Work Safety Risk Analysis in The Construction of Roll in Roll Out 500GT Vessel

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Abstract. Workplace accidents have the potential to transpire during any work-related undertaking. Accidents may arise due to factors such as malfunctioning machinery, improper use of tools, or human error on the part of workers. The purpose of this study was to identify prospective workplace accidents in order to facilitate the implementation of preventative measures at PT Industri Kapal Indonesia (IKI), a shipbuilding company in Makassar, Indonesia. This study used the Job Safety Analysis (JSA) method and the Hazard Identification Risk Assessment and Risk Control (HIRARC) approach. This study identified three distinct job categories encompassing a cumulative total of thirteen procedural stages that exhibit the propensity for occupational hazards within the construction process of the Roll in Roll Out (RORO) 500GT vessel.

Keywords: Work accidents, risk, HIRARC, JSA.

Introduction

There are inherent hazards of accidents at work. The nature of the industry, the technology used, and the risk management strategies used by the organization all affect how big these risks are. Employees may experience work-related accidents while performing their jobs for a corporation. The two main causes of workplace accidents are dangerous individual behavior and harmful environmental conditions.

According to Republic of Indonesia Law No. 1 of 1970, it is stipulated that all employees are entitled to receive safeguards for their occupational safety, to enhance their welfare, and to contribute to the advancement of national production and productivity. Similarly, it is imperative to ensure the safety of every individual present in the workplace. In compliance with relevant regulations, it is mandatory for all companies that employ workers and encounter potential hazards to furnish safety protection measures. The primary factor contributing to work accidents is the lack of efficient managerial measures in addressing occupational hazards and risks.

Risk management for workplace safety is an endeavor to control and avert potential hazards. Techniques like Job Safety Analysis (JSA) and Hazard Identification, Risk Assessment and Risk Control (HIRARC) are used to spot risks in ongoing tasks before they happen. HIRARC is a set of procedures designed to find dangers that could appear during regular or irregular business operations. It entails evaluating the risks connected to those hazards and putting safety measures in place to reduce the amount of risk, eventually preventing accidents [1]. JSA, on the other hand, is a job hazard analysis that focuses on work tasks in order to detect hazards before incidents or work accidents occur, according to OSHA 3071 (updated in 2002).

PT. Industri Kapal Indonesia (IKI) is a state-owned enterprise that specializes in the fabrication of new ships and the upkeep of vessels constructed from steel, aluminum, and wood materials. IKI is recognized as the most extensive shipyard within the Eastern Indonesia region. Indeed, alongside the objectives and operational aspects of shipbuilding enterprises, there exist inherent hazards that are intrinsically linked to the construction procedures.

Currently, the production department of IKI is engaged in the construction of the Roll In Roll Out (RORO) 500 GT KTB - Wakatobi, a 500 Gross Tonnage(GT) vessel. Following the construction portion, interior work will begin. This study's objective is to conduct a work safety risk assessment throughout the various stages of the RORO 500 GT shipbuilding activity. This is done to ensure that any potential mishaps on the job can be discovered as well as averted.

Method

This study utilizes a mixed-methods approach, incorporating both qualitative and quantitative methods. It commences with a comprehensive review of the existing literature to investigate the established parameters of HIRARC (Hazard Identification, Risk Assessment, and Risk Control) and JSA (Job Safety Analysis) that are relevant to the context of IKI. The researchers conducted interviews with key personnel involved in the construction of the RORO500 GT KTB ship, including the Head of Occupational Health, Safety, and Environment (HSE), Head of Production, and Supervisor of the Construction Department. These interviews aimed to gather information pertaining to the work process, identification of hazards and risks, as well as the control measures implemented during the construction phase. Direct observations are made by observing the work processes in the production department, specifically in the construction of the ship. In the identification stage of this research, including hazard identification, risk assessment, and risk control before being incorporated into HIRARC. Direct observations were made by witnessing the work processes in the production department, specifically in the ship's construction. These observations were made by observing the ship being built. In addition, the researcher routinely watched and evaluated potentially dangerous circumstances and dangers in the workplace, as well as making use of the approach of scenario analysis. The present and the future are both subject to a variety of possible outcomes, which can be described via scenario analysis. When doing a risk assessment, the researcher considers and evaluates the probable outcomes and the factors that led to those outcomes for each scenario.

Results and Discussion

HIRARC is a series of processes aimed at identifying hazards that may arise in routine or non-routine activities within the company. It involves assessing the risks associated with those hazards and developing hazard control programs to minimize the level of accidents. The development of HIRARC for the ship construction process at PT. Industri Kapal Indonesia is divided into three parts. The first part is hazard identification. After the hazard identification phase, the second part involves risk assessment and risk control. Here is the breakdown of the HIRARC:

Hazard Identification

Hazard identification is a systematic effort to identify hazards in activities. Hazard identification is conducted to determine what risks may be faced and occur in a work process [2]. The activities that have potential hazards in the construction process of the Roro 500GT KTB (Wakatobi) ship at PT. Industri Kapal Indonesia (Persero) include plate dismantling, cleaning, fabrication assembly, bending, ballast tank assembly process, bridge deck assembly, main deck and bow section assembly, as well as ballast tank erection process, bridge deck erection, main deck erection, bow section erection, and welding of plate-to-plate connections.

