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ORIGINAL ARTICLE

An Assessment Model for Occupational Health and Safety Risk of Street Lighting Poles Fabrication

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ABSTRACT – Engineering, Procurement, and Construcion company is vulnerable to risks of environment and health. There are several techniques for examining occupational safety and health, especially in risk analysis. This study is intended to evaluate environmental safety and health at street lighting poles project in EPC Company, named PT. Duta Hita Jaya. Primary and secondary datas were used. As primary data, observation-questionnaires-and interviews were conducted. Historical data of work accident and other documents related to working procedures was being used as secondary datas. Four respondents involved to answer the questionnaires. HIRARC model was applied to define potential risks that might occur. In addition, 5W1H or Kipling Method was implemented to construct strategies of minimizing the risks. This study reveals that during fabrication, materials transporting-assembling-finishing have high exposures to risks. Particularly, risk of being exposed to sparks is the highest risk with score of 9.

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INTRODUCTION

In Indonesia, the issue of Occupational Safety and Health (OSH) is generally still not fully prioritized. The awareness level of work safety is still marginal [1]. Work accidents were inevitable which reached 12 accidents per hours, moreover, several companies suffered maasive loss due to work accidents every year. In 2007, cases of work accidents in Indonesia had decreased and stabilized at the number of 100,000 work accidents per year. However, in 2017, the number of work accidents has increased significantly to 123,000 cases of work accidents especially in steel fabrication and construction projects. PT. Duta Hita Jaya is one of the biggest engineering, procurement, and construction company in Indonesia, particularly in steel fabrication. During 2019, total of 84 work accidents had caused the total lost of company up to Rp. 256.890.902,- excluding the death insurance. Various risk caused by activities of lifting rigging, grinding, cutting wheel, cutting asetelin, welding, and pipes rolling [2]. The scope of safety at steel fabrication depends on the number of safety decisions and awareness of the project owners. Over years, the company attempted to enhance the level occupational safety and health in steel fabrication plants, but it was found hard to apply systematic method in the field [3]–[5].

Based on maintaining the safety and health of employees who worked in fabrication plants, it is mandatory to implement a safety management system [6]–[8]. This system consisted of identifying and evaluating prominent hazards throughout the fabricating process and also predicted its severity and likelihood [9]–[11]. This is also called as risk analysis method which desired to generate matrix of occurrence possibility and level of consequences. In the last decade, safety risk assessment has been used to make decision regarding to the principal risks. Due to occupational safety and health policy in Indonesia, Ministry of Manpower has established Government Regulation No 88/2019 and should be adopted by all companies operated in Indonesia. The regulation serves as a foundation for efforts to create a safe working climate. This regulation would cover all aspects of the organization's operations, including personnel, facilities, and materials, work procedures and design, and the provision of products and services.

There were several sequence assessments in HIRARC model, as can be seen in Figure 1, to capture hazard identification and safety-health implementation in the work operations. The principal risk identifications were such as current hazard evaluation, the percentage of occurance evaluation, and appropriate controls recommendation [12], [13]. Meanwhile, a Kipling Method or 5W1H (shown in Figure 2) was aimed to construct a systematic information about deeper understanding of circumstances and risk mitigations surrounded the work place and occupational and health safety problems [14]–[16]. The potential hazards in poles fabrication plants might varied and could impact severely to the employees and working performances. Therefore, the current study aimed to examine hazards, calculate risks, determine control measures, and set mitigation strategies based on collected datas in order to compile model of occupational and healthy risk alleviation. There are 6 (six) parts in this article consist of theoretical background in the introduction, explaination of whole process of fabrication, brief definitions of HIRARC Model and Kipling Method, descriptions of data processing's results, discussion about current research compare to previous findings, and research conclusion..

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The Urge of Tackling The Risk

A variety of important advantages are provided by street lighting. It can be used to increase security and quality of life in urban areas by artificially extending the hours of brighten so that activity can take place even it had been entered evening time. Street lighting also increases the safety of drivers, cyclists, and pedestrians.

Prabaswari stated that fabrication process that involved metals often caused injuries and dangerous side effects, which the worst was death [17]. Street lighting poles was one of the most important parts that need intense fabrication method. Since over decades ago, street lighting poles became immense business activities which inline with growth of pavement construction. Along with this phenomenon, working environment and its vicinity of street lighting's pole fabrication should become primary concern among facility operation managers, staffs, and field operators.

There were numerous generic risk evaluation methods available to determine the extent of risk. Major hazards which often occur were related to working in heights, grinding, cutting, and welding. Although those risks were common, but most workers underestimated the severe impacts that might happen. According to Lee and Tang these are types of failure in the street lighting pole fabrication which can cause costly damage : strucked down by heavy materials, unintended cut-ropes, exposed to ultraviolet, squeezed by heavy materials, workers fell, scratched by materials, dislocated hands [18], [19]. Details of consequences and estimated losses in the pole fabrications are written in Table 1.

