

SURAT TUGAS

Nomor: 383-R/UNTAR/PENELITIAN/XII/2023

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Judul	: Analysis of occupational safety and healthy risk using job safety analysis (JSA), AS/NZS 4360:2004, and failure mode and effect analysis (FMEA) on public street lighting poles process at PT indalux Enterprindo
Nama Media	: Proceeding of the 4th Tarumanagara International Conference of the Applications of Technology and Engineering (TICATE) 2021
Penerbit	: AIP Conference Proceeding
Volume/Tahun	: Volume 2680 / Issue 1 / 7 Desember 2023
URL Repository	: https://pubs.aip.org/aip/acp/article-abstract/2680/1/020172/2928566/Analysis-of-occupational-safety-and-healthy-risk?redirectedFrom=fulltext

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RESEARCH ARTICLE | DECEMBER 07 2023

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Lamto Widodo ✉; I. Wayan Sukania; Gerry Williekumaro



AIP Conf. Proc. 2680, 020172 (2023)

<https://doi.org/10.1063/5.0128195>



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Analysis of Occupational Safety and Healthy Risk Using Job Safety Analysis (JSA), AS/NZS 4360:2004, and Failure Mode and Effect Analysis (FMEA) on Public Street Lighting Poles Process at PT Indalux Enterprindo

Lamto Widodo^{1,2, a)} I Wayan Sukania^{1,2, b)} and Gerry Williecumaro^{1, c)}

Author Affiliations

¹*Industrial Engineering Department, Universitas Tarumanagara, Jl. Letjen S.Parman No.1, Jakarta 11440, Indonesia*

²*Work System Design and Ergonomic Laboratory, Industrial Engineering Department, Universitas Tarumanagara, Jl. Letjen S.Parman No.1, Jakarta 11440, Indonesia*

Author Emails

^{a)} *Corresponding author: lamtow@ft.untar.ac.id*

^{b)} *wayans@ft.untar.ac.id*

^{c)} *gerry.rzw@fti.untar.ac.id*

Abstract. PT. Indalux Enterprindo is a make to order company engaged in manufacturing which produces public road lighting poles. All operational activities carried out at PT. Indalux Enterprindo has a variety of potential hazards to occupational safety and health. Company data shows that there were 17 cases of work accidents in 2019. Thus, corrective action needs to be taken to avoid losses. This study used the Job Safety Analysis (JSA) method, then carried out risk analysis and assessment using the AS/NZS 4360: 2004 semi-quantitative risk analysis method and Failure Mode and Effect Analysis (FMEA) to determine the level of occupational safety and health risks in the production department. Based on the JSA stages, there are 14 potential hazards in the Public Street Light Pole (PJU) production process and 21 potential hazards in the Indalux Antik Pole (TIA) production process. From the calculation of the risk assessment, the risk of work accidents is high, namely the hands/fingers are cut by the shearing machine, the hands/fingers are caught in the bending machine, are exposed to sparks and inhaled iron powder, the eyes are exposed to sand powder, hit by steel, and respiratory problems due to the smell of paint. The implementation that was applied was the installation of a warning sign and a proposed work instruction plan.

Keywords: Occupational Health and Safety, Job Safety Analysis (JSA), AS/NZS 4360:2004, Failure Mode and Effect Analysis (FMEA)

INTRODUCTION

An industrial company is one of the businesses that will move continuously to keep up with the times. Not a few new competitors have sprung up and many companies have had to go out of business. Industrial companies must always think of various ways in order to remain competitive in a large market so that they can last a long time. Not only thinking about the sustainability of the company, but the company must also pay attention to the sustainability of workers in industrial companies. The safety and health of workers will greatly affect the company's production process and the company's survival.

Work safety is safety that is related to engines, aircraft, work tools, materials and their processing processes, workplaces and their environment and ways of doing work. Work safety can also be interpreted as an effort or activity to create a safe work environment and prevent all forms of accidents that may occur. Work safety applies in all workplaces, whether on land, at sea, on the surface of the water, in the water or in the air. Such workplaces are scattered in economic activities, agriculture, mining industry, public works transportation, services and others [1].

