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Implementation of Job Safety Analysis and HIRADC as Occupational Risk Control Strategies in the Preventive Maintenance Process at PT XYZ

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Abstract

This research focuses on potential hazards and the risk of accidents that may occur during preventive maintenance, which requires awell planned approach. The objective of this study is to identify hazards, analyze the extent of the risks, and evaluate methods that canbe used to control those risks. Data collection was conducte dusing the JSA (Job Safety Analysis) method to identify hazards at each stage of the work and the HIRADC (Hazard Identification, Risk Assessment, and Determining Control) to assess risk levels and select appropriate control measures. The findings of this study revealthe presence of various potential hazards, such as mechanical, electrical, and human factors, with varying threat levels ranging from low to high Risk management includes administrative controls, the use of personal protective equipment, and inspections of the tools used. It is hoped that the application of the JSA and HIRADC methods can effectively assist in the identification and control of risks, although their implementation still requires improvement particularly regarding monitoring of worker compliance. It is recommended to enhance training on workplace safety and conduct periodic evaluations of risk control measures.

Introduction

Occupational Health and Safety (OHS) is an essential element in today's industry that focuses on operational sustainability and worker protection. The implementation of an OHS system aims not only to reduce the likelihood of workplace incidents but also to create a safe, efficient, and productive working environment (Ashari, 2022; Hameed et al., 2024; Benson et al., 2024; Asiedu et al., 2025). Based on information from the Ministry of Manpower of the Republic of Indonesia, the rate of occupational accidents in Indonesia still remains significant (Priono, 2025; Kurnianto et al., 2023; Firmansyah et al., 2024; Rifqi et al., 2023; Simarmata et al., 2025).

Figure 1 shows that the number of occupational accidents in Indonesia increased annually. Based on the data, the percentage increase in cases each year can be observed, where in 2020 there were 221,740 recorded cases, increasing to 234,370 cases in 2021 (an increase of 5.7%). A further rise occurred in 2022 with 297,725 cases (an increase of 27.0%), followed by 370,747 cases in 2023 (an increase of 24.5%), and 462,241 cases in 2024 (an increase of 24.7%). However, in 2025 there was a decline to 238,675 cases (a decrease of 48.4%). Workplace accidents can be influenced by several factors, including human error, such as employees' non-compliance with safety regulations and the improper use of personal protective equipment. In addition, hazardous working conditions, such as poor lighting, uncomfortable workplace design, and unidentified hazards, also contribute to the high number

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of workplace accidents (Marsukik et al., 2024; Odebiyi & Okafor, 2023; Adamopoulos & Syrou, 2022; Abikenova et al., 2023; Dodoo & Al-Samarraie, 2023; Raman & Mitra, 2023; Prajapati et al., 2023).

