Equivalent: Jurnal Ilmiah Sosial Teknik
Volume 8, Issue 2, 343-356
e_ISSN: 2775-0833
https://jurnalequivalent.id/index.php/jequi/index
DOI: doi.org/10.59261/jequi.v8i2.293

Occupational Safety and Health Risk Evaluation in Container Handling Operations Using the HIRADC Method: A Case Study at PT. Kaltim Kariangau Terminal, East Kalimantan, Indonesia

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Article Info:

Article history:
Received: March 12, 2026
Revised: April 20, 2026
Accepted: April 22, 2026

Keywords:
hazard identification; occupational health and safety; risk assessment and control

Abstract

Background: Occupational safety and health is a critically important aspect of container loading and discharging operations at ports, encompassing efforts to create a safe, healthy work environment and prevent workplace accidents and work-related diseases.
Objective: This study aims to analyze the application of occupational safety and health in the process of loading and discharging containers at *PT.* Kaltim Kariangau Terminal.
Methods: This study uses the HIRADC (Hazard Identification, Risk Assessment, and Determining Control) method.
Results: The results of the risk level assessment before control indicate a High Risk level of 9 risks (23.1%), a Moderate Risk level of 17 risks (43.6%), and a Low Risk level of 13 risks (33.3%). After control, the High Risk level is reduced to 0 risks (0%), with no remaining high-risk work activities; the Moderate Risk level is 8 risks (20.6%); and the Low Risk level is 31 risks (79.4%). To address these hazards and risks, *PT.* Kaltim Kariangau Terminal has implemented risk controls, namely substitution, engineering controls, administrative controls, and personal protective equipment.
Conclusion: The findings demonstrate that systematic hazard identification and hierarchical risk control, when applied rigorously to RTG crane operations in container terminals, can deliver measurable reductions in worker exposure to life-threatening risks and provide a replicable OSH management model for the Indonesian port sector.

To cite this article: Usman, A. F., Ningrat, A., Muslihati, Rachmianty, A., & Rusnaedi. (2026). Occupational safety and health risk evaluation in container handling operations using the HIRADC method: A case study at PT. Kaltim Kariangau Terminal, East Kalimantan, Indonesia. *Equivalent: Jurnal Ilmiah Sosial Teknik*, 8(2), 343–356. https://doi.org/10.59261/jequi.v8i2.293

INTRODUCTION

The work environment is the most influential factor affecting employee performance, as it directly or indirectly impacts workers' output (Al Zhafir et al., 2026; Hasiany et al., 2024; Sutapa et al., 2022). Poor work environment will undoubtedly have a negative impact on employees, reducing their motivation, enthusiasm, and job satisfaction, ultimately decreasing employee performance (Adinata & Turangan, 2023; Bhastary & Suwardi, 2018; Musinguzi et al., 2018).

The Social Security Administration for Employment (*BPJS Ketenagakerjaan*) recorded

234,270 workplace accidents in Indonesia in 2021. This number increased by 5.65% from the previous year, when there were 221,740 cases. Looking at the chart above, the number of workplace accidents in Indonesia has been steadily rising over the past five years. In 2017, there were 123,040 cases, which increased to 173,415 cases in 2018. A year later, workplace accidents further increased to 182,835 cases. Domestic workplace accidents rose to 221,740 cases in 2020 and continued to increase to 234,270 cases in 2021 (Mahdi, 2022).

The port and maritime sector consistently ranks among Indonesia's highest-risk industries: container terminal operations involve the simultaneous operation of heavy-lifting machinery (RTG cranes, reach stackers), high-density vehicle movement, and close-proximity manual handling—conditions that create compound exposure to mechanical, ergonomic, and environmental hazards (G. N. Putri & Ariesyadi, 2023; Sjarifudin et al., 2023; Sulistiowati & Prasetyo, 2023). Despite this operational complexity, systematic hazard identification using structured methods such as HIRADC remains unevenly applied across Indonesian container terminals (A. A. Putri et al., 2024; Riyanta, 2023; Ruslan et al., 2025).

According to data released by the Indonesian Ministry of Employment in 2020, 57.5% of the 126.51 million people working in Indonesia had a low level of education. This condition affects the low awareness of workers regarding the importance of occupational safety and health (OSH) culture. At the same time, employers are at risk of incurring significant costs if workplace accidents occur, causing losses for both the individuals and the companies.

PT. Kaltim Kariangau Terminal is a container terminal company established to manage and provide port services. The terminal has a container stacking yard capable of accommodating 300,000 TEUs. This container terminal not only serves local shipments but also international imports and exports. Container ports are one of the workplaces with the potential for workplace accidents. Based on data obtained from Lloyd's List Intelligence Casualty Statistics Analysis: AGCS, in 2013, Indonesia ranked first in total losses with 296 cases related to cargo handling and container loading/unloading. Other data from the Directorate of Sea Transportation, Ministry of Transportation, in 2011 recorded 178 accidents and 343 casualties due to human factors, natural factors, and technical factors.