A work accident is an accident that occurs when someone is doing work. A work accident is an unplanned event caused by an act of carelessness or an unsafe condition or both. Work accidents happen to someone because employees act carelessly and often create unsafe conditions. If a worker gets a work accident usually the ability to make a living is temporarily lost. Work accidents can cause a person to become disabled or injured [2]. Health and safety factors affect worker productivity. Affecting factors include hot environmental conditions, noisy environments, lack of resources and facilities. Found between indicators of productivity and health and organizational attributes. Lack of skills in ergonomics and training, communication and resources are believed to be some of the factors contributing to poor ergonomic conditions and consequently loss of worker productivity and deterioration of health and safety in the industry[3].

In a business activity, risk is something that cannot be avoided. Risk is indeed a natural thing in business activities. Given the uncertainty regarding the occurrence of risks, individuals and institutions, they should try to establish anticipatory steps to deal with that risk [4].

To identify risks, several methods can be used, including JSA, inspection, check list, HAZOPS, FMEA, audit, critical incident analysis, FTA, event tree analysis, qualitative analysis, semi-quantitative analysis, and quantitative analysis [5] [6]- [9]. Several studies have been carried out to analyze occupational safety and health risks using the JSA method, semi-quantitative analysis and FMEA [10] [11] -[13] . This method is suitable to be applied to find out what causes accidents at each stage and what level of risk is the highest so that prevention can be sought.

PT. Indalux Enterprindo is a make to order company engaged in manufacturing which produces public road lighting poles. All operational activities carried out at PT. Indalux Enterprindo has various kinds of potential occupational safety and health hazards because it involves various activities using tools and machines and power tools. The company has prepared Personal Protective Equipment (PPE), but according to the results of observations, many workers do not use the complete PPE according to company regulations. As a result, there were many accidents experienced by workers at PT. Indalux Enterprindo. The head of the production floor said that so far there has been no discipline on the use of PPE. According to the results of interviews with several workers, some PPE was missing and some were no longer suitable for use.

The number of work accidents that occurred at PT. Indalux Enterprindo in 2019-2020 can be seen in Table 1 below.

TABLE 1. Work Accident Data at PT. Indalux Enterprindo (2019-2020)

No	Types of Work Accidents	Number of Accident
1	Eyes exposed to iron powder	4
2	Eyes exposed to powdered sand	3
3	Exposed to welding sparks	2
4	Hand pinched in the tool box	1
5	Finger is injured while drilling	1
6	Hand hit the hammer while making the mold	1
7	Hand hit by grinding tool	1
8	Hand pinched by steel material	2
9	Foot hit by hammer	1
10	Hand caught by steel material	1

Based on the above problems, the authors are interested in analyzing occupational safety and health risks and trying to reduce the number of work accidents in the production department at PT. Indalux Enterprindo.

RESEARCH METHODOLOGY

This research was conducted at PT. Indalux Enterprindo, a company that produces public road lighting poles. The research is focused on the production process of public road lighting poles. The research begins with field observations and interviews with the head of the production floor. The methods used are Job Safety Analysis (JSA), AS/NZS 4360:2004, and Failure Mode and Effect Analysis (FMEA). This study examines recommendations for reducing occupational safety and health risks.

RESULT AND DISCUSSION

Based on existing work data at PT. Indalux Enterprindo, the sequence of work steps carried out on the production floor can be described in the following chart.

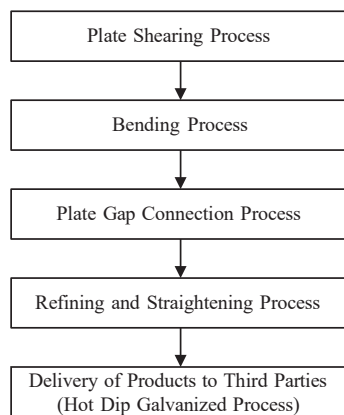


FIGURE 1. Workflow for Making Public Street Light Poles

From the order of work done on the production floor of PT. Indalux Enterprindo above, then carried out observations of the potential hazards that exist in each work process using the Job Safety Analysis (JSA) form. Job Safety Analysis is an analytical method to assess risk and identify control measures needed to eliminate or reduce existing risks [14] [15][6]. The