Risk Assessment

Risk assessment starts by establishing criteria for likelihood and consequence, followed by hazard identification, risk assessment, and determination of risk level [3]. Risk analysis itself utilizes a risk assessment matrix, as shown in Figure 1.

The risk levels identified in the construction process of the Roro 500GT KTB (Wakatobi) shipbuilding at PT. Industri Kapal Indonesia (Persero) are as follows:

Medium risk is present in activities such as plate dismantling, cleaning, assembly, and bending, which are associated with potential hazards such as dust accumulation on plates, hot working environment, noise, uneven work surfaces, conjunctivitis, lifting and lowering heavy plates, manual plate handling, prolonged squatting, plate insertion into bending machines, plate removal, striking of welding slag, sharp puzzle edges, scattered plate remnants, bending machine, hammering during slag cleaning, electrical cable installation disorder, welding cables, holders, and short circuits.

Probability/ Likelihood of Hazard	Severity of Hazard				
	Insignificant	Minor	Moderate	Major	Catastrophic
Rare	1	2	3	4	5
Unlikely	2	4	6	8	10
Possible	3	6	9	12	15
Likely	4	8	12	16	20
Almost Certain	5	10	15	20	25

Risk Levels	
1 to 2	**Low**
3 to 6	**Medium**
7 to 12	**High**
More than 12	**Extreme**

Figure 1. Risk Level Indication

High risk is identified in activities such as assembly of bridge deck, main deck, ballast, and bow compartment tanks, as well as main deck erection. Hazards associated with these activities include inhalation of welding fumes, hot working climate, noise, welding radiation, uneven work surfaces, conjunctivitis, pushing, pulling, gripping, high-force assembly processes, lifting and lowering heavy loads (plates), squatting, kneeling, bending, striking during assembly and cleaning of welding slag, psychological factors, gas cylinders, hammers, sparks, and welding slag, ballast tank components, bridge deck, main deck, bow compartment, liver block chain, crawler crane, chain block, disorderly cable installation, welding cables, holders, and short circuits.

Extreme risk is found in activities such as erection of ballast tanks, bridge deck, and bow compartment, involving hazards like inhalation of welding fumes, hot working environment, welding radiation, vibrations, low lighting, heights, confined workspaces, working at heights, uneven work surfaces, personnel within a 2-meter distance, exposure to dangerous noise levels, conjunctivitis, heavy welding, striking of welding slag, excessive bending, twisting of back/neck in all directions, jumping, psychological and emotional factors, gas cylinders, hammers, sparks, welding slag, steel sling, ballast tank components, crawler crane, chain block, welding cables, holders, and short circuits.

Risk Control

The next step after risk identification and analysis is to implement risk control measures. The selection of control measures should consider the hierarchy of controls, starting from elimination, substitution, engineering controls, administrative controls, and personal protective equipment (PPE). Risk control measures can be implemented in various ways with several options, such as reducing the likelihood, reducing the consequences, partially or entirely transferring the risk, or avoiding the risk altogether. Hazard sources usually originate from equipment or technical facilities in the work environment. Therefore, hazard control can be achieved through direct improvements to the relevant technical aspects. PT. Industri Kapal Indonesia (Persero) implements risk control measures in accordance with the ANSI ZIO: 2005 standard. [4]

Hierarchy of Control		
Elimination	Eliminating the Source of Hazard	Safe and secure workplace/job reduces hazard.
Substitution	Substituting tools/engine/materials	
Engineering	Modifying or designing equipment/machinery/workplace to be safer.	
Administrative	Procedures, rules, training, work duration, hazard signs, signs, posters, labels.	Safe workforce reduces exposure.
APD (PPE)	Personal Protective Equipment	

Figure 2. Hierarchy of Control Risk

Additional Controls / Mitigation

The determination of additional controls or mitigation should consider the hierarchy of controls, starting from elimination, substitution, technical controls, administrative controls, and the provision of safety equipment tailored to the organizational conditions [5]. Therefore, hazard control can be achieved through direct improvements in the relevant technical aspects [6].

The additional controls/mitigation provided during the fabrication phase include wearing ear covers, avoiding touching the area around the eyes, treating allergic conjunctivitis with antihistamines, and treating bacterial conjunctivitis with antibiotic eye drops. When handling plates with both hands, it should be done according to the implementation procedures to reduce the risk of hazards. Continuous squatting should be avoided, inspecting the welding cables before use, arranging electrical cable installations, and avoiding excessive stacking of plugs that can generate excessive heat and potentially cause fires.