Container terminal activities are closely tied to loading and unloading activities. Human resources play a crucial role in these activities. Every activity in the port carries the risk of workplace accidents for the workers (Gul & Ak, 2018; Kurniawan & Kurniawan, 2020). Therefore, it is essential to address and regulate occupational safety and health. Occupational safety and health principles serve two purposes: they are a means to achieve optimal worker health in all formal and informal sectors, contributing to worker welfare, and they are a means of improving work capacity and human factors in production to enhance performance (Alamsyah & Muliawati, 2013).

Legislation on Occupational Safety and Health is found in Law No. 1 of 1970, which regulates workplace safety in all types of workplaces, whether on land, underground, on the water surface, underwater, or in the air, within the jurisdiction of the Republic of Indonesia. Occupational Safety and Health, as defined in Government Regulation No. 50 of 2012 on the Implementation of Occupational Safety and Health Management Systems, encompasses all activities to ensure and protect worker safety and health through accident prevention and the prevention of work-related diseases.

According to Clarke (2016), workplace accidents do not occur by chance but have underlying causes. Therefore, the causes of accidents must be investigated and identified, allowing corrective actions to address the root causes and further preventive measures to prevent recurring accidents.

Studies on occupational safety in Indonesian port operations have examined OSH management system implementation Jannah (2017) and Revanza (2022) and general K3 compliance using HIRA methodology Mustari (2022), but these studies predominantly focus on construction projects and manufacturing settings rather than container terminal RTG crane operations specifically. Documented container terminal hazard profiles, but without applying the HIRADC hierarchical control framework mandated under Indonesian Government Regulation No. 50 of 2012. The gap this study addresses is therefore both empirical and methodological: no prior

published study has applied the full HIRADC framework—including the before-and-after risk level comparison—to RTG crane container handling operations at an Indonesian regional terminal.

This study's novelty lies in three contributions: (1) a complete HIRADC-based hazard catalog for RTG crane loading and unloading operations across nine activity categories, providing an OSH reference tool for comparable Indonesian terminals; (2) empirical quantification of risk level shift following hierarchical control implementation, demonstrating the measurable effectiveness of substitution, engineering, administrative, and PPE controls; and (3) a practical OSH evaluation framework applicable by port HSE practitioners without requiring advanced statistical expertise.

Moreover, grounded in this understanding, this study pursues three specific objectives: (1) to identify and catalog hazards and risks in the RTG crane container handling process at PT. Kaltim Kariangau Terminal using the HIRADC method; (2) to assess the risk level of each identified hazard before and after control implementation; and (3) to evaluate the effectiveness of the risk control hierarchy applied by the terminal in reducing worker exposure to High Risk and Moderate Risk hazards

METHOD

The methodology employed in this study is qualitative descriptive, with data analysis using the HIRADC (Hazard Identification, Risk Assessment, and Determining Control) method. The research was conducted at the Container Terminal of PT. Kaltim Kariangau Terminal. The research was carried out from November 2024 to May 2025. The population in this study consists of 23 individuals, including RTG Operators and Senior Field Operations Executives at PT. Kaltim Kariangau Terminal. The research sample, representing a portion of the population, was determined using the Slovin formula, resulting in a sample size of 19 individuals.

Data for this research were collected through both primary and secondary sources. Primary data were obtained through direct field surveys to identify hazards and risks. Data collection was carried out by the researcher through interviews with several RTG Operators and Senior Field Operations Executives. Questionnaires were also used to determine the likelihood and impact levels of identified hazards and risks. Secondary data were obtained from the company's internal records, specifically from PT. Kaltim Kariangau Terminal.

To analyze the data effectively, information regarding the potential hazards of loading and unloading activities in the container yard at PT. Kaltim Kariangau Terminal, methods to minimize workplace accidents, and measures for implementing Occupational Safety and Health (OSH) were required. The collected data were processed for use in the research. The data processing in this research involved applying the HIRADC method, which includes identifying hazards, conducting risk assessments, and implementing risk controls. Risk analysis was based on the considerations of risk sources, hazard consequences, and the likelihood of these consequences occurring. The risk assessment measurements comprised two parameters: severity and probability. The following is the risk assessment scale and its explanations:

Table 1. Severity Assessment

Level	Description	Details
1	Insignificant	No injuries, low financial loss
2	Minor	First aid required, immediate on-site treatment, moderate financial loss
3	Moderate	Medical treatment needed, on-site treatment with external assistance, high financial loss
4	Major	Extensive injuries, loss of production capability, off-site release with adverse effects, significant financial loss
5	Catastrophic	Fatality, hazardous material release with severe adverse effects, very high financial loss

Source: Secondary Data 2025

Table 2. Probability Assessment.