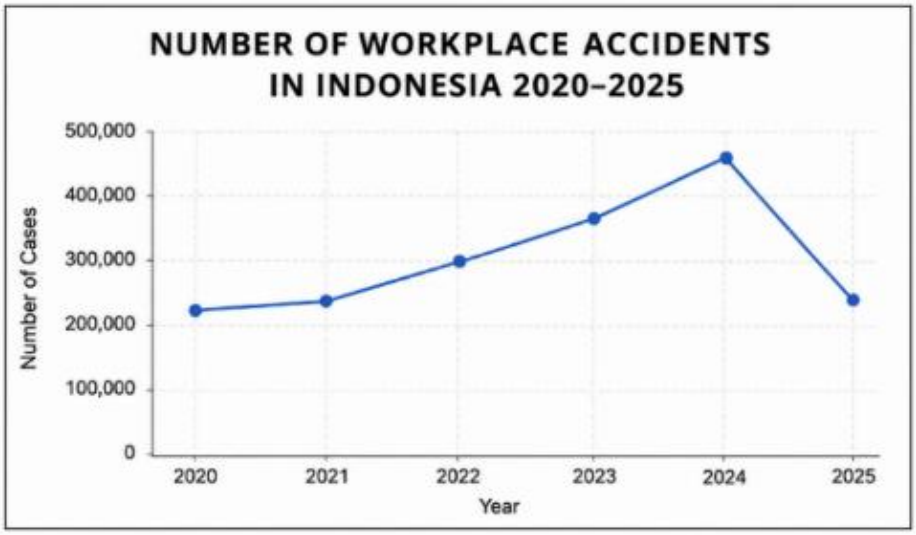

Figure 1. Occupational Accident Rate Graph 2020–2025

From a management perspective, inadequate implementation of occupational safety and health management systems, such as insufficient controls, limited training, and the absence of risk assessments, also become contributing factors. Another important factor is unfit work equipment and inadequate maintenance, as well as heavy workloads that may cause fatigue and reduce workers' concentration (Firmansyah & Waluyo, 2024; Husaeni et al., 2025; Lestari et al., 2024; Sunaryo & Ratriwardhani, 2022). The purpose of occupational health and safety is not only to protect employees from workplace hazards but also to serve as an important indicator in improving company efficiency, productivity, and reputation. Occupational health and safety can improve and ensure the best physical, mental, and social health quality for every employee, as well as prevent threats to health and safety arising from hazardous work environments (Faizah et al., 2021; Rotaru & Cioca, 2024; Amoadu et al., 2023; Adamopoulos & Syrou, 2022; Iavicoli et al., 2022). According to Law Number 1 of 1970 concerning Occupational Safety, the objective of occupational safety and health is to prevent workplace accidents and occupational diseases. The scope of OHS includes workplaces, equipment, materials, and work methods. The implementation of an effective OHS system can reduce the potential threats of workplace accidents and material losses caused by failures in hazard control (Cholil et al., 2020; Kineber et al., 2023; Angriani, 2025; Skripnik et al., 2023). Therefore, every company is required to have a planned, measurable, and sustainable OHS management system.

Based on the increasing number of workplace accidents nationally, as well as the dominant causal factors including human factors, work environment, equipment, and OHS management systems, these conditions are related to the research object conducted at PT XYZ. PT XYZ is a company engaged in the distribution and rental of heavy equipment, which involves considerable occupational risks, especially in preventive maintenance activities and heavy equipment repair processes. Preventive maintenance is carried out routinely to prevent damage and ensure that equipment continues to function optimally in the long term (Mobley, 2002). However, these activities also have the potential to cause various hazards, such as injuries due to equipment usage, exposure to hazardous chemicals, and accident risks caused by negligence or non-compliance with work procedures (Saputra, 2024). Based on PT XYZ's internal data, several workplace accident cases were still recorded within the last year, ranging from minor injuries to serious injuries occurring during heavy equipment maintenance

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processes. The following graph presents workplace accidents that occurred during the past year at PT XYZ.