Furthermore, the additional controls/mitigation provided during the assembly phase include wearing ear covers, wearing safety glasses, providing sheltered areas, following the proper procedures for pushing, pulling, holding with high force during the assembly process, lifting, lowering/carrying heavy loads (plates), and squatting, kneeling, and bending according to the implementation procedures to reduce the risk of hazards. Avoid touching the area around the eyes, treat allergic conjunctivitis with antihistamines, and treat bacterial conjunctivitis with antibiotic eye drops. Arrange electrical cable installations, avoid excessive stacking of plugs that can generate excessive heat and potentially cause fires, inspect the liver block chain before use.

Lastly, the additional controls/mitigation provided during the erection phase include wearing ear protection, avoiding touching the area around the eyes, treating allergic conjunctivitis with antihistamines, and treating bacterial conjunctivitis with antibiotic eye drops. Perform welding according to the work procedures, avoid touching welding slag, avoid hammering before the welding sparks cool down, inspect welding cables, holders, and crawler cranes before use, arrange electrical cable installations, wear ear covers, inspect chain blocks and steel slings before use, avoid excessive stacking of plugs that can generate excessive heat and potentially cause fires, provide safety harness for welding processes, and renovate the welding ladder platform to make it more ergonomic.

Job Safety Analysis (JSA)

Job Safety Analysis is a procedure used to review methods and identify unsafe/high-risk tasks, and correct them before accidents occur. It is an initial step in analyzing hazards and accidents in order to create a safe work environment [7]. The process of creating JSA involves assessing risks and identifying hazards that may arise at each stage of the job [8].

The prioritization in determining the type of work to be analyzed in JSA focuses on jobs with the highest incidence of work accidents or work-related illnesses [9]. This aligns with Indonesian safety signs, which state that one of the factors to prioritize in determining the type of work to be analyzed using JSA is jobs with the highest incidence of work accidents or work-related illnesses (PAK). Therefore, the analysis for creating JSA is only conducted for jobs with extreme risks even after mitigation measures, such as the ballast tank, bridge deck, and bow recess fabrication processes [10]. These three stages of work have been assessed to have an extreme risk level caused by hazards such as inhaling welding fumes that can cause respiratory infections, hot working environments that can cause dehydration, welding sparks that can cause eye injuries, vibrations, inadequate lighting, working at heights that can result in falls, uneven work surfaces, limited personnel access within a 2-meter range, exposure to dangerous noise levels, confined workspaces, conjunctivitis, heavy welding, striking welding slag that can cause burns, excessive bending, rotating the back/neck in all directions, jumping, psychological and emotional factors, gas cylinders, hammers, welding sparks, steel sling ropes, ballast tank components, crawler cranes, chain blocks, welding cables, holders, and short-circuits that can cause fires.

Preventive measures or controls are provided based on the Operational K3 Control SOP, K3 Incident Handling, ISO 9001:2015, ISO 14001:2015, OHSAS 18001:2007, and input from researchers. When the crawler crane moves to the construction site, personnel should not run in the work area, pay attention to the surroundings, wear safety shoes and coveralls, and temporarily stop the work process until the erection process is complete. When adjusting the crawler crane's position, personnel should not approach the crawler crane, wear coveralls, and use a safety helmet. When attaching steel sling ropes to the frame, safety gloves should be worn. When lifting pre-made frames using the crawler crane and chain block, personnel should check the steel sling ropes before use, avoid being in the area around the erection process, check the chain block before use, and avoid standing beneath the materials during the erection process.

When positioning the frame on top of completed blocks, personnel should wear a safety helmet, use a safety harness, be cautious when adjusting the main deck frame position, maintain a safe distance from the frame position, and wear coveralls and safety gloves. Lastly, during the welding process to join frames and blocks, personnel should wear safety goggles and welding helmets, install additional lighting around the welding area, avoid excessive stacking of plugs, check the cables before use, check the welding cables and holders to ensure proper insulation, wear a mask during welding, and if possible, use a respirator mask, wear safety gloves, wear coveralls, use a safety harness belt to prevent falling hazards if grip is lost, wear safety shoes and helmets to prevent foot injuries when falling from heights, wear ear protection (earplugs or earmuffs), wear safety clothing, wear safety gloves, wear a safety helmet, avoid continuous welding positions, stretch before performing work activities, perform stretching exercises at the workplace periodically every ±1-2 hours of working in the same position. Static and dynamic stretching movements should be performed, involving movements of the head, neck, shoulders, arms, waist, and legs.

Conclusion

Based on the 4 categories of risk assessment, there are 3 risk: Medium risk is present in the plate dismantling, cleaning, assembly, and bending stages. High risk occurs in the assembly of ballast tanks, bridge decks, main decks, bow compartments, and in the erection process of the main deck and welding of plate joints. Extreme risk is found in the erection process of ballast tanks, bridge decks, and bow compartments, and there are no work processes categorized as low risk. Risk control measures are based on the hierarchy of control.

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