Level	Description	Details
5	Almost Certain	Expected to occur in most circumstances
4	Very Likely	Likely to occur in most circumstances
3	Possible	May occur at some point
2	Occasional	Could occur at some point
1	Rare	Only likely to occur in exceptional circumstances

Source: Secondary Data 2025

The risk level obtained after analyzing based on probability and severity parameters can be categorized in the risk value matrix as follows:

Tabel 3. Level Assessment Matrix Probability dan Severity

Probability		***Severity***				
		Insignificant (1)	**Minor (2)**	**Moderate (3)**	**Major (4)**	**Catastrophic (5)**
Almost Certain	5	M	H	E	E	E
Very Likely	4	L	M	H	E	E
Possible	3	L	M	M	H	E
Occasional	2	L	L	M	M	H
Rare	1	L	L	L	L	M

Source: Secondary Data 2025

The risk level is determined from the calculation results of two parameter matrices, namely L = Low Risk, M = Moderate Risk, H = High Risk, and E = Extreme Risk. The risk assessment process is carried out with the aim of recognizing and identifying hazards that may occur in an organization's activities and ensuring that risks which may arise to workers or persons in an organization can be assessed, prioritized, and controlled at an acceptable level. A HIRADC table is then compiled, which is a tool for organizing information related to the identification of hazards, risks, and necessary risk controls. This table helps in collecting and presenting data in a structured manner.

RESULTS AND DISCUSSION

Results

Research Objects and Subjects

The object of this research is the loading and unloading process using a Rubber Tired Gantry Crane (RTG) at PT. Kaltim Kariangau Terminal. The types of activities or work that have potential danger include: 1) Pre-start inspection of the Rubber Tired Gantry (RTG) unit, 2) Climbing the Rubber Tired Gantry (RTG) ladder, 3) Operator activities in operating the Rubber Tired Gantry (RTG), 4) Rubber Tired Gantry (RTG) gantry travel activities, 5) Hoist up/down activities, 6) Rubber Tired Gantry (RTG) trolley activities, 7) Head truck activities, 8) Tallyman activities for recording or reporting, 9) Use of slings, 10) Locking and unlocking Rubber Tired Gantry (RTG) equipment, 11) Container stacking, 12) Dangerous goods container handling, 13) Field conditions. Meanwhile, the subject of this research is identifying hazards, risk assessment, and risk control using the HIRADC method in the loading and unloading process at the Container Yard at PT. Kaltim Kariangau Terminal. Analysis of the data obtained in the form of hazard identification and risk control data is then used to compile the HIRADC table, which aims to assess the risk level before and after implementing controls with the aim of reducing the risk level.

Respondent Characteristics

Table 4. Characteristics of respondents based on length of service

Respondent Characteristics	Amount	Percentage
Length of Work Period		
>1 Year	1	5%
1 – 5 Year	6	32%
5 – 10 Year	8	42%
10 – 15 Year	4	21%
Total	19	100%

Source: Primary data, 2025

From the data presented in Table 1, based on length of service, we can determine the number of respondents, namely RTG Operators and Senior Field Operations Executives. The respondent with less than 1 year of work experience amounts to 1 person, accounting for 5% of the total respondents. There are 6 respondents with work experience between 1 and 5 years, constituting 32% of the total. The group with work experience between 5 and 10 years includes 8 respondents, making up 42% of the total. Finally, there are 4 respondents with work experience between 10 and 15 years, representing 21% of the total respondents. It can be concluded that the group with 5 to 10 years of work experience is the largest among the respondents.

Risk Assessment Before Control Is Implemented

Risk is the potential for harm or loss arising from a hazard. The risk level ranges from low to very high. Risk assessment is conducted by determining the product of the probability and severity of each identified potential hazard. Probability and severity levels are determined based on questionnaire distribution, interviews, and field observations. The probability and severity scales range from 1 to 5, with different descriptions for each value.

Table 5. HIRADC table for risk assessment before control is carried out

No.	Job Activity	Hazard	Risk	Initial Risk		
				P	S	RR
1.	Prestart Check Unit Equipment	Visual inspection: oil and fuel leaks	Slippery floors, fire, environmental pollution	4	1	4/L
		Startup equipment check	Property damage	4	1	4/L
		Emergency button check	Property damage	4	1	4/L
2.	Ascending and Descending RTG Stairs	Repetitive climbing and descending staircase motion	Minor injuries, slipping, severe injuries (bone fractures), death	5	2	10/ H
		Oil spill on RTG stairs	Minor injuries, slipping, severe injuries (bone fractures), death	3	2	6/M
		Weather conditions (Heavy rain)	Minor injuries, slipping, fractures, death	3	2	6/M
3.	Operator Operating RTG	Operator's lack of awareness of the surroundings	Property damage, loss	3	1	3/L
		Collision with container boxes	Property damage, loss, severe injuries (head injury), death	3	4	12/ H
4.	RTG Equipment Performing Gantry	Collision with Tronton delivery/receiving trucks	Property damage, loss, minor injuries, severe injuries, death	2	3	6/M

