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Analysis of Potential Risks and Work Accidents Using Hazard Identification, Risk Assessment and Risk Control (HIRARC) Method: a Warehouse Support Case Study of PT. Vale Indonesia Tbk

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ABSTRACT

Occupational Safety and Health (OSH) aims to maintain and improve the health and safety of the employees. Low levels of workplace safety may result in significant effects on the health of the employees. This research intends to use the HIRARC (Hazard Identification, Risk Assessment, and Risk Control) technique to identify the likely hazards and assess the potential accident or financial loss that the company could incur. A case study of the warehouse of PT Vale Indonesia Tbk, one of the leading mining companies in Indonesia, is used to evaluate the effectiveness of the method. The results show that there are multiple classifications of the level of risk that can be encountered in the warehouse's operational activities, including extreme, high, moderate and low level. Ultimately, this research proposes a series of improvement recommendations to minimize the occurrence of risks and hazards.

1. INTRODUCTION

The workplace accident is an unforeseen or unplanned event that might result in injury or death, loss of equipment, property damage, and environmental destruction [1]. Low levels of workplace safety may result in significant effects on the health of the employees. To prevent the workplace injuries and illnesses, the Occupational Safety and Health (OSH) must be considered as the key aspect aimed at maintaining and improving the health and safety of employees by reducing morbidity and work-related injuries [2]. It consists of multidisciplinary activity that enhances the promotion and maintenance of the highest degree of the physical, mental, and social well-being among the employees in the occupations. The implementation of OSH will lead to sustainable work environments and work organizations [3].

In Indonesia, the efforts of preventing the workplace accident still face a number of challenges. This is reflected in the traditional mindset of employees and companies that view accidents as catastrophes. In addition, many companies and employees still disregard the health and safety regulations legislated by the government [4]. Such negligence may result in the workplace accidents that affect the company, the environment and the workers themselves. Therefore, the assessment of potential situations that can harm companies and workers is fast becoming a key instrument to identify the risks and improve risk management of potential hazards.

Hazard Identification, Risk Assessment and Risk Control (HIRARC) is known as a method for identifying and analyzing occupational hazards by classifying their likelihood, frequency and severity to ultimately assess the adverse consequences [5] [6]. It starts with identifying the source of danger for each activity. The level of potential danger is then assessed using the likelihood and severity scale. Subsequently, the risk control is carried out to reduce exposure to hazards in each work activity.

In recent years, there has been an increasing interest in the application of HIRARC method in the safety and health management system. Irawan et al. developed the HIRARC method in the raw materials store, in production and in the finished goods store [4]. Their study identified 4 potential hazards with a high risk category. Widodo et al. used the HIRARC method to classify 10 potential hazards encountered in the shop floor of a manufacturing company [7]. The suggested strategy is to make the visual display,

use personal protective equipment (PPE), establish good work practices, conduct health and safety training, as well as conduct safety campaigns. The study on the application of the HIRARC method in the Production System Laboratory of the Universitas Sumatera Utara was carried out by [5]. Several types of potential hazards have been identified, including ergonomic, mechanical, transportation and biological hazards. Using the 5S method, they reported that the risk can be reduced by 17.15%. Sitepu and Simuanungkalit identified the potential hazards that may arise in the palm factory [8]. They found that there are 21 types of risk, which were further categorized into 2 classifications; medium and high risks. Putra et al. attempted to minimize the workplace accident during the docking process with the HIRARC method [9]. They recommended the system improvement based on the risk score obtained from the hazard measurement. Nugroho et al. used HIRARC approach to analyze OSH at Indonesian Navy ship project [6]. The outcome of their study recommended the elimination, control of administration, and use of PPE to reduce the potential for accidents. Application of the HIRARC method in the activity of lifting building materials with a tower crane was suggested by [10]. The resulting study indicated 11 risks with 2 of which were classified as extreme level. They recommended that the company establish and maintain the procedures through the implementation of a range of activities.

This research intends to use the HIRARC method to identify the likely hazards and assess the potential accident or financial loss that the company could incur. A case study of the warehouse of PT. Vale Indonesia, Tbk, one of the leading mining companies in Indonesia, is used to evaluate the effectiveness of the method. The activities in the warehouse include refueling, storage and retrieval, loading, packaging and battery charging. In this study, the questionnaires on the hazards arising from the operational activities in the warehouse, its possibility and severity were distributed to the warehouse workers. Ultimately, the identified risks were categorized and analyzed in order to propose improvement recommendations to the company.