Thus, safety and health management plans should be made due to assure the safety of street lighting pole fabrication which eventually will enhance business performance through cost efficiency. In addition, renewal of plant equipment and strict implementation of personal protective means have to be done.

Table 1. Risk Exposure during Fabrication of Street Lighting Poles.

Impacts / Risks	Consequences	Estimated Losses
Crushed by the material	Death / Fracture / Injury	Rp. 250,000 up to a guaranteed death
Cut off sling	Death / Fracture / Injury	Rp. 250,000 up to a guaranteed death
Exposed to ultraviolet light	Blindness	Total disability compensation for both physically and mentally
Worker slipped	Injury / Fracture	Rp. 250,000 up to Rp. 500,000
Pinched	Bone injuries / fractures in the limbs	Rp. 250,000 up to Rp. 500,000
Worker fell	Death / Fracture / Injury	Rp. 250,000 up to a guaranteed death
Etched material	Bone injuries / fractures in the limbs	Rp. 250,000 up to Rp. 500,000
Dislocated hand	Minor injuries	Rp. 100,000

Source : Documents of PT. Duta Hita Jaya

Altough Standard Operating Procedures had been staked, safety and health risk still needed to be updated with information from diverse disciplines and actual facts. This study proposed both HIRARC and Kipling Method to investigate the occupational health and safety of street lighting poles fabrication process in PT. Duta Hita Jaya.

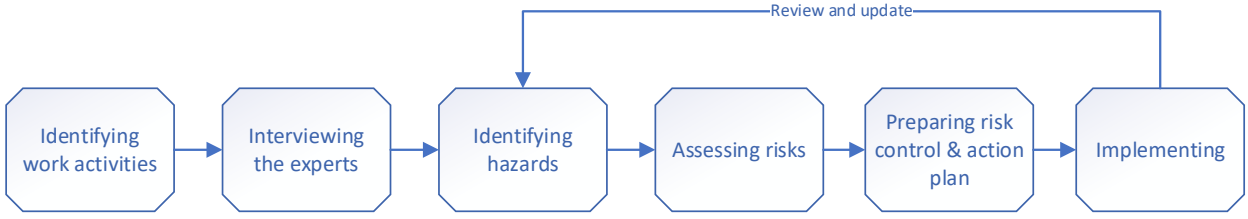

Figure 1. Flowchart of HIRARC Model [12], [13]

In accordance to attempt ensuring the safety of the pole fabrications, HIRARC model was reviewed to investigate the occupational safety and health during the fabrication process. A HIRARC Model describes as a sequential process of identifying risks until implementing the safety and health management [11], [18], [19]. The process are : identifying work activities; interviewing the experts; identifying hazards; assessing risks, preparing risk control and action plan; implementing the strategy (can be seen in Figure 1). The implementation process should be reviewed and updated to maintain the risk minimizing's goals. On the other side, utilizing the Kipling Method or "5Ws-1H" allows this research to carefully cover the all aspects of occupational health and safety improvement strategy (such as improvement targets, necessary actions, time and place to be awared of, the responsible person, and the process to be carried out) which can be seen in Figure 2.

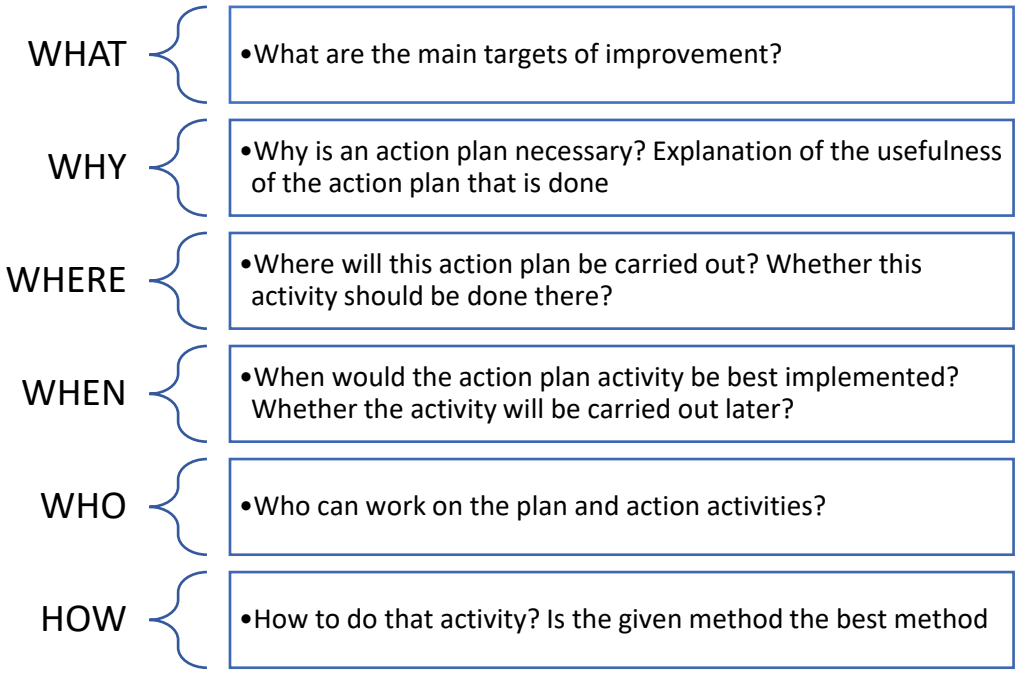

Figure 2. Kipling (5W1H) Framework [20], [21]