No.	Job Activity	Hazard	Risk	Initial Risk		
				P	S	RR
	Movements	Collision with other RTGs	Property damage, loss, minor injuries, severe injuries, death	2	3	6/M
		Tallyman being hit by RTG during gantry	Property damage, loss, minor injuries, severe injuries, death	3	3	9/ M
5.	Hoist Up and Hoist Down Spreader RTG	Wire Rope failure when lifting loads	Property damage, loss, minor injuries, severe injuries, death	3	4	12/ H
		Container weight exceeding RTG's capacity	Property damage, loss, minor injuries, severe injuries, death	3	4	12/ H
		Operator and Tallyman unaware of the equipment	Property damage, loss, minor injuries, severe injuries, death	2	3	6/M
		Weather conditions (Heavy rain / Strong wind)	Property damage, loss, minor injuries, severe injuries, death	2	3	6/M
6.	RTG Trolley	Shifting activities when lifting container boxes	Property damage, loss, severe injuries, minor injuries	4	3	12/ H
7.	Lock and Unlock RTG Spreader Equipment	Mechanical Hazards	Property damage, loss, minor injuries, severe injuries, death	4	3	12/ H
		Container boxes falling / Contents falling	Property damage, loss, minor injuries, severe	3	4	12/ H
8.	Tallyman Activities - Recording and Reporting	Sun Exposure	Dehydration, working fatigue	5	1	5/M
		Hit by Head Truck	Property damage, loss, severe injuries, minor injuries	3	2	6/M
		Crushed by Container Box	Property damage, loss, severe injuries, minor injuries	3	4	12/ H
9.	Sling Usage	Tally climbing on top of container boxes	Property damage, loss, severe injuries, minor injuries	3	2	6/M
		Pinched during sling installation	Property damage, loss, severe injuries, minor injuries	2	1	2/L
		Sling Rope Breakage	Property damage, loss, severe injuries, minor injuries	3	2	6/M
10.	Head Truck Activities	Tire Burst	Property damage, loss, severe injuries, minor injuries	2	1	2/L
		Oil Spill	Property damage, loss, minor injuries, severe injuries, environmental pollution	3	1	3/L
		Collision with Other	Property damage, loss,	2	2	4/L

No.	Job Activity	Hazard	Risk	Initial Risk		
				P	S	RR
		Trucks	severe injuries, minor injuries			
		Working beneath heavy equipment	Property damage, loss, severe injuries, minor injuries	4	3	12/ H
11.	Container Stacking	Uneven container stacking	Property damage, loss, severe injuries, minor injuries	3	2	6/M
		Non-unidirectional container door	Property damage, loss	3	1	3/L
		Weather conditions (Rain, Strong Wind)	Property damage, loss, container falls, severe/minor injuries	2	1	2/L
		5-Tier container stacking	Property Damage, Losses, Major and Minor Injuries	4	2	8/M
12.	Handling Dangerous Goods Container	Improper handling of DG container according to procedure	Mishandling can result in: (environmental damage, fire, death, occupational diseases) Company losses, Inappropriate container content	3	3	9/M
		Incorrect Documentation	Mishandling, Operational losses, Inappropriate container content	2	3	6/M
		Incorrect Labeling	Mishandling, Inappropriate content, Fire, Toxicity, Environmental pollution, Health issues	2	3	6/M
13	Field Conditions	Uneven Roads	Property Damage, Loss	4	1	4/L
		Damaged Roads	Property Damage, Loss	4	1	4/L
		Noise	Occupational Diseases	3	1	3/L
		Dust	Acute Respiratory Infections	5	1	5/M

Source: Data Analysis 2025

The results above show that, on average, jobs are categorized as Low Risk, where the work does not result in severe injuries and does not require medical treatment; Moderate Risk, where the work is hazardous, requiring medical treatment but not leading to lost workdays or fatalities; and High Risk, where the work is highly risky and can lead to severe injuries requiring medical treatment, lost workdays, or even fatalities.

Out of the 39 risk levels analyzed in the HIRADC table, the results of the assessment before control measures are implemented, expressed as percentages, are as follows:

$$R = \frac{Amount\ Risk}{Total\ Risk} \times 100\%$$

1. $\frac{\text{High Risk}}{39} = \frac{9}{39} \times 100\% = 23{,}1\ \%$
2. $\frac{\text{Moderate Risk}}{39} = \frac{17}{39} \times 100\% = 43{,}6\ \%$
3. $\frac{\text{Low Risk}}{39} = \frac{13}{39} \times 100\% = 33{,}3\%$

From the results of the risk assessment before control measures, the percentages show that High-Risk jobs account for 23.1%, Moderate-Risk jobs account for 43.6%, and Low-Risk jobs account for 33.3% of the total jobs assessed.

