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Risk Assessment on Loading and Unloading Heavy Material in Non-Destructive Testing Industry

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Abstract

Heavy material loading and unloading are critical activities in many industries, often associated with significant safety risks. Proper hazard identification, risk assessment, and risk control (HIRARC) are essential to minimize these risks and ensure a safe working environment. This study aimed to identify potential hazards associated with the loading and unloading of heavy materials activity, to assess risk assessment that related to loading and unloading heavy material activity using the HIRARC assessment form, and to propose effective risk control measures for loading and unloading heavy material activity and improve workplace safety. The research integrated qualitative and quantitative methods such as field observation and semi-structured interviews. The HIRARC methodology is applied systematically to evaluate risks and recommend controls. The study identifies improper lifting techniques, exposure to sharp edges, improper trolley design, and exposure to dust as the primary risks during loading and unloading operations. Risk assessments reveal to medium. Mitigation strategies are proposed to address these challenges by using rust-resistant material for the block, providing a clear SOP, and using a cut-resistant glove and safety shoes. By implementing the HIRARC framework, workplaces can effectively manage and mitigate hazards, reducing the likelihood of incidents and fostering a safer working environment. This research improves safety practices in industries reliant on heavy material handling operations.

1. Introduction

Material handling is vital in industrial operations, ensuring goods' safe and efficient movement. Handling heavy materials in the oil and gas industry is essential but poses significant safety challenges. Workers are exposed to musculoskeletal injuries, falling objects, and hazardous environments. These hazards can lead to serious workplace accidents, financial losses, and operational disruption without appropriate risk assessment and controls. Therefore, identifying and mitigating these risks is essential to improving workplace safety and efficiency.

Previous studies have emphasized the importance of hazard identification and risk assessment in high-risk industries. Researchers have applied various safety frameworks, such as the Hazard Identification, Risk

Assessment, and Control (HIRARC) approach, to assess workplace risks systematically. Studies have shown improper manual handling techniques and inadequate safety measures contribute to workplace injuries [1]. Implementing risk control strategies, including engineering and administrative controls, effectively reduces workplace accidents [2]. Despite these findings, few studies focus on heavy material handling in the oil and gas industry's nondestructive testing (NDT) environments.

This study aims to fill this gap by assessing the risks associated with heavy material handling in the NDT industry using the HIRARC framework. It aims to identify potential hazards, assess their severity, and propose effective risk control measures. By applying a structured risk assessment approach, this study improves workplace safety and minimizes occupational risks during handling operations.

2. Methodology

This study uses the HIRARC framework to systematically identify, assess, and manage hazards related to heavy material loading and unloading activities to improve workplace safety. The research targeted male workers from the Kajang office and freelance NDT workers, employing a structured data collection and analysis approach. The study utilized the HIRARC assessment form based on the Department of Occupational Safety and Health (DOSH) Malaysia guidelines to ensure a standardized hazard evaluation. The HIRARC process involved hazard identification, risk assessment, and risk control, with risk levels determined using a risk matrix that calculates risk as the product of likelihood and severity. The study design was finalized early, and descriptive analysis was used to evaluate the results. Based on the findings, practical recommendations were proposed, including engineering controls, administrative measures, and personal protective equipment (PPE), to enhance safety practices. These insights contribute to better risk management in material handling and provide a foundation for future research in workplace safety.

2.1 Research Design

The research design integrated qualitative and quantitative approaches, ensuring a comprehensive understanding of workplace safety challenges and their potential solutions. The qualitative method was conducted through field observation with the inspection checklist (OSHWA) and semi-structured interviews to identify workplace hazards and understand employee perceptions of safety challenges. The quantitative method was focused on risk assessment, using a standardized risk matrix to evaluate the likelihood and severity of identified hazards.

2.2 Focused Group Discussion

This research was conducted based on a focused group discussion of workers from the Kajang office and freelance NDT workers regarding loading and unloading heavy material. The field observation and semi-instructed interview were conducted during the loading and unloading of heavy material at office Kajang.

2.3 Location of Field Observation

The field observation was at the Bandar Seri Puteri, Kajang office. The specific activity was held in the pantry area, where blocks are stored. In addition, the activity was held at the parking area office.

2.4 Flowchart

This research framework explores hazards, evaluates risks, and recommends risk control strategies in loading and unloading heavy material activity. It provides a structured methodology to meet the study's goals by methodically addressing the key phases of HIRARC: Hazard Identification, Risk Assessment, and Risk Control. The overarching objective is to enhance workplace safety and efficiency in material handling processes. Below is the diagram of a research framework for this project:

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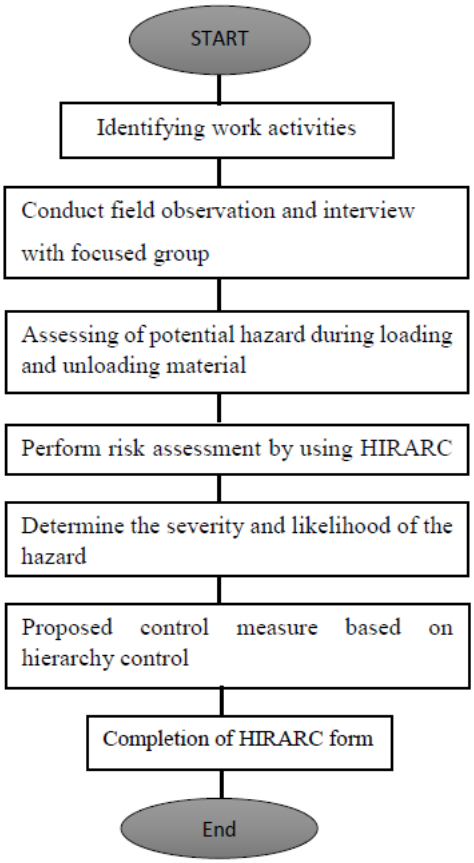