The rest of this work is structured as follows. Section 2 discusses the methodology used in this study. Section 3 provides results and discussions. Section 4 presents the research conclusions.

2. METHODOLOGY

This study begins with the field observation conducted on operational activities at the warehouse area owned by PT Vale Indonesia Tbk. Based on the observation, the problems are then formulated. The phases of the HIRARC methodology are determined based on the literature reviews, including hazard identification, risk assessment and risk control. Subsequently, the concluded results are considered as a proposed improvement of the system.

1. Hazard Identification
   The process of identifying hazards entails a search for potential dangers in the work environment [4]. In this phase, the observations and interviews with the employees were carried out in order to identify the source of hazards in the operational activities of the warehouse.
2. Risk Assessment
   A risk assessment is a set of procedures undertaken to assess the level of potential hazards that may occur [4]. During this phase, questionnaires were distributed to employees to assess the likelihood and severity of each hazard. The risk assessment is performed based on the Australian Standard/New Zealand Standard for Risk Management scale (AS/NZS 4360:2004). The likelihood and severity scale can be seen in Table 1 and Table 2. Afterwards, the risk levels are mapped in the risk matrix, as shown in Table 3. Table 3 displays several classifications including extreme (E), high (H), medium (M), low (L), and extremely low (EL).

Table 1 Likelihood Scale

Scale	Designation	Description
1	Rare	Almost never occur
2	Unlikely	Sometimes occurs
3	Moderate	Risk may occur, but not often
4	Likely	Occur multiple times within a given period of time
5	Almost certain	Can occur at any time under normal conditions

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Tabel 2 Severity Scale

Scale	Designation	Description
1	No influence on work process, no injuries, minimal economic loss, medical expenses < 100 thousand rupiahs	Negligible
2	Provide first aid, not require outside assistance, moderate financial loss, medical expenses > 1 million rupiahs	Minor
3	Requires medical care, employment interruption, financial loss, substantial financial loss, medical expenses < 10 million rupiahs	Moderate/serious
4	Absence, permanent or partial disability, moderate environmental damage, significant economic loss, medical expenses < 50 million rupiahs	Major
5	Death, permanent/severe disability, serious environmental damage, enormous economic loss, medical expenses > 50 million rupiahs	Catastrophic

Table 3 Risk Matrix

Likelihood	**Severity**				
	1 *(Negligible)*	2 *(Minor)*	3 *(Moderate /Serious)*	4 *(Major)*	5 *(Catastrophic)*
5 (Almost Certain)	M	H	H	E	E
4 *(Likely)*	L	M	H	H	E
3 *(Possible)*	L	M	M	H	H
2 *(Unlikely)*	L	L	M	M	H
1 *(Almost Never)*	N	L	L	L	M

3. Risk Control

Risk control is the process of mitigating the dangers posed by potential hazards in the workplace [10]. This phase includes recommendations for mitigating potential risks. Afterwards, a grouping or hierarchical classification of controls is undertaken in order to establish priorities for enhancing the management of risk associated with hazards. As indicated in Fig. 1, there are five control hierarchy categories.

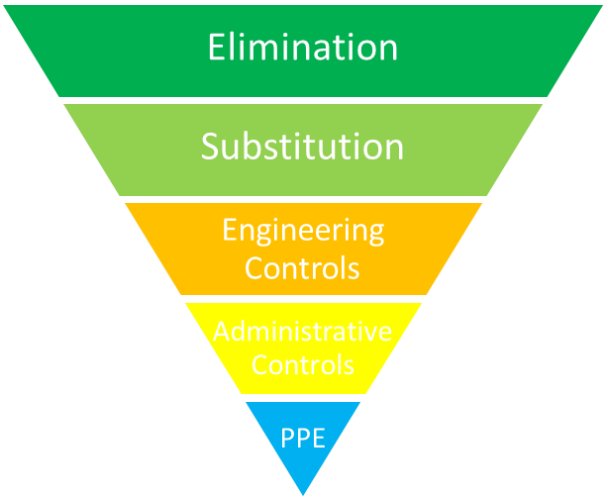

Fig. 1 Hierarchy of Risk Management

3. RESULTS AND DISCUSSIONS

PT Vale Indonesia Tbk is an integrated nickel mining and processing company operating in Soroako Block, East Luwu District, South Sulawesi. PT Vale Indonesia Tbk is a subsidiary of Vale, a Brazilian multi-mining company with an average annual production of 75,000 tons. PT Vale is a mining corporation that PT Vale Indonesia Tbk uses foreign investment to oversee construction contracts ratified in 2014 and valid until 2025. Based on direct site observations and interviews with the workers, the following activities and risks were identified in Table 4.