Risk Assessment After Risk Control

Risk control is carried out to minimize work-related accidents and losses for both the company and the workers themselves. Risk control is a critical component of risk management. PT. Kaltim Kariangau Terminal has four risk control hierarchies implemented. The risk controls applied are substitution, engineering controls, administrative controls, and personal protective equipment (PPE). The risk level results obtained after implementing these controls can be seen in table 6.

Table 6. HIRADC Table for Risk Assessment After Control

No.	Job Activity	Hazard	Risk	Initial Risk		
				P	S	RR
1.	Prestart Check Unit Equipment	Visual inspection: oil and fuel leaks	Slippery floors, fire, environmental pollution	4	1	4/L
		Startup equipment check	Property damage	4	1	4/L
		Emergency button check	Property damage	4	1	4/L
2.	Ascending and Descending RTG Stairs	Repetitive climbing and descending staircase motion	Minor injuries, slipping, severe injuries (bone fractures), death	5	2	10/ H
		Oil spill on RTG stairs	Minor injuries, slipping, severe injuries (bone fractures), death	3	2	6/M
		Weather conditions (Heavy rain)	Minor injuries, slipping, fractures, death	3	2	6/M
3.	Operator Operating RTG	Operator's lack of awareness of the surroundings	Property damage, loss	3	1	3/L
		Collision with container boxes	Property damage, loss, severe injuries (head injury), death	3	4	12/ H
4.	RTG Equipment Performing Gantry Movements	Collision with Tronton delivery/receiving trucks	Property damage, loss, minor injuries, severe injuries, death	2	3	6/M
		Collision with other RTGs	Property damage, loss, minor injuries, severe injuries, death	2	3	6/M
		Tallyman being hit by RTG during gantry	Property damage, loss, minor injuries, severe injuries, death	3	3	9/ M
5.	Hoist Up and Hoist Down Spreader RTG	Wire Rope failure when lifting loads	Property damage, loss, minor injuries, severe injuries, death	3	4	12/ H
		Container weight exceeding RTG's capacity	Property damage, loss, minor injuries, severe injuries, death	3	4	12/ H
		Operator and Tallyman unaware of the equipment	Property damage, loss, minor injuries, severe injuries, death	2	3	6/M
		Weather conditions	Property damage, loss,	2	3	6/M

No.	Job Activity	Hazard	Risk	Initial Risk		
				P	S	RR
		(Heavy rain / Strong wind)	minor injuries, severe injuries, death			
6.	RTG Trolley	Shifting activities when lifting container boxes	Property damage, loss, severe injuries, minor injuries	4	3	12/ H
7.	Lock and Unlock RTG Spreader Equipment	Mechanical Hazards	Property damage, loss, minor injuries, severe injuries, death	4	3	12/ H
		Container boxes falling / Contents falling	Property damage, loss, minor injuries, severe	3	4	12/ H
8.	Tallyman Activities - Recording and Reporting	Sun Exposure	Dehydration, working fatigue	5	1	5/M
		Hit by Head Truck	Property damage, loss, severe injuries, minor injuries	3	2	6/M
		Crushed by Container Box	Property damage, loss, severe injuries, minor injuries	3	4	12/ H
9.	Sling Usage	Tally climbing on top of container boxes	Property damage, loss, severe injuries, minor injuries	3	2	6/M
		Pinched during sling installation	Property damage, loss, severe injuries, minor injuries	2	1	2/L
		Sling Rope Breakage	Property damage, loss, severe injuries, minor injuries	3	2	6/M
10.	Head Truck Activities	Tire Burst	Property damage, loss, severe injuries, minor injuries	2	1	2/L
		Oil Spill	Property damage, loss, minor injuries, severe injuries, environmental pollution	3	1	3/L
		Collision with Other Trucks	Property damage, loss, severe injuries, minor injuries	2	2	4/L
		Working beneath heavy equipment	Property damage, loss, severe injuries, minor injuries	4	3	12/ H
11.	Container Stacking	Uneven container stacking	Property damage, loss, severe injuries, minor injuries	3	2	6/M
		Non-unidirectional container door	Property damage, loss	3	1	3/L
		Weather conditions (Rain, Strong Wind)	Property damage, loss, container falls, severe/minor injuries	2	1	2/L
		5-Tier container stacking	Property Damage, Losses, Major and Minor Injuries	4	2	8/M
12.	Handling	Improper handling of DG	Mishandling can result in:	3	3	9/M

No.	Job Activity	Hazard	Risk	Initial Risk		
				P	S	RR
	Dangerous Goods Container	container according to procedure	(environmental damage, fire, death, occupational diseases) Company losses, Inappropriate container content			
		Incorrect Documentation	Mishandling, Operational losses, Inappropriate container content	2	3	6/M
		Incorrect Labeling	Mishandling, Inappropriate content, Fire, Toxicity, Environmental pollution, Health issues	2	3	6/M
13	Field Conditions	Uneven Roads	Property Damage, Loss	4	1	4/L
		Damaged Roads	Property Damage, Loss	4	1	4/L
		Noise	Occupational Diseases	3	1	3/L
		Dust	Acute Respiratory Infections	5	1	5/M

Source: Data Analisiys 2023

Based on the table 6, the reduction in risk levels for all jobs after implementing risk control measures is a positive outcome for both the company and the workforce. The shift from High Risk to Moderate Risk indicates progress in enhancing workplace safety, but it does not imply complete safety. There are still potential risks that may harm workers and the company. Therefore, continuous monitoring and oversight of even minor tasks are necessary to prevent workplace accidents.