FABRICATION PROCESS

Street light pole manufacturing had been proliferating in the last two decades along with advancement of the manufacturing technology. Light poles had standards of height and materials. There were several types of street light poles such as iron, fibre-reinforced plastic, light cement, and alumunium. Besides, street light pole fabrications were executed based on customer requests and will be customized. The most common street pole material was iron and alumunium. Specific fabrication process was described as : transporting materials, shearing, bending materials, finishing, assembling, and automatic welding. Each phase was checked by a quality control to make sure the output quality meets customer's requirement [12], [17], [22].

HIRARC AND KIPLING METHOD (5W1H) FRAMEWORK

Hazard Identification

Nowadays, risk and safety studies has been diverted to operational and environmental rather than design. In street lighting poles fabrication, density of operational hazardous works due to maintenance is least noticed. The risks related to unmaintained facilities lead to corrosion and damage sling which can harm workers. There are also various of risk that related to human errors such as being exposed to the ultraviolet light, pinched, fell, etched by materials, and dislocated muscles. The risks look simple, but if not being well considerated those risks would generate significant losses.

This research, hazard identification is related to the hazard quantification and level of occurance. Several methods were applied such as checklisting the hazards, inspecting workplace, analysing task safety, and investigating accidents. Observation has been taken in one place since the street lighting poles fabrication is centered in PT. Duta Hita Jaya Workshop, and throughout the process. Combining with a view to map process flow of street lighting poles fabrication, interviews with technicians-operators-supervisors-and HSE Experts. Some feedbacks from various level in the workshop were important to capture the hazards and risks of work environment. Hazard checklist was aimed to list intended and unintended hazards to deepen understanding of the hazards. The checklist was adopted from Kasim and modified by discussing with the experts [13]. The hazard identification checklist was aimed to assess each involved parameters, to inspect effectiveness of selected safety measure, and (if possible) to implement the measurement of safety to attain tolerable risks. The particular aspects as the focus of this study were people, method, facility, and process (which will be detailed in 18 hazards). The hazard checklist had been applied to several process that mentioned above such as transporting materials, shearing, bending materials, finishing, assembling, and automatic welding. Interview was conducted using semi-structured questions to form a fishbone diagram that indicate factors of accidents occurance. Factors were grouped by 4 aspects as mentioned before.,

Risk Assessment

After defining main hazards , questionnaires were sent to production supervisor, HSE expert, crane operator, and technicians to scale the likelihood and severity or known as risk assessment. This assessment examines magnitudes of risks, decides whether risks can be acceptable or unacceptable, and prepares options of risk control. Thus, identified hazards can de prioritized.

Assessment of likelihood in the fabrication plant was based on likelihood level that adopted from Gurmu and Wang which ranged from "rare" to "almost certain" as shown in Table 2 [4], [9]. On the other hand, severity was grouped by impact level of injury to a worker's health, property, and/or environment. Generally, severity divided into 5 (five) groups : insignificant, minor, moderate, major, and catastrophic [10]. Level of Severity is shown in the Table 3. Level of likelihood and severity were examined simultaneously, this step involved a research method transition from qualitative into quantitative method. After that, the assessment will be continued into capturing a risk matrix ranking. Risk matrix rangking was the most common tools of risk assessment which also consider consequence, axis of severity, and likelihood. Combination of these three factors generated an estimation of risk ranking (as seen in Table 4). Risk Calculation was described as L x S (Relative Risk). L was indicated as 'Likelihood' and S was defined as 'Severity'.

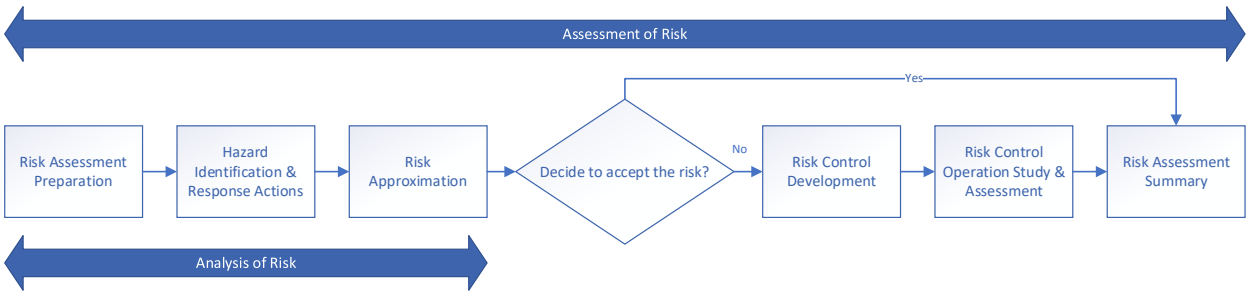

Figure 3. Risk Assessment Step [3], [4]