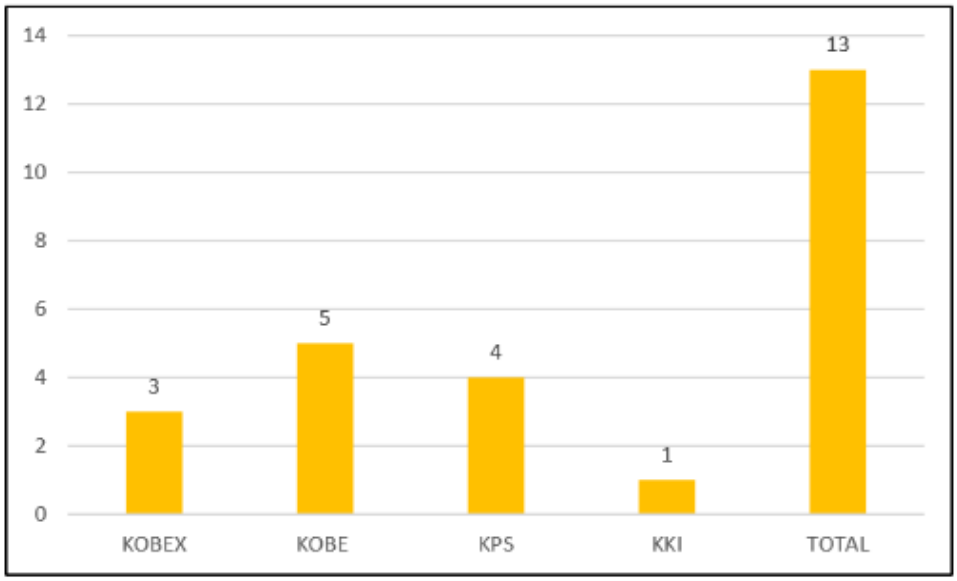

Figure 2. Workplace Accident Graph January–December 2025

This condition indicates that although safety procedures have been implemented, there are still gaps in the risk control system that need improvement. Therefore, a systematic method is required to identify, assess, and manage risks during the work process. One effective method for identifying risks and determining preventive measures is Job Safety Analysis (JSA). JSA is a method aimed at breaking down a job into more detailed steps, then assessing potential hazards in each activity and determining appropriate preventive actions. This method helps workers understand existing risks and ensures that every activity is performed safely in accordance with established procedures (Purbarani, 2024; Hong & Cho, 2023; Schulte et al., 2022).

However, to improve the accuracy of the analysis, the Hazard Identification, Risk Assessment, and Determining Controls (HIRADC) approach can be implemented. This approach includes identifying hazards, assessing risks based on likelihood and impact, and determining appropriate control measures according to the level of risk (Marsukik et al., 2024). The implementation of JSA using the HIRADC approach in the preventive maintenance process at PT XYZ is expected to reduce workplace accident rates and improve the safety culture within the workplace. Through analysis of each stage of work activities, the company can develop safer, more efficient work methods that align with risk management principles. JSA is closely related to Hazard Identification, Risk Assessment, and Determining Controls (HIRADC), which are implemented within the occupational safety and health management system (Haristama et al., 2023; Henny et al., 2025; Rahardja, 2023). JSA focuses on analyzing hazards and risks specific to a particular job, while HIRADC has a broader scope covering all organizational activities. Both methods complement each other in creating a safe work environment through the application of structured prevention and risk control principles. The integration of JSA with the HIRADC method is expected to support the company in improving employee occupational safety and health while providing recommendations for improvement in creating a productive and safe working environment (Reigeil & Rahmanto, 2025; Rifqi et al., 2023; Lari, 2024; Benson et al., 2024; Botti et al., 2022; Shabani et al., 2023).

Based on the background and problem identification that have been described, preventive maintenance activities at PT XYZ still involve various potential hazards and occupational

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risks that may threaten workers' safety and health. These risks include the possibility of injuries caused by the use of work equipment, exposure to hazardous chemicals, and workplace accidents resulting from non-compliance with procedures or worker negligence (Saputra, 2024; Bollans & Preece, 2023). In addition, the absence of a systematic risk analysis has caused the implemented control measures to be less effective in preventing workplace accidents. The implementation of the Job Safety Analysis (JSA) method integrated with the Hazard Identification, Risk Assessment, and Determining Control (HIRADC) approach has also not been comprehensively applied in the preventive maintenance process, resulting in suboptimal hazard identification and risk control (Faizah et al., 2021). Through this research, the company is expected to gain a clearer understanding of existing occupational risks and obtain applicable control recommendations to improve occupational safety and health, reduce workplace accident rates, and create a safer, more productive, and sustainable working environment.

Methods

Research Methodology

This study employed a concurrent mixed-methods design, integrating qualitative and quantitative approaches simultaneously to obtain a comprehensive understanding of occupational hazards and safety risks in preventive maintenance activities at PT XYZ. The qualitative approach was used to explore actual working conditions, preventive maintenance practices, potential hazards, and the implementation of Occupational Health and Safety (OHS) programs through direct field observations, semi-structured interviews, and documentation studies. Meanwhile, the quantitative approach was utilized to assess occupational risks systematically using the Hazard Identification, Risk Assessment, and Determining Control (HIRADC) method. The integration of qualitative and quantitative findings enabled a more accurate and practical analysis of workplace hazards and supported the implementation of Job Safety Analysis (JSA) in preventive maintenance activities. The research was conducted at PT XYZ, located in Bekasi, West Java, Indonesia, over a three-month period from September to November 2025. The object of this study focused on preventive maintenance activities in the service division, particularly on hazard identification, risk assessment, and occupational risk control during heavy equipment maintenance activities.