Furthermore, the post-control assessment of the 39 risk levels analyzed from the HIRADC table, when expressed as percentages, yields the following results:

$$R = \frac{Amount\ Risk}{Total\ Risk} x\ 100\%$$

1. $\underline{\text{High Risk}} = \frac{0}{39} x\ 100\% = 0\ \%$
2. $\underline{\text{Moderate Risk}} = \frac{8}{39} x\ 100\% = 20{,}6\ \%$
3. $\underline{\text{Low Risk}} = \frac{31}{39} x\ 100\% = 79{,}4\ \%$

From the results of the risk assessment after risk control has been carried out, the percentage form above shows that the High Risk work level gets a percentage of 0%, the Moderate Risk work level gets a percentage of 20.6%, and the Low Risk work level gets a percentage of 79.4%.

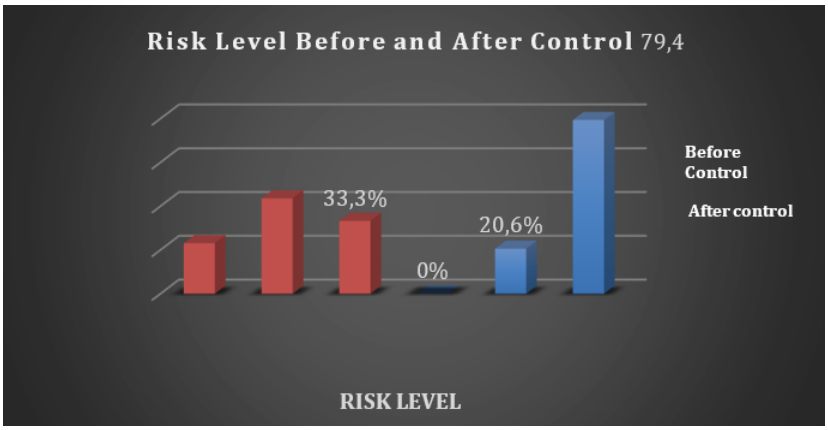

Figure 1. Risk Level Comparison Chart

Based on the figure 1, the risk level in each job category before control implementation decreased after risk controls were applied. Based on the data analyzed, implementing risk control measures is a critical effort to maintain occupational safety.

The risk level comparison across all nine RTG activity categories consistently shows reduction following control implementation. The most significant shifts occurred in Pre-start Checking and RTG Ladder Climbing activities, where High Risk classifications were eliminated through a combination of engineering controls (safety interlocks, improved access platforms) and administrative measures (mandatory pre-shift checklists, competency verification). This evidence confirms that systematic risk control is essential for achieving measurable hazard reduction in high-energy operational environments.

Discussion

The complete elimination of High Risk hazards—from 9 hazards (23.1%) to 0 (0%) following hierarchical control implementation—is the central scientific finding of this study. This outcome aligns with and extends previous HIRADC-based studies in Indonesian occupational settings. Jannah (2017) applied HIRADC and JSA to a high-rise construction project in Jakarta and found that hierarchical control measures reduced extreme and high-risk categories by approximately 60%, though full elimination was not achieved. The more complete risk reduction observed in the present study may reflect the controlled operational environment of a container terminal, where standardized procedures, fixed machinery configurations, and dedicated HSE supervision create more favorable conditions for control effectiveness than construction sites. Revanza's (2022) HIRA-based study found similar patterns of risk reduction following engineering and administrative controls, though without evaluating RTG-specific hazards.

The distribution of hazards across the nine RTG activity categories reveals a meaningful pattern: pre-start checking and ladder climbing activities generated disproportionately high concentrations of High Risk classifications, while tallyman recording and administrative tasks were predominantly Low Risk. This hierarchy reflects the physical exposure gradient of RTG crane operations—activities requiring proximity to high-energy mechanical systems carry inherently greater hazard potential than administrative support roles. The post-control shift of former High Risk hazards into the Moderate Risk tier—rather than direct reclassification to Low Risk—suggests that while engineering and PPE controls effectively reduce probability and/or severity, residual risk remains for activities involving heavy machinery interaction, which is consistent with theoretical expectations for occupational risk in mechanically intensive operations.