Controls

In the measurement of control, considerations were made based on source of the hazard and integrative controls of engineering-administration-and equipment of personal protection. The controls, which aimed to verify and regulate hazard, were resulting from parallel experiment or standard comparation. The goal is to reduce or avoid hazards [6], [10].

Table 2. Sample Scale *Likelihood*.

Scale	Rating %	Occurance	Description
1	0-10	Very rare	Rare
2	10-25	Rarely	Unlikely
3	25-45	Can happen once in a while	Possible
4	45-70	often	Likely
5	70-100	Can happen at any time	Almost Certain

Source: Janius [6] and Simpson & Sam [10]

Table 3. Sample Scale *Severity*.

Scale	Impacts	Description
1	Without accidents and material loss	*Insignificant*
2	Initial accident assistance, medium material loss	*Minor*
3	Required medical treatment	*Moderate*
4	Serious accidents, loss of operability	*Major*
5	The loss is very large and the impact is very broad	*Catastrophic*

Source: Janius [6] and Simpson & Sam [10]

Table 4. Risk Matrix.

Likelihood	*Consequence (Severity)*				
	1 *(Insignifant)*	2 *(Minor)*	3 *(Moderate)*	4 *(Major)*	5 *(Catastrophic)*
5 *(Almost Certain)*	*High*	*High*	*Extreme*	*Extreme*	*Extreme*
4 *(Likely)*	*Moderate*	*High*	*Extreme*	*Extreme*	*Extreme*
3 *(Possible)*	*Low*	*Moderate*	*High*	*Extreme*	*Extreme*
2 *(Unlikely)*	*Low*	*Low*	*Moderate*	*High*	*Extreme*
1 *(Rare)*	*Low*	*Low*	*Moderate*	*High*	*High*

Source: Janius [6] and Simpson & Sam [10]

Kipling Method

Implementing the "5W1H" of the Kipling methods allows the researcher together with workers (as respondents) to thoroughly evaluate risk control with several highest risk ratings and levels that PT Duta Hita Jaya (DHJ) workers experienced on scene when they were doing duty on job. A number of various benefits are obtained by applying this approach of finding facts [16], [20], [23]. First, it enables work issue standard to be more applicable and measurable during performing street lighting poles fabrication. Second, these methods can be used to asses and develop about fabrication standard operational procedure, operational standard of safety issue, equipment and vehicle maintenance education. Third it provides about employee's disciplinary action and awareness of the personal protection equipment standard application. Fourth, it enables company of being knowledgeable about the importance of maintenance schedule to company machinery and equipment in order to perform job properly and safely.

Applying each 5Ws and 1H with targeted workers could reveal clearly details information in the fabrication workshop. 5W1H was intended to reveal the covered information of existing risk events. Moreover, 5Ws can be used to delve deeper into the circumstances about what kind of condition and risks surrounding workers when they did their job or that usually appear on hand. While, 1H can be implied to find an alternatives solution to support team management decision when the risk evaluation has been made [14], [16]. There are some pro's and con's in using 5W1H. The pro's of 5W1H can be explained as : simple assessment, detail information of risk urgency, its impact on work environment, and its person who responsible for the risk assessment and mitigation. On the other hand, the con's of using 5W1H had not scientifically proven of the implication eventhough it is the most practical way to dig in related information [21].

WHO
Who is responsible to daily worker's activities? Who evaluates these workers? Who is person in charge and problem solvers on fabrication team?
WHAT
What does cause dangers around? What are the risk factors and significant problems happen on fabrication? What action could be used and adapted to solve the problem?
WHEN
When the risks happen? When the worker aware the existence of risk? When the company and workers have to solve those problem?Were the changing shift affected to the bigger risk due to maintenance setting?
WHERE
Where the risks usually happen? Which location is the risks can be found on scene and should be most attentioned?
WHY
Why did the risk occur? Why the Problem and trouble can be appeared on scene? Why accidents or dangers can be happened?
HOW
How will the risk be inspected and treated? How company and its workers should act and adapt to the solution?

The results of Kipling Method application was completing the results of HIRARC. Eventhough the 5W1H had scientific issues, this method has the most detail information related to risk mitigation of street lighting pole fabrications. Kipling method relied on expert judgement approach which useful during the risk mitigation planning and the best accepted approach. In addition, expert judgement helped the risk mitigation strategy to be implemented at most practical ways [15], [21].