Table 4. Questionnaire Result

No	Step Activity	Risk (s)	Score	
			Likelihood	Severity
1	Refueling in dispenser 1 and dispenser 2	Spilled fuel	3	3
		Fire	2	5
		Fuel smell	5	2
2	Refueling at the loading arm	Falls from the fuel truck	3	3
		Spilled fuel	3	3
		Fire	2	5
		Fuel smell	5	3
3	Filling the fuel into the storage tank	Fuel smell	5	3
		Fire	2	5
		Spilled fuel	2	3
4	Storage and retrieval with ladders	Falls from a height	1	4
		Struck by materials	3	2
		Dust	4	2
5	Gathering of materials with forklift	Hit by forklift	3	4
		Knocking over or hitting buildings/storage racks	4	5
		Items lifted fall	3	5
		Damaged pallet	4	4
6	Walking in storage rack area	Struck by materials	2	5
7	Electronic forklift battery charging	Electrical short circuit	2	5
8	Lifting/moving goods manually	Dust	4	2
		Chronic pain	4	3
		Struck by materials	3	4
9	Loading goods manually	Chronic pain	4	3
		Pinched/scratched/crushed by goods	3	4
10	Truck arrival in receiving area	Crashed onto the storage platform	3	4
		Worker hit by truck	2	5
11	Goods wrapping	Sliced by cutter	2	2

In the next step, a risk assessment is carried out by analyzing and evaluating the risks by taking into account the likelihood of its occurrence and its severity. The calculated risk value is used to determine the risk level. the decision is based on five scaled risk mappings; very low, low, moderate, high and extreme. Table 5 shows the risk mapping result.

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Table 5. Risk Mapping Result

Likelihood	***Severity***				
	1 *(Negligible)*	2 *(Minor)*	3 *(Moderate /Serious)*	4 *(Major)*	5 *(Catastrophic)*
5 (Almost Certain)	5	10	15	20	25
4 *(Likely)*	4	8	12	16	20
3 *(Possible)*	3	6	9	12	15
2 *(Unlikely)*	2	4	6	8	10
1 *(Almost Never)*	1	2	3	4	5

Risk control aims to minimize the risk level of the identified potential hazards. As demonstrated in Table 6 there are a variety of risk classification categories including extreme risk, high risk, moderate risk, and low risk. After evaluating the risk rating and determining the risk level, a control review is performed to provide control recommendations for the identified hazard to minimize or eliminate the hazard that arises. Table 7 deliberates the risk management categories and improvement recommendations.

Table 6. Risk Rating and Risk Level

No	**Step Activity**	**Risk (s)**	**Score**		**Risk Rating**	**Risk Level**
			Likelihood	**Severity**		
1	Refueling in dispenser 1 and dispenser 2	Spilled fuel (R1)	3	3	9	Medium
		Fire (R2)	2	5	10	High
		Fuel smell (R3)	5	2	10	High
2	Refueling at the loading arm	Falls from the fuel truck (R5)	3	3	9	Medium
		Spilled fuel (R6)	3	3	9	Medium
		Fire (R7)	2	5	10	High
		Fuel smell (R8)	5	3	15	High
3	Filling the fuel into the storage tank	Fuel smell (R9)	5	3	15	High
		Fire (R10)	2	5	10	High
		Spilled fuel (R11)	2	3	6	Medium
4	Storage and retrieval with ladders	Falls from a height (R12)	1	4	4	Low
		Struck by materials (R13)	3	2	6	Medium
		Dust (R14)	4	2	8	Medium
5	Gathering of materials with forklift	Hit by forklift (R15)	3	4	12	High
		Knocking over or hitting buildings/storage racks (R16)	4	5	20	Extreme
		Items lifted fall (R17)	3	5	15	High
		Damaged pallet	4	4	16	High
6	Walking in storage rack area	Struck by materials (R18)	2	5	10	High