TABLE 2. Job Safety Analysis of Public Street Lighting Pole Products

No	Step Activity	Potential Accident / Hazard	Current Control
1	Cutting steel plate	1. Electric shock; 2. Cut hands / fingers; 3. Scratched steel plate	1. Use safety gloves; 2. Technique to put the plate in a safe position; 3. There is an SOP for the use of shearing machines
2	Steel plate bending	1. Electric shock; 2. Hands / fingers pinched	1. The existence of SOP for the use of bending machines; 2. Use safety gloves
3	Joining the plate gap by welding	1. Stuck welding machine; 2. Hit by a CO2 tube; 3. Electric shock; 4. Exposed to sparks; 5. Crushed by steel;	1. Use safety gloves; 2. Positioning the tool so it doesn't move; 3. Operators must be trained in welding;
4	Smooth and straighten the parts affected by welding	1. Electric shock; 2. Exposed to sparks; 3. Exposed to iron powder; 4. Scratched grinding machine;	1. Use safety gloves; 2. Operators must be trained in using the tools;

From the table above, it can be seen that in the process of making Public Street Light Pole there are 4 processes / step activities with a total hazard potential reaching 14 hazards, where each process has several potential hazards. From the observations made at each stage of the process which are data using the Job Safety Analysis (JSA) form, then a risk assessment is carried out on work processes that have a fairly large potential hazard. The risk assessment is carried out using 2 methods, namely the AS/NZS 4360:2004 semi-quantitative analysis method and the Failure Mode and Effect Analysis (FMEA) method.

The analysis was carried out based on the results of the interview and for the risks found from the observations analyzed based on the researcher's point of view with consideration according to reality. The results of risk analysis can be seen in tables 3 and 4.

Australian Standard/New Zealand Standard 4360: 2004 is used to measure the value of the level of risk which is a priority to be addressed. The AS/NZS 4360:2004 method uses the Likelihood (L), Consequences (C), and Exposure (E) scales which are then calculated using the formula: [17]

$$\text{Value Risk} = \text{Likelihood (L)} \times \text{Consequences (C)} \times \text{Exposure (E)}$$

TABLE 3. AS/NZS 4360:2004 Analysis Results on Public Road Light Pole Production Process

No	Stage of Works	Job Details	Risk	Risk Analysis			Risk Level
				L	E	C	
1	Cutting steel plate	Turn on the engine power	Electrocuted	3	1	5	15 <i>Acceptable</i>
		Put the steel plate into the shearing machine	Cut hands / fingers	3	2	25	150 <i>Substantial</i>
		Take pieces of steel plate	Scratched steel plate	10	2	1	20 <i>Priority 3</i>
							15 <i>Acceptable</i>
2	Steel plate bending	Turn on the engine power	Electrocuted	3	1	5	15 <i>Acceptable</i>
		Put the steel plate into the bending machine	Pinched hands / fingers	3	1	15	45 <i>Priority 3</i>
3	Joining the plate gap by welding	Setting up a welding machine	Hit by a welding machine	3	1	1	3 <i>Acceptable</i>
		Check the state of the CO2 tube	Hit by a CO2 tube	3	1	1	3 <i>Acceptable</i>
		Regulating the power supply voltage	Electrocuted	3	1	5	15 <i>Acceptable</i>
		Joining the plate gap by means of quantum welding	Got sparks	10	6	1	60 <i>Priority 3</i>
		Joining the plate gap by means of long welding	Got sparks	10	6	1	60 <i>Priority 3</i>
			Crushed by steel	3	1	1	3 <i>Acceptable</i>
							15 <i>Acceptable</i>
							60 <i>Priority 3</i>
4	Smooth and straighten the parts affected by welding	Turn on the grinding machine	Electrocuted	3	1	5	15 <i>Acceptable</i>
		Smooth the welding part with a grinding machine	Exposed to fire	10	6	1	60 <i>Priority 3</i>
			Exposed to iron powder	10	6	1	60 <i>Priority 3</i>
			Grinding machine scratched	3	2	5	30 <i>Priority 3</i>
							15 <i>Acceptable</i>