METHOD

This research combined HIRARC and Kipling Method to solve the problems in the field. First, observation was conducted in the Street Lighting Poles Fabrication Plant of PT. Duta Hita Jaya. Based on expert judgement and adopted risk matrix score of [6] and [10], questionnaires to asess HIRARC were constructed. The questionnaires were distributed to technicians-operators-supervisors-and HSE Experts that involved in the poles fabrication. After the results of HIRARC were obtained, the data was being analyzed futher using deep interview with framework of 5W1H or Kipling Method. This method was aimed to capture specific risk mitigation of the top 5 highest risk activities. Details of the method was written in the section of HIRARC and Kipling Method Framework.

RESULTS

Collected data showed that most of major danger risks and accidents at work came from misconducting or abandonding the company standard and/or regulations. Lack of SOP, PPE, work control evaluation brought several risks to field workers. Several methods were applied to gather data such as interview, hazard checklist and analysis, and field observation. There are eighteen crucial hazards as identified by an analysis of hazard checklist technique. Framework of HIRARC in research of street lighting poles fabrication showed in Table 6 below. According to risk parameters, the results were grouped into four levels with three degrees of risk using the risk assessment technique. The percentage of risk assessment described as 5.5% low risk, 16.7% medium risk, and 77.8% high risk. There was no risks classified as extreme risks in this study. Hazards were resulted by several types of activities such as transporting material, shearing process, bending process, welding process, assembling process, and finishing process. Each activities consisted of several

hazard types with each proportion, described as : hazards in transporting materials 15.7% (3 items); hazards in shearing process 15.7% (3 items); hazards in bending process 21.05% (4 items); hazards in welding process 15.7% (3 items); hazards in assembling process 15.7% (3 items); hazard in finishing process 15.7% (3 items). Table 5 showed the results of 19 important hazards. The most dangerous group of activities were transporting materials and finishing process which had high risk level ranged 8 to 9 for each hazards. Meanwhile the least risky hazard was worker negligence, which grouped into low level risk with score 3. The highest risk hazards were exposed to sparks (both in welding and grinding process), exposed to beam radiation, and not wearing eye protection or personal protective equipment which scored 9.

At the same time, there were sub-activities considered as highly dangerous hazard but with least score of 4 such as unclosed cable to the power supply (both in shearing and bending machines), cutting results are still sharp, and intentionally not using personal protective equipment for welding-long clothes-and trousers. A brief detail of important hazards with risk level can be seen in Table 5.

Table 5. Results 18 Important Hazards With level Of Risk.

No	Hazard	Risk
1	Exposed to sparks and welding beam radiation	9(H)
2	Exposed to sparks from the grinding work process	9(H)
3	Not wearing eye protection or personal protective equipment	9(H)
4	The position of the workers in the unmarked stock pile area	8(H)
5	Corrosion occurs and the sling does not match the load that being lifted	8(H)
6	Method of mounting on the crane is inappropriate when the material fed to the next process	8(H)
7	The carrying capacity of the sling does not match the material being lifted, resulting the sling being cut off	8(H)
8	Sling that are no longer suitable for usage	8(H)
9	The material is slipped from the grip when welding the base plate	8(H)
10	Rolled over material pile from the stock pile	8(H)
11	Unfocused workers during transporting materials	8(H)
12	unclosed cable to the power supply of the shearing machine	4(H)
13	Cutting results are still sharp	4(H)
14	Uncovered cable to the power supply of the bending machine	4(H)
15	Not wearing personal protective equipment for welding, long clothes and trousers	4(H)
16	Unfocused workers during bending the parts	6(M)
17	Vulnerable and unreplaced sling for lifting heavy weight bended materials	4(M)
18	the cables were unintentionally openned and linked to the power supply of the welding machine	4(M)
19	Negligence of workers	3(L)

Source: Data Processing

Table 6. Framework of HIRARC during The Poles Fabrication.

Activities	Hazard Identification			Risk Assesment			Risk Level
	Hazard	Consequences	Risk control	L	S	R	
Transporting Material	1. The position of the workers in the unmarked stock pile area. 2. Unfocused workers during transporting materials	Crushed By The Plate When Lifted	1. provide a green lane for securing the distance of workers from the material to be launched. 2. there are no workers who pass through the reporting area other than operator personnel and workers. 3. Obliging all workers (operators / related workers)	4	2	8	H
	Corrosion Occurs and the sling does not match the load being lifted	The Sling Is Cut Off When Lifting The Plate	1. provide a sign and an explanation for each size of the sling according to the weight of the load to be lifted. 2. explain to workers about the proper and correct installation of slings. 3. Do trial and error before the implementation of work begins	4	2	8	H
	Method of mounting on the crane is inappropriate when the material fed to the next process	Crushed By The Plate When It Is Launched Into The Shearing Table	1. provide a green lane for securing the distance of workers from the material to be launched. 2. Provide the appropriate load on the crane. 3. Provide a methode of installation according to a predetermined procedure	4	2	8	H
Shearing Process	unclosed cable to the power supply of the shearing machine	Electrocuted Shearing Machine	1. Provide periodic maintenance on the machine. 2. Obliging workers to follow predetermined work steps. 3. Obliging workers to wear complete personal protective equipment.	4	1	4	M
	The result of cutting is still sharp	Scratched Plate	1. Provide warning signs to always be alert and focus on points where workers can cleary see the warning signs. 2. Care on the blade in order to give a perfect cut. 3. Obliging workers to wear complete personal protective equipment	1	4	4	H

Table 6. Framework of HIRARC during The Poles Fabrication (cont.).