***Fig. 1*:** Diagram of research flowchart

3. Result and Discussion

The hazard identification section outlines significant risks associated with heavy material handling, divided into three main areas: preparation, loading and unloading, and housekeeping activities. In the preparation phase, workers encounter dangers such as exposure to rust and pinch points, which can lead to injuries like cuts or delays. During loading and unloading, risks include improper lifting techniques, sharp edges, and unsecured trolleys, potentially resulting in back pain, hand injuries, or serious accidents. Housekeeping issues involve limited space, dust exposure, and incorrect lifting, which can obstruct emergency equipment and lead to back pain or irritation of the eyes and skin. These hazards emphasize the importance of implementing specific strategies to improve workplace safety.

***Table 2*:** Hazard and type of hazard

No	Work Activity	Hazard	Type of Hazard
1.	Preparation of block	Exposed to rust block	Physical hazard
		Pinch point	Physical hazard
2.	Loading and unloading a block	Improper technique of lifting	Ergonomic hazard
		Exposed to sharp edges	Physical hazard
		Improper design of the trolley	Safety hazard
3.	Housekeeping the block	Insufficient space	Physical hazard
		Exposed to dust	Health hazard
		Improper technique of lifting	Ergonomic hazard

When compared with existing literature, the findings align with prior research emphasizing the importance of structured risk management approaches like HIRARC in industrial settings. For instance, Suhardi et al. [3] demonstrated that applying the HIRARC method effectively reduces workplace accidents by systematically

identifying and mitigating risks. Similarly, Mahusain [4] emphasized the necessity of detailed risk assessments in welding operations, highlighting that improper manual handling leads to musculoskeletal disorders, a trend also observed in this study.

***Table 3*:** Risk level

Risk Assessment					
No.	Hazard	Likelihood	Severity	Risk	Value
1.	Miscommunication of instruction	2	2	4	Low
	Exposed to rust block	3	2	6	Medium
	Pinch point	3	2	6	Medium
2.	Improper technique of lifting	4	2	8	Medium
	Exposed to sharp edges	4	2	8	Medium
	Improper design of trolley	4	2	8	Medium
3.	Insufficient space	3	2	6	Medium
	Exposed to dust	4	2	8	Medium
	Improper technique of lifting	4	2	8	Medium

Furthermore, Carrivick et al. [5] discussed how consultative teamwork in manual handling operations significantly reduces injury risks. The present study echoes this finding by emphasizing the role of administrative controls, such as regular training programs, in reducing improper lifting techniques. Additionally, Rahman et al. [6] highlighted that older workers are particularly susceptible to musculoskeletal injuries due to improper lifting, reinforcing the need for ergonomic control measures such as improved lifting equipment and proper workstation design.

The risk assessment process classified all identified hazards as medium-risk, including improper lifting techniques, exposure to sharp edges, and inadequate storage space. The literature supports the prioritization of medium-risk hazards, as Javadi et al. [7] indicated that moderate risks in NDT processes if left unaddressed, can escalate into severe safety incidents.

The implementation of risk control measures should follow the hierarchy of controls. Engineering controls, such as rust-resistant materials, enhanced trolleys, and protective gear for sharp edges, are recommended. Additionally, administrative measures like regular training on proper lifting techniques and awareness programs are crucial, along with personal protective equipment (PPE) such as cut-resistant gloves and masks. These strategies align with previous studies, such as Kabul and Yafi [8], which emphasized that combining engineering, administrative, and PPE measures is the most effective approach to occupational safety.

By integrating insights from previous studies, this research reinforces the effectiveness of the HIRARC framework in mitigating hazards during heavy material handling. The study contributes to the growing evidence supporting structured safety management practices in industrial environments.

4. Conclusion

This study identified medium-risk hazards associated with heavy material loading and unloading operations, including improper lifting techniques, exposure to sharp edges, and insufficient storage space. To address these risks, immediate solutions include enforcing PPE such as cut-resistant gloves and safety shoes, implementing clear SOPs, conducting mandatory training on proper lifting techniques, improving trolley stability, and enforcing regular housekeeping inspections. For long-term risk reduction, organizations should invest in engineering controls such as rust-resistant materials and proper racking systems, introduce automation and lifting aids to minimize manual handling, conduct periodic ergonomic risk assessments, and foster a strong safety culture through continuous training and incident reporting systems. Additionally, research into advanced risk mitigation techniques, such as real-time hazard monitoring and wearable safety sensors, should be explored to enhance worker protection further. By integrating these immediate and long-term solutions, workplaces can significantly reduce safety risks, improve operational efficiency, and foster a proactive safety culture in material handling activities.

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Conflict of Interest

The authors declare no conflict of interest regarding the paper's publication.

Author Contribution

The study's conceptualization and design, data collecting, analysis and interpretation of the findings, and paper preparation are all acknowledged to be entirely within the author's domain.

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