Research Participants and Data Sources

This study utilized both primary and secondary data sources. Primary data were obtained through field observations, interviews, and documentation. Semi-structured interviews were conducted with five key informants consisting of one service supervisor, one safety officer, and three experienced maintenance technicians directly involved in preventive maintenance activities. Informants were selected using a purposive sampling technique based on the following criteria: (1) actively involved in preventive maintenance activities, (2) having at least three years of work experience, and (3) possessing adequate knowledge regarding occupational safety procedures and maintenance operations. Secondary data included workplace accident records, standard operating procedures (SOPs), maintenance reports, safety reports, and other company documents related to occupational health and safety.

Data Collection Procedures

Data collection was conducted systematically through the following stages:

Preliminary Observation

Initial observations were conducted to identify work processes, equipment used, workplace conditions, and potential hazards during preventive maintenance activities.

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Field Observation of Preventive Maintenance Activities

Direct observations were carried out during preventive maintenance operations to document work sequences, unsafe acts, unsafe conditions, and existing control measures implemented by the company.

Interviews

Semi-structured interviews were conducted with selected informants to obtain in-depth information regarding work procedures, hazard experiences, safety practices, accident history, and challenges encountered during maintenance activities.

Documentation Study

Supporting documents, photographs, standard operating procedures, maintenance records, and workplace accident reports were collected to validate observational and interview findings.

Collection of Occupational Accident Data

Historical workplace accident and incident records provided by PT XYZ were reviewed to support hazard identification and risk assessment processes.

Research Procedure

The research procedure began with a literature review and preliminary observations to identify existing occupational safety problems. Subsequently, primary and secondary data were collected through observations, interviews, documentation, and company reports. Hazard identification and risk assessment were then performed using the HIRADC method. Activities categorized as having the highest risk levels were further analyzed using Job Safety Analysis (JSA) to develop appropriate control recommendations based on the hierarchy of controls. Finally, conclusions and recommendations were formulated to improve occupational health and safety performance in preventive maintenance activities.

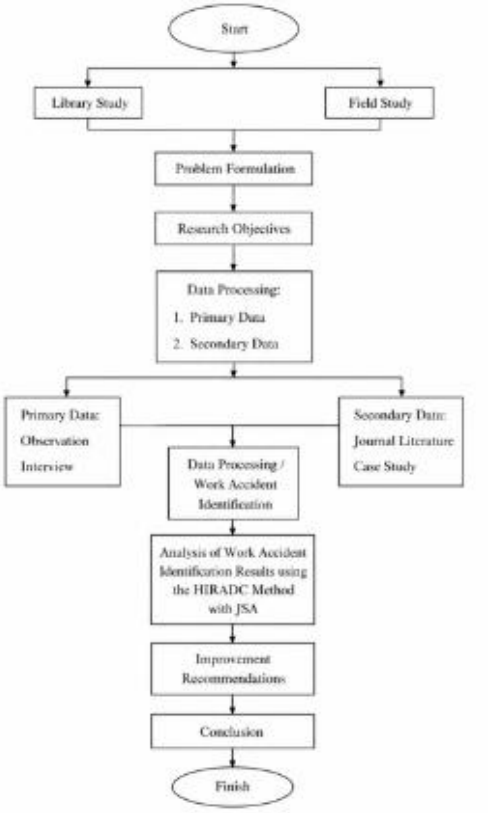

Figure 3. Research Flowchart

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The research flowchart began with literature review and preliminary observation at PT XYZ, followed by problem identification and determination of research objectives. The study then applied a mixed-methods approach through primary and secondary data collection using observation, interviews, documentation, journals, and company reports. Furthermore, hazard identification and risk assessment were conducted using the HIRADC method by evaluating likelihood and severity levels. High-risk activities were then analyzed in detail using the Job Safety Analysis (JSA) method to determine appropriate risk control measures based on the hierarchy of controls. Finally, conclusions and recommendations were formulated to improve occupational health and safety in preventive maintenance activities at PT XYZ.

Data Analysis Techniques

Data analysis was conducted using descriptive qualitative and quantitative approaches. Qualitative data obtained from interviews and observations were analyzed through data reduction, data display, and conclusion drawing to identify recurring themes related to workplace hazards, unsafe behaviors, and existing safety practices.