Activities	Hazard Identification			Risk Assesment			Risk Level
	Hazard	Consequences	Risk control	L	S	R	
Bending Process	The carrying capacity of the sling does not match the material being lifted, resulting the sling being cut off	Crushed By The Plate When Launched Into The Bending Table	1. Provide a green lane for securing the distance of workers from the material. 2. Determine the power capacity of the sling according to the load. 3. Obliging workers to wear complete personal protective equipment	4	2	8	H
	Uncovered cable to the power supply of the bending machine	Electrocuted Bending Machine	1. Provide periodic maintenance on the machine. 2. Provide understanding to workers to understand how the machine works. 3. Obliging workers to wear complete personal protective equipment.	4	1	4	H
	Unfocused workers during bending the parts	Wedged Bending Machine	1. Provide warning signs to always be alert and focus on points where workers can cleary see the warning sign. 2. Provide understanding to workers to understand how the machine works. 3. Obliging workers to wear complete personal protective equipment.	3	2	6	M
	Vulnerable and unreplaced sling for lifting heavy weight bended materials	The Sling Is Cut Off When Lifting The Hexagonal Forming Material (TSICOWLTHFM)	1. provide a sign and an explanation for each size of the sling according to the weight of the load to be lifted. 2. Make sure the sling is still fit for use or not. 3. Obliging workers to wear complete personal protective equipment.	4	1	4	M

Table 6. Framework of HIRARC during The Poles Fabrication (cont.).

Activities	Hazard Identification			Risk Assesment			Risk Level
	hazard	consequences	Risk control	L	S	R	
Automatic Welding Process	Negligence of workers	Hands Trapped During The Straightening Process	1. Provide warning signs to always be alert and focus on points where workers can cleary see the warning signs. 2. Obliging workers to wear complete personal protective equipment.	1	3	3	L
	Sling that are no longer suitable for usage	Crushed By An Iron Pipe As It Was Launched Onto The Automatic Welding Table	1. Provide training on proper and correct sling installation. 2. provide a sign and an explanation for each size of the sling according to the weight of the load to be lifted 3. Always remaind workers to always use compilsory complete personal protective equipment.	4	2	8	H
	Not wearing special personal protective equipment for welding, long clothes and trousers	Etched Iron Pipe	1. The importance of following the procedures that apply in the area. 2. Provide special training to workers on how the machine works. 3. Obliging workers to wear complete personal protective equipment.	1	4	4	H
Assembly Process	The material is slipped from the grip when welding the base plate	Crushed By An Iron Pipe During The Assembly Process	1. The importance of following the procedures that apply in the area. 2. Ensure the grip strength is in accordance with the load requirements. 3. Obliging workers to wear complete personal protective equipment.	4	2	8	H
	The cables were unintentionally openned and linked to the power supply of the welding machine	Electrocuted Welding Machine	1. Provide periodic maintenance on the machine. 2. Provide understanding / training about how welding machine work. 3. Obliging workers to wear complete personal protective equipment.	4	1	4	M

Table 6. Framework of HIRARC during The Poles Fabrication (cont.).

Activities	Hazard Identification			Risk Assesment			Risk Level
	hazard	consequences	Risk control	L	S	R	
Assembly Process (cont.)	Exposed to sparks and welding beam radiation	Eye Irritation When Welding In The Assembly Process	1. Urge workers to work according to predetermined work oprational standads. 2. Provide understanding to workers in order to minimize the risk of work accidents. 3. Obliging workers to wear complete personal protective equipment.	3	3	9	H
	Rolled over material pile from the stock pile	Crushed By The Material During The Finishing Process	1. Provide a green lane for securing the distance of workers from the material. 2. Ensure the stack of material is in a safe position so that it does not roll over. 3. Obliging workers to wear complete personal protective equipment.	4	2	8	H
Finishing process	Exposed to sparks from the grinding work process	Eye Irritation When Welding In The *Finishing Process*	1. The Need to be given an understanding of how to use a grinding machine. 2. Ensure that grinding machine is complete with safety and is suitable for use. 3. Obliging workers to wear complete personal protective equipment.	3	3	9	H
	Not wearing eye protection or personal protective equipment	Entry Of Grinder Gram Into The Eye	Obliging workers to comply with oprational standards and use complete personal protective equipment in accordance with with occupational health and safety regulations.	3	3	9	H

The three highest dangerous hazards were then proceeded into 5W1H analysis to obtain detail information about characteristics of risks and how to mitigate the risks, as can be seen in Table 7. According to the interview with several experts, 5W1H needed to be digged in according to the top 5 hazards with high level of risks.