7	Electronic forklift battery charging	Electrical short circuit (R19)	2	5	10	High
8	Lifting/moving goods manually	Dust (R20)	4	2	8	Medium
		Chronic pain (R21)	4	3	12	High
		Struck by materials (R22)	3	4	12	High
9	Loading goods manually	Chronic pain (R23)	4	3	12	High
		Pinched/scratched/crushed by goods (R24)	3	4	12	High
10	Truck arrival in receiving area	Crashed onto the storage platform (R25)	3	4	12	High
		Worker hit by truck (R26)	2	5	10	High
11	Goods wrapping	Sliced by cutter (R27)	2	2	4	Low

Table 7. Risk Improvement Recommendations

No	Step Activity	Risk (s)	Category	Recommendation
1	Refueling in dispenser 1 and dispenser 2	Spilled fuel	ADMINISTRATION	Updating the SOPs and conducting weekly evaluation
		Fire	SUBSTITUTION	Updating existing SOPs, installing no-smoking signs, and using electronic devices around dispenser 1 and dispenser 2
		Fuel smell	PPE	Updating SOPs and installing signs requiring the use of masks
2	Refueling at the loading arm	Falls from the fuel truck	PPE	Using full body harness, updating the SOPs
		Spilled fuel	ADMINISTRATION	Updating the SOPs and conducting weekly evaluation
		Fire	SUBSTITUTION	Provision of fire extinguishers, updating of SOP, Installation of sign prohibited from smoking and using electronic devices in the loading arm area
		Fuel smell	PPE	Wearing a mask, placing a shield with a mask in the loading arm area
3	Filling the fuel into the storage tank	Fuel smell	PPE	Updating SOPs and installing signs requiring the use of masks
		Fire	SUBSTITUTION	Updating existing SOPs, installing no-smoking signs, and using electronic devices around dispenser 1 and dispenser 2
		Spilled fuel	ADMINISTRATION	Updating the SOPs and conducting weekly evaluation
4		Falls from a height	-	-

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	Storage and retrieval with ladders	Struck by materials	ELIMINATION	Ladders are no longer used as tools for picking up and storing items
		Dust	PPE	Use of masks
5	Gathering of materials with forklift	Hit by forklift	PLANNING	Establishment of pedestrian lanes
		Knocking over or hitting buildings/storage racks	PLANNING	Installing convex mirrors on each corner of the storage rack
		Items lifted fall	ADMINISTRATION	Ensuring that the pallets used are still usable
		Damaged pallet	ADMINISTRATION	Inspecting the feasibility of pallets before use and replacing unsuitable pallets
6	Walking in storage rack area	Struck by materials	PLANNING	Establish proper road lines, wear helmets and work according to SOPs
7	Electronic forklift battery charging	Electrical short circuit	PLANNING	Ensure the charging space is secure before used and designate a separate area for charging
8	Lifting/moving goods manually	Dust	PPE	Wear mask, work according to SOP
		Chronic pain	ADMINISTRATION	Work according to SOP, pay attention to body position before lifting goods, do not lift heavy items, socialize to employees regarding the proper body position when lifting goods
		Struck by materials	ADMINISTRATION	Lifting large objects should be avoided, and the proper lifting position should be maintained
9	Loading goods manually	Chronic pain	ADMINISTRATION	Work according to SOP, pay attention to body position before lifting goods, do not lift heavy items, socialize to employees regarding the proper body position when lifting goods
		Pinched/scratched/crushed by goods	ADMINISTRATION	Lifting large objects should be avoided, and the proper lifting position should be maintained
10	Truck arrival in receiving area	Crashed onto the storage platform	PLANNING	Installing a stopper and inspecting the truck's parking sensor
		Worker hit by truck	PLANNING	Install a no-passing sign when the vehicle is in operation
11	Goods wrapping	Sliced by cutter	-	-

4. CONCLUSION

This research uses the HIRARC method to identify and analyze the potential hazards in PT Vale Indonesia Tbk. There are approximately 11 activities and 27 potential risks in Warehouse Support of PT

Vale Indonesia Tbk. From the 27 risks that have been identified through risk level, 2 of them are classified as low, 7 are classified as medium, 17 are classified as high, and 1 is classified as extreme. Based on risk level classification, this study categorizes the following hierarchical control; 6 PPE categories, 6 PLANNING categories, 9 ADMINISTRATION categories, 3 SUBSTITUTION categories, and 1 ELIMINATION category. Meanwhile, the other two risk management enhancements were not implemented since the risk level category remained low. By categorizing the risk levels, it is suggested to the company to carry out the risk control through an analysis of the level of risk that may be encountered, and it is suggested to implement the recommended control improvements.

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