Actions and Handling of Work Accident Cases

The implementation of occupational health and safety at PT. Kaltim Kariangau Terminal for container handling processes appears to be in line with Standard Operating Procedures (SOPs). These SOPs adhere to ISO 9001:2008 standards and cover various aspects, including

accident investigation procedures, emergency response procedures, personal protective equipment, spill response procedures, safety behavior observations, hazard identification, risk assessment procedures, hazardous waste management, and more.

The multi-tier compliance architecture documented here—combining ISO 9001:2008-aligned SOPs, active HSE field supervision, and structured accident investigation—represents a more comprehensive safety management system than found in many comparable Indonesian port terminals. This institutional OSH infrastructure is a necessary precondition for the high control effectiveness observed in the HIRADC assessment: risk control measures are only effective when supported by enforcement mechanisms, and the existing supervision and reporting channels at PT. Kaltim Kariangau Terminal provide that institutional backbone.

Supervision and oversight activities are also in place at PT. Kaltim Kariangau. These include direct visits and field observations to assess potential hazards, control measures to mitigate these hazards, field condition patrols, and the reprimanding of workers who do not comply with safety and health SOPs. Moreover, there are established reporting and handling procedures in case of workplace accidents. These procedures involve creating an accident report, reporting it to the Assistant Manager of Container Service Operations, and then transferring the case to the HSE (Health, Safety, and Environment) supervisor for a root cause investigation to address the issues effectively.

CONCLUSION

This study applied the HIRADC method to evaluate occupational safety and health risk in RTG crane container handling operations at PT. Kaltim Kariangau Terminal, East Kalimantan. The central finding is unambiguous: all 9 High Risk hazards identified before control (23.1% of 39 total hazards) were eliminated following implementation of hierarchical risk controls. Post-control, the risk profile shifted to 0% High Risk, 20.6% Moderate Risk (8 hazards), and 79.4% Low Risk (31 hazards)—a transformation that directly answers the study's core research question on HIRADC effectiveness.

The four-tier control hierarchy deployed—substitution, engineering controls, administrative measures, and personal protective equipment—proved highly effective in reducing worker exposure to life-threatening hazard categories. Activities involving direct RTG crane interaction, particularly pre-start checking and ladder climbing, represented the highest pre-control risk concentrations and benefited most significantly from engineering and PPE interventions.

The persistence of Moderate Risk hazards after control reflects residual risk inherent in mechanically intensive operations, which cannot be fully eliminated without operational redesign. In practice, these findings demonstrate that systematic HIRADC implementation—integrated with an ISO-aligned SOP framework and active HSE supervision—constitutes a practical and scalable OSH management model for Indonesian container terminals. Port operators, HSE practitioners, and regulators can use the documented hazard catalog and control hierarchy as a replicable reference for comparable RTG crane operational environments across Indonesia's rapidly expanding container port sector.

ACKNOWLEDGEMENT

The authors would like to express their sincere gratitude to PT. Kaltim Kariangau Terminal for granting permission and providing full support during the research process. Appreciation is also extended to the management, RTG operators, and Senior Field Operations Executives who participated as respondents and contributed valuable data and insights. The authors also thank Politeknik Maritim AMI Makassar for academic support and facilitation in completing this research. Finally, the authors acknowledge all parties who have contributed, directly or indirectly, to the completion of this study.

AUTHOR CONTRIBUTION STATEMENT

Arif Fuddin Usman: Conceptualization, methodology, supervision, writing – original draft, and final approval. Andi Ningrat: Data collection, investigation, and writing – review & editing. Muslihati: Data analysis, validation, and interpretation of results. Andi Rachmianty: Literature review, data curation, and visualization. Rifkah Fitriah: Editing, proofreading, and formatting of the manuscript. All authors have read and agreed to the published version of the manuscript and contributed significantly to the completion of this research.

REFERENCES

Adinata, M. C., & Turangan, J. A. (2023). Pengaruh Motivasi Kerja, Stres Kerja, dan Lingkungan Kerja terhadap Kepuasan Kerja Karyawan PT X. *Jurnal Manajerial Dan Kewirausahaan*, *5*(1), 195–201. https://doi.org/10.24912/jmk.v5i1.22567

Al Zhafir, H., Nandito, J., & Ulya, I. (2026). Implementation of Occupational Health and Safety Using the Hiradc Method (Hazard Identification, Risk Assessment, and Determining Control) In Mining Areas: Literature Review. *International Conference of Public Health*, 246–251.

Alamsyah, D., & Muliawati, R. (2013). Pilar dasar ilmu kesehatan masyarakat. *Yogyakarta: Nuha Medika*, 13–17.

Bhastary, M. D., & Suwardi, K. (2018). Analisis Pengaruh Keselamatan Dan Kesehatan Kerja (K3) Dan Lingkungan Kerja Terhadap Kinerja Karyawan Di Pt. Samudera Perdana. *Jurnal Manajemen Dan Keuangan*, *7*(1), 47–60. https://doi.org/10.33059/jmk.v7i1.753

Clarke, S. (2016). Managing the risk of workplace accidents. *Risky Business*, 403–431.