Table 7. Improvement 5W1H.

	Hazards	Exposed to sparks and welding beam radiation;	Exposed to sparks from the grinding work process;	Not wearing eye protection or personal protective equipment
Who	Who is responsible?	HSE officer; production supervisor; and worker itself		
What	What caused the risk?	Not understand the standard operation procedures and neglecting personal protection usage		
When	When did the risk occur?	Welding and Grinding process		
Where	Where did the risk occur?	In the fabrication plant especially in welding and grinding sites		
Why	Why did it happen? And why did it need to be solved	Most of workers had low education level and often disobeying the safety procedures. Indeed workers were skillful, but less careful about personal protection. The accidents that appeared had generated huge loss to company profit		
How	How to minimize or diminish the hazards?	Regular socialization and trainings are needed due to gaining the safety protocols and proper machinery operation, especially in welding and grinding	Reward and punishment to workers who obey or disobey the safety protocols and ensure that the machinery is safe and having maintenance regularly	

Table 7. Improvement 5W1H (cont.).

Factor		The position of the workers in the unmarked stock pile area	Corrosion occurs and the sling does not match the load that being lifted
Who	Who is responsible?	HSE officer; production supervisor; purchasing officer; and worker itself	HSE officer; production supervisors; and workers
What	What caused the risk?	The area is full of bulky materials and arranged in narrow distance; the stock pile area did not have warning sign or safety sign to stand	Unregular maintenance of the tools and workers often dare to take risks of using broken tools in terms of fulfilling the deadline
When	When did the risk occur?	During transporting the materials and receiving incoming materials	Most fabrication area; but more often when assembling the street light poles
Where	Where did the risk occur?	In the stock pile area (receiving and transporting materials)	Especially in the assembly area
Why	Why did it happen? And why did it need to be solved	Workers do not understand the dangers of doing the job and lack of sign in the area	Lack of coordination between workers, HSE and supervisors regarding the maintenance of the tools such as replacing the inappropriate slings
How	How to minimize or diminish the hazards?	Requires workers to use personal protective equipment Do training as often as possible, being monitored at least once a week Make a danger sign in the work area with string fluoresence paint and contrast color that easily caught by the eye	Establishing particular standard operating procedures for workers with heavy materials Obliging workers to use complete personal protective equipment without exception Provide maintenance on the machine as regularly as possible (or as needed)

DISCUSSION

Street lighting aims to improve community mobility and safety for road users. The installation of lighting poles uses high-risk steel fabrication, so it is a strategy to reduce work accidents. Based on this research, Occupational Health and Safety (K3) is important for every worker to pay attention to. Work accidents are unavoidable which reaches 12 accidents per hour, moreover some companies experience huge losses due to work accidents every year. Therefore, it is important to maintain the safety and health of employees working in a fabrication plant, therefore it is mandatory to implement a safety management system. It aims to assess hazards, calculate risks, determine control measures, and establish mitigation strategies.

HIRARC model was designed to stay inline with Presidential Decree number 88 Year 2019. In the installation of street lighting poles, the implementation of Occupational Safety and Health is very important to be considered by the company. In street lighting poles fabrication, 15 high risk activities are identified which ranged from score of 4 to 9. In addition, particular protective equipments especially eye googles for covering eyes from sparks are the most important. This result was supported by [6] that said protective eye glasses were the main safety tools for heritage construction workers since these workers highly intensed with welding activities.

Meanwhile the other risks like the position of the workers in the unmarked stock pile area are also need to be improved. The danger that arises from this risk is the danger of being hit. This hazard can occur when 2 or more people are transferring materials or are in the vicinity, where one party does not see the other party, resulting in an accident being hit. Some of the solutions that can be used to prevent these accidents are using personal protective equipment to reduce the severity if an accident occurs, conducting regular training on these risks so that workers know the dangers of their work, and making danger signs that can be easily seen so that workers always remember and be alert to the hazards in the area and know each other work positions. This fact were inline with the researches of [7][9][11-12].

The other risks that should be improved are corrosion occurs and the sling does not match the load that being lifted. The danger that arises from this risk is the danger of being hit. This hazard can occur because the unregular maintenance of the tools and workers often dare to take risks of using broken tools in terms of fulfilling the deadline. Some solutions that can be used to prevent these accidents are to establish special standard operating procedures for workers with heavy materials so that workers who read them can avoid these accidents, obliging workers to use complete personal protective equipment without exception to reduce the severity if an accident occurs, and provide maintenance on the machine as

regularly as possible (or as needed) so that the machine is maintained and workers can avoid accidents caused by tool damage.