Quantitative analysis employed the HIRADC method consisting of three stages:

Hazard Identification

Potential hazards associated with each preventive maintenance activity were identified through field observations, interviews, and document reviews.

Risk Assessment

Each identified hazard was evaluated based on two parameters: likelihood and severity.

Risk Assessment Criteria Table:

Table 1. Likelihood of Hazard Parameters

Level	Description	Explanation
5	Almost Certain	Occurs at any time
4	Likely	Frequently occurs
3	Possible	Occurs occasionally
2	Unlikely	Does not occur frequently
1	Rare	Almost never occurs

Table 2. Severity of Hazard Parameters

Level	Description	Explanation
5	Catastrophic	Involves multiple casualties and significant financial losses, disrupting company operations and affecting the entire organization.
4	Major	Serious injuries involving more than one person, causing substantial losses and disrupting the production chain.
3	Moderate	Fairly serious injuries requiring medical treatment and resulting in considerable economic impact.
2	Minor	Minor injuries resulting in insignificant losses.
1	Insignificant	No injuries occur, and the financial loss is relatively small.

Source: Firmansyah & Waluyo (2024)

After determining both parameters in the tables above, the risk assessment matrix level can be obtained, as shown in the following table:

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Table 3. Risk Assessment Matrix

Probability/ likehood of hazard	Severity of hazard				
	Insignificant	Minor	Moderate	Major	Catastropic
5	5	10	15	20	25
4	4	8	12	16	20
3	3	6	9	12	15
2	2	4	6	8	10
1	1	2	3	4	5

Source: Firmansyah & Waluyo (2024)

Then, the formula used for risk evaluation is as follows:

Risk Value = Severity (level of severity) × Likelihood (probability of occurrence)

Determining Control Measures

Control measures were established based on the hierarchy of controls, including elimination, substitution, engineering controls, administrative controls, and personal protective equipment (PPE).

Relationship Between HIRADC and JSA

The HIRADC method was employed as the primary tool to identify hazards and assess occupational risk levels in all preventive maintenance activities. Subsequently, activities categorized as high and extreme risk were selected for further analysis using the Job Safety Analysis (JSA) method. JSA provided a more detailed examination of work steps, specific hazards, potential accident scenarios, and recommended control measures for critical activities. Therefore, HIRADC functioned as a screening and risk prioritization tool, whereas JSA served as an in-depth analytical tool for activities with the highest occupational risks.

To ensure consistency between the methodology and research findings, qualitative evidence obtained from observations and interviews was incorporated into the results section in the form of summarized observation findings and representative interview excerpts related to unsafe conditions, worker perceptions, and existing safety practices.

The final stage involved drawing conclusions based on both HIRADC and JSA analyses to formulate recommendations aimed at improving occupational health and safety systems in preventive maintenance activities at PT XYZ and creating a safer, more productive, and sustainable working environment.

Results and Discussion

Stages of Maintenance Activities

Preventive maintenance activities at PT XYZ are carried out through several systematic stages to ensure that the units operate properly and safety.

Figure 5. Stages of Maintenance Activities

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The first stage is tool preparation, which aims to support and facilitate the maintenance process. At this stage, mechanics prepare the required tools and equipment to ensure that all maintenance activities can be performed efficiently and without interruption.

The second stage is unit inspection, which involves both mechanical and electrical inspections. This process is conducted to identify any abnormal conditions during unit operation, such as unusual engine noises, malfunctioning components, or other indications of damage. Through this inspection process, mechanics are able to detect potential problems at an early stage before they develop into more serious failures.

The next stage is repair and cleaning. Cleaning activities are carried out on the unit body, engine area, and motor area using a vacuum tool to remove dust and dirt that may affect unit performance. If abnormal conditions are identified during the inspection process, repairs are immediately performed. For instance, if unusual noise is detected in the gearbox area, a more detailed inspection and repair of the gearbox are conducted to prevent further damage.

After the repair and cleaning process, lubrication activities are performed. Lubrication is applied to several important components, including the mast area, motor gears, and mast bearings using anti-rust lubricant. This process aims to reduce friction, prevent corrosion, and maintain the optimal performance of moving components.

