4	2	con	con
Shoes, gloves, masks, glasses, etc	5	4	3	4	5	3	4.00	0.89	3	4	5	2	con	con
First aid	1	3	1	2	5	4	2.67	1.63	1	3	4	3	div	div
Delegation of safety responsibilities to workers	4	4	4	4	5	4	4.17	0.41	4	4	4	0	con	con

Note : con = convergent (reach consensus)
div = divergent (does not reach consensus)

In Delphi method round 2, six respondents who were the same as in the first round of the Delphi method were given the summary of the first Delphi. That summary shows the average score for each sub-aspect. The summary is used as the consideration to fill the questionnaire in Delphi round 2. Respondents can improve their view of the importance of improvement in 19 sub-aspects using the same Likert questionnaire as the Delphi round 1. Like Delphi round 1, IQR and Standard deviation are also calculated to determine the consensus. The calculation of IQR and Standard deviation in Delphi round 2 are the same as in Delphi round 1. Delphi round 2 shows a better result than Delphi round 1 because only one sub-aspect that does not reach a consensus is the seat sub-aspect. After obtaining 18 sub-aspects that have reached the consensus, the next step is to determine the rank of aspects based on the average value of each sub-aspect from Delphi round 2. The ranking of sub-aspects can be seen in Table 6.

Table 6.

Ranking of Sub-Aspects

Sub-Aspects That Need Improvements	Average	Ranking
Noise	4.67	1
Dust	4.50	2
Housekeeping/general order cleanliness	4.50	3
Shoes, gloves, masks, glasses, etc	4.50	4
Delegation of safety responsibilities to workers	4.33	5
Floor/stairs	3.67	6
Chemicals	3.50	7
Material storage and handling	3.33	8
Waste disposal	3.33	9
Working tools or machines	3.33	10
Hazardous postures	3.17	11

First aid	3.17	12
Lighting	3.00	13
Work surfaces	3.00	14
Temperature	2.83	15
Fire prevention	2.83	16
Drinking water	2.83	17
Walls	2.50	18

Based on the ranking of sub-aspects, noise is a sub-aspect with the highest priority for improvement. So, in this study, the proposed improvement will focus on noise control in the workplace. Noise occurs in 3 processes: forging, pemetakan, and finishing, using a grinder machine. Noise control will be carried out in each process through several stages. The stages include elimination, substitution, engineering control, administrative control, and the use of PPE. In the forging process, noise is produced from two sources, gamelan forging activity and other processes that coincide with the forging process, that is, the finishing process using a grinder. Noise level and duration of noise exposure felt by workers in the forging process can be seen in Table 7.

Table 7

Noise at Forging Process

Noise Level	Type of Noise	Duration of Exposure per day (minute)	Allowed Daily Exposure Duration (minute)	Note
96	Continue	240	40	Affected by the noise of grinding machine
95,6	Repetitive Impulsive	300	44	Does not affected by the noise of the grinding machine

In the forging process, the elimination stage until administration control controls the noise can not be made, so the last stage to control the noise is using personal protective equipment as a hearing protection device. The proposed type of hearing protection device is an earplug and can be seen in Table 8.

Table 8.

Proposed Hearing Protection Device For Workers in Forging Process

Work Station / Process	**Hearing Protection**	**Brand**	**NRR**	**Unit Price**	**Picture**
Forging	Earplug	Besgard	30 dB	Rp 32,000	

The proposed improvement by procuring hearing protection devices for workers in the forging process made Gamelan Wirun Palu Gongso Industry have to purchase earplugs for ten workers, costing Rp 320,000 per month, because the earplugs have to be replaced within a month. In the

pemetakan process, noise is generated from gamelan hitting/forging activity. Noise level and duration of noise exposure felt by workers in the pemetakan process can be seen in Table 9.

Table 9

Noise at Pametakan Process

Noise Level	**Type of Noise**	**Duration of Exposure per day (minute)**	**Allowed Daily Exposure Duration (minute)**	**Note**
93	Repetitive Impulsive	60	70	No impact from other sources

Table 10

Noise in Finishing Process

Noise Level	Type of Noise	Duration of Exposure per day (minute)	Allowed Daily Exposure Duration (minute)	Note
96,2	Continue	240	38	No impact from other sources

In the finishing process, noise control cannot be carried out from the elimination stage until the engineering control stage. The next stage of noise control is administrative control. Administrative control is done by making Standard Operating Procedure (SOP) that requires the worker to turn off the grinding machine after working for 30 minutes, and then that worker has to leave the noisy working area for 5 minutes. The time off between work hours is intended so the workers are not continuously exposed to noise exceeding the noise exposure limit. The proposed SOP for the finishing process can be seen in Table 11.

Table 11

Proposed SOP for Gamelan Finishing Process Using Grinder

STANDARD OPERATING PROCEDURE
GAMELAN FINISHING PROCESS USING GRINDER

GENERAL

The process of finishing the gamelan using a grinder is a process that aims to change the appearance of the gamelan, which was initially not shiny because the combustion process becomes shiny due to the grinding of the gamelan surface.

TOOLS NEEDED

- Grinder
- Water Hose
- Gloves
- Earmuff
- Safety Goggles

WORKING INSTRUCTION

- Prepare the gamelan to be ground and place it in the finishing work area

- Use personal protective equipment (gloves, earmuff, and safety goggles)
- Check the condition of the grinder
- Turn on the grinder
- Polish gamelan surface using the grinder
- Drain the water on the surface of gamelan during the grinding process
- Turn off the grinder after working for 30 minutes
- Take personal protective equipment off (gloves, earmuff, and safety goggles)
- Come out of the noise work area
- Take a rest outside the noise work area for 5 minutes
- Back to the finishing work area
- Repeat step 2 until step 11 to complete the gamelan finishing process using a grinder.

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Noise control in the finishing process does not stop at administrative control. Noise control using personal protective equipment as a hearing protection device is still carried out to reduce the risk of noise to workers' health. The proposed type of hearing protection device is an earmuff and can be seen in Table 12

Table 12

Proposed Hearing Protection Device For Workers in Finishing Process

Work Station / Process	Hearing Protection	Brand	NRR	Unit Price	Picture
Finishing	Earmuff	Krisbow	35 dB	Rp 193,000	

CONCLUSION

The result of the working condition assessment using the ILO-PATRIS Check Sheet, which involves workers' participation, found 19 sub-aspects as hazards. The result of determining the priority of improvement by the Delphi method obtained the noise sub-aspects with the highest average score. So, the proposed improvement is focused on controlling noise at work. Noise control is carried out in 3 processes. That processes are forging, pemetakan, and finishing using a grinder. Noise control can be done in the forging and pemetakan process using an earplug as a hearing protection device. Meanwhile, noise control that can be done in the finishing process using a grinder is making an SOP that requires workers to take a break and leave the noisy work area after working for 30 minutes. Workers in the finishing process using a grinder are also required to use earmuffs as a hearing protection device.

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