This study is not only useful for the installation of lighting poles, but the other works too such as building construction etc. because the risks such as grinding and wileding sparks, being hit by others when transferring material, lack of maintenance and accidents caused by tools are also present on those works. To reduce work accidents in the future, stakeholders should provide a new safe standard operational procedure, timeline, maintenance, training, work rules, and how to coordinate.

From the results of the information explained by the workers in detail and clearly in the fabrication workshop with the application of the "5W1H" method from the Kipling method, namely the risk of being exposed to sparks and welding radiation, as well as the risk of being exposed to sparks from the milling work process carried out by HSE officers, production supervisors, and the workers themselves, the cause of this risk occurs because they do not understand standard operating procedures and ignore the use of personal protection during the welding and milling process in the fabrication plant, especially at the welding and milling site. This happens because most workers have a low level of education and often do not comply with safety procedures. Indeed skilled workers, but less careful about personal protection. Accidents that have arisen have resulted in huge losses to the company's profits to reduce these hazards. Regular socialization and training is needed to obtain safety protocols and correct machine operation, especially in welding and milling.

Meanwhile, the risks that are often carried out by workers in the manufacturing process are not wearing eye protection or personal protective equipment carried out by HSE officers, production supervisors, and the workers themselves, the cause of these risks is because workers do not understand standard operating procedures and ignore the use of personal protection. When the welding and milling process is located in the fabrication plant, especially at the welding and milling site, this happens because most of the workers have a low level of education and often do not comply with safety procedures [4-5]. Indeed skilled workers, but less careful about personal protection. Accidents that have arisen have resulted in huge losses to the company's profits to reduce these hazards. Regular socialization and training are needed to obtain safety protocols and correct machine operation, especially in welding and milling.

Another risk that needs to be considered by HSE officers, production supervisors, purchasing officers, and the workers themselves is improving the position of workers in the stock pile area that is not marked, the cause of this risk is because this area is full of large materials and is arranged in a narrow space, the area is the stock pile does not have a warning sign or safety sign to stand up, that risk occurs During transporting material and receiving incoming material located in the stock pile area (receiving and transporting material) This is because workers do not understand the dangers carried out while working and the lack of signs on the area. Therefore, to minimize and reduce these hazards, workers are required to use personal protective equipment, conduct training as often as possible which is monitored at least once a week, and make danger signs in the work area with string fluorescence paint and contrasting colors that are easy to catch the eye.

Meanwhile, other risks, especially in the assembly area, are carried out by HSE officers, production supervisors, and workers which cause irregular maintenance of tools and workers often dare to take the risk of using damaged tools to meet deadlines. large is the fabrication area, but more often when assembling street light poles. This is due to the lack of coordination between workers, HSE and supervisors regarding equipment maintenance such as replacing inappropriate slings. To minimize and reduce these hazards, it is necessary to establish special standard operating procedures for workers with heavy materials, requiring workers to use complete personal protective equipment without exception and provide maintenance on the machine as often as possible (or as needed).

CONCLUSION

As the research conducted, there is several results from work accident analysis in PT. Duta Hita Jaya. It can be concluded some of key point. First, It is known there is several factors can be found and determine the occurrence of risk in the manufacture of public street lighting lampposts such as; employee hit by plate and sling was cut when shunting movement, electrocuted by machine power and scratched plated when searing material, crushed by plate, zapped by electricity machine, cramped in machine, broken sling during bending process, hand smacked, struck by iron pipe, scratched by iron pipe at automatic welding process, crushed by iron pipe, machinery electrocuted, eyes irritation when conducting assembly process, eyes irritation by grinder micro particle when conducting finishing process.

Second, there are several processes with highest potential health and safety risk of creating highway lighting poles process at PT. Ambassador Hita Jaya. Those process include: Assembly process with a source of danger of being exposed to sparks and exposure to radiation from welding rays. It had eye irritation risk during wielding with score risk rating 9 which is a High-risk Level, Finishing process with a source of danger of being exposed to sparks from the grinding process. It also had eye irritation risk during grinding with score risk rating 9 which is a High-risk Level; Finishing process with a source of danger from employee didn't use eyeglasses, eye cover, or other PPE. It also had eye irritation risk from grinder micro particle invades internal eyes cell with score risk rating 9 which is a High-risk Level.

Third, It is necessary to propose control improvement like repairing the cranes that are no longer suitable for workers. This control will make employees more convenience to carry out their labor to move materials with very heavy material weights, by doing this it will result the proposed improvement index at highest rate at 93.75%.

The company also need to provide a new regulatory procedure and timeline to solve several problems such as maintenance, worker training and certification since problem of the health risk also come from lack of worker awareness and coordination on field. Checking their current equipment, power-tools, PPE, heavy material vehicle also need to be done and company management should discipline workers with deviant behavior using several warnings and punishments

in near future. Future research also needs to examine the existing standard operation procedure and evaluates its performances.

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