Gul, M., & Ak, M. F. (2018). A comparative outline for quantifying risk ratings in occupational health and safety risk assessment. *Journal of Cleaner Production*, *196*, 653–664. https://doi.org/10.1016/j.jclepro.2018.06.106

Hasiany, S., Difa, G. F., Awan, F. N., & Prasetio, B. (2024). Risk Analysis Using HIRADC Method (Hazard Identification Risk Assessment and Determining Control) in the Palm Oil Processing Plant of PT. Perkebunan Nusantara VII Unit Bekri Lampung Tengah. *World Chemical Engineering Journal*, *8*(1), 1–5. https://doi.org/10.62870/wcej.v8i1.20632

Jannah, M. R., El Unas, S., & Hasyim, M. H. (2017). *Analisis risiko Keselamatan dan Kesehatan Kerja (K3) melalui pendekatan HIRADC dan metode job safety analysis pada studi kasus proyek pembangunan menara x di jakarta*. Brawijaya University.

Kurniawan, A. Y., & Kurniawan, F. (2020). Risk Management Related to Identifying Work Accidents in Loading and Unloading Container Activities at The Berlian Terminal Tanjung Perak Surabaya with the Hazard Identification Risk Assessment and Determining Control (HIRADC) Method. *Neutron*, *19*(2), 26–32.

Mahdi, M. I. (2022). Kasus kecelakaan kerja di Indonesia alami tren meningkat. *DataIndonesia. Id*.

Musinguzi, C., Namale, L., Rutebemberwa, E., Dahal, A., Nahirya-Ntege, P., & Kekitiinwa, A. (2018). The relationship between leadership style and health worker motivation, job satisfaction and teamwork in Uganda. *Journal of Healthcare Leadership*, 21–32. https://doi.org/10.2147/JHL.S147885

Mustari, M. U., Rahman, E. S., & Zulhajji, Z. (2022). Analisis implementasi sistem manajemen K3 pada laboratorium teknik instalasi tenaga listrik Sekolah Menengah Kejuruan Negeri di Kabupaten Gowa. *Jurnal Media Elektrik*, *19*(2), 120–126. https://doi.org/10.59562/metrik.v19i2.5458

Putri, A. A., Dhani, M. R., & Leonard, R. (2024). Analisis Risiko Pengoperasian Harbour Mobile Crane (HMC) Menggunakan Metode HIRADC dan FTA. *Conference on Safety Engineering and Its Application*, *8*(1).

Putri, G. N., & Ariesyadi, H. D. (2023). Analysis of occupational safety and health (K3) risk management in construction industry (case study: Construction of natural gas transmission pipelines). *Devotion: Journal of Research and Community Service*, *4*(9), 1895–1907. https://doi.org/10.59188/devotion.v4i9.565

Revanza, M. R. (2022). *Analisis Kecelakaan Kerja Menggunakan Metode Hira (Hazard*

Identification And Risk Assesment) Dan Jsa (Job Safety Analysis)(Studi Kasus: Pt Jaga Usaha Sandai).

Riyanta, W. (2023). HIRADC Analysis for Rolling Stock Body Lifting Ngrombo Railway Maintenance Center. *Civil Engineering Collaboration*, 34–39. https://doi.org/10.35134/jcivil.v8i2.59

Ruslan, S. N. L., Kamsulzain, N. B., Musa, M. A., Shamsudin, M. Z., & Zamli, Z. (2025). Ergonomic Hazard Identification, Risk Assessment, and Control in Fish Landing Operations in Kuantan, Pahang, Malaysia. *International Journal of Allied Health Sciences*, *9*(2). https://doi.org/10.31436/ijahs.v9i2.1015

Sjarifudin, D., Kurnia, H., Nuryono, A., & Tambunan, E. B. M. (2023). Hazard identification risk assessment and determining control (HIRADC) method for shoe cutting dies production. *Jurnal Sistem Teknik Industri*, *25*(2), 322–333. https://doi.org/10.32734/jsti.v25i2.12186

Sulistiowati, T. P., & Prasetyo, E. (2023). Analysis of Potential Risk of Hazards with Job Safety Analysis (JSA) Method in Loading and Unloading Activities at The Container Terminal of PT. Pelindo Semarang. *Menara Journal of Health Science*, *2*(4), 806–815.

Sutapa, I. K., Santiana, I. M., Susila, I. N., & Sudiarsa, M. (2022). Assessment of Occupational Safety and Health Risk (K3) Using the Hiradc (Hazard Identification Risk Assessment and Determining Control) Method in the Sanur Sea Port Facility Construction Project. *International Conference on Applied Science and Technology on Engineering Science*, 113–119. https://doi.org/10.5220/0011713800003575