Failure Mode and Effect Analysis (FMEA) is used to measure the level of risk by knowing the highest RPN value so that it can be seen which is the top priority. The Failure Mode and Effect Analysis (FMEA) method uses the Severity, Occurrence, and Detection scales which are then calculated using the formula: [18]

$$\text{RPN} = \text{Severity (S)} \times \text{Occurrence (O)} \times \text{Detection (D)}$$

TABLE 4. Results of FMEA Analysis on Public Road Light Pole Production Process

No	Step Activity	Potential Hazard	Basic Risk		Current Control	Basic Risk D	RPN	Category	Control Recommendation
			S	O					
1	Turn on the engine power	Electrocuted	8	8	Use safety gloves	4	256	High	Using rubber gloves, giving a warning sign
2	Put the steel plate into the shearing machine	Cut hands / fingers	9	3	Technique for placing a safe plate position, SOP for the use of shearing machines	2	54	Low	Work should be done by two people to supervise each other
3	Take the results of the steel plate cut	Scratched steel plate	2	9	Use safety gloves	5	90	Low	Use complete PPE
4	Turn on the engine power	Electrocuted	8	8	Use safety gloves	4	256	High	Using rubber gloves, giving a warning sign
5	Put the steel plate into the bending machine	Pinched hands / fingers	9	3	SOP for the use of bending machines	2	54	Low	Work should be done by two people to supervise each other
6	Take the results of bending the steel plate	Scratched steel plate	2	9	Use safety gloves	5	90	Low	Use complete PPE
7	Setting up a welding machine	Hit by a welding machine	6	8	Positioning the tool so it doesn't move	2	96	Low	Giving sign the position of the tools
8	Check the state of the CO2 tube	Hit by a CO2 tube	6	8	Positioning the tool so it doesn't move	2	96	Low	Giving sign the position of the tools
9	Regulating the power supply voltage	Electrocuted	8	8	Use safety gloves	4	256	High	Using rubber gloves
10	Joining the plate gap by means of quantum welding	Got sparks	5	10	Use safety gloves	5	250	High	Using complete PPE and welding mask
11	Joining the plate gap by means of long welding	Got sparks	5	10	Use safety gloves	5	250	High	Using complete PPE and welding mask
		Crushed by	6	8	Understand	5	240	High	Work should be done
12	Turn on the grinding machine	Electrocuted	8	8	Use safety gloves	4	256	High	Using rubber gloves
13	Smooth the welding part with a grinding machine	Exposed to fire	5	10	Use safety gloves	5	250	High	Using complete PPE and welding mask
		Inhalation of iron powder	5	10	Use safety gloves	5	250	High	Using complete PPE and and N-95 mask
		Grinding machine scratched	7	8	Use safety gloves	2	112	Moderate	Using leather mixed jeans gloves, and a face shield

The critical score of RPN in the production process of Public Street Light Pole is as follows [19]:

$$\text{Total RPN} = 2856$$

$$\text{RPN Critical Score} = \text{The Amount of Risk} \quad 16 = 178,5$$

CONCLUSION

Based on the results of the analysis and discussion that has been done, the conclusions that can be drawn from this study are as follows:

1. The causes of work accidents that occurred at PT. Indalux Enterprindo is mostly caused by the negligence of the workers and the workers' lack of discipline in using PPE and there are still some PPE that are not available and are not suitable for use.

2. Based on the results of the Job Safety Analysis (JSA), it is known that in the process of making Public Street Light Poles (PJU) there are 4 processes / step activities with a total hazard potential reaching 14 hazards.
3. Based on the calculation of semi-quantitative analysis AS/NZS 4360: 2004 and Failure Mode and Effect Analysis (FMEA), the high risk of work accidents found in the production process at PT. Indalux Enterprindo is a hand / finger cut by a shearing machine, a hand / finger pinched by a bending machine, exposed to sparks and inhaled iron powder, eyes exposed to sand powder, and hit by steel.

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