The following stage is documentation. Documentation is conducted by taking photographs of the maintenance activities and unit conditions as evidence that preventive maintenance has been completed. These photographs are then used for reporting purposes to supervisors.

The final stage is reporting. At this stage, mechanics prepare a service report containing information regarding the unit condition, maintenance findings, repair actions, and maintenance completion status. This report serves as official documentation confirming that the preventive maintenance process has been successfully carried out.

Identification of Potential Hazards and Risks in Maintenance Activities

Table 4. Hazard Identification

No	Sub-Activity	Potential Hazard	Possible Risk
1	Carrying tools and equipment	Falling, slipping	Foot injuries, bruises
		Struck by object	Injuries to certain body areas
2	Parking the unit	Rolling, pinching	Fractures, serious injuries
3	Preventive Maintenance		
	Disconnect/connect battery	Pinch points or sharp surfaces	Electric shock, pinched injuries
		Battery short circuit	Electric shock, serious injuries
	General inspection	Falling, slipping	Foot injuries
	Cleaning the unit	Eye irritation	Reduced vision
		Respiratory disorders	Shortness of breath, reduced lung function
	Oil replacement	Heat exposure	Burns
		Contamination	Skin irritation
4	Remove/install spare parts	Pinch points / sharp surfaces	Open wounds, severe injuries to certain body areas
		Damaged tools	Open wounds
5	Operational testing	Incorrect operation	Electrical short circuit
6	Clean-up	Untidy workspace	Tripping, slipping
		Falling, slipping	Foot injuries
		Contamination	Skin irritation

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Hazard Factors in the Preventive Maintenance Process

Table 5. Hazard Factors

No	Factor	Cause
1	Human / Workers	Lack of competence
		Fatigue during work
		Poor communication during work
		Failure to use PPE
2	Equipment	Tools are no longer suitable for use
		Tools are not appropriate for the type of task being performed
3	Environment	Narrow work area
		Insufficient lighting
		Weather changes

Data Processing Using the HIRADC Method

The preparation of the HIRADC in this study began with the process of identifying potential hazards and risks in all preventive maintenance activities at PT XYZ. Furthermore, each identified hazard was assessed to determine its risk level. The results of the risk assessment were then used as a reference for establishing appropriate risk control measures. The following table presents the HIRADC related to the preventive maintenance process.

Table 6. Risk Analysis Results

No	Work Activity	Potential Hazard	Risk	L	S	R	Recommended Control Measures
1	Carrying tools and equipment	Falling, slipping	Foot injuries	3	2	6	Ensure walking on pedestrian pathways; be careful when floors are wet; avoid carrying items that obstruct vision
		Struck by object	Injuries to certain body areas	2	3	6	Be cautious when passing forklift areas; establish clear two-way communication with operators
2	Parking the unit	Rolling, pinching	Fractures, serious injuries	2	3	6	Ensure the work area is level; turn off the key switch or pin code; use the parking brake if available and ensure it is functioning properly
3	Preventive Maintenance						Use standard PPE including safety shoes, helmets, gloves, and safety glasses
	Disconnect or connect battery	Pinch points or sharp surfaces	Electric shock, pinched injuries	2	4	8	Pay attention to pinch points and sharp surfaces; avoid placing body parts near pinch points and sharp surfaces
		Battery short circuit	Electric shock, electrical	2	4	8	Ensure battery plugs are in good condition; ensure no exposed

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			short circuit				wires; repair immediately if damage is found
	General inspection	Falling, slipping	Foot injuries	2	1	2	Ensure the work area is clean and organized; clean oil or water spills immediately
	Cleaning the unit	Eye irritation and respiratory disorders	Reduced lung function	3	2	6	Use safety glasses and masks during blower spraying; use the blower carefully; ensure proper air circulation
	Oil replacement	Heat exposure	Burns	1	3	3	Ensure oil is drained when cool
		Contamination	Skin irritation	1	3	3	Ensure oil containers match oil capacity; clean oil spills immediately
4	Remove/install components	Pinch points or sharp surfaces	Open wounds, severe injuries	4	4	16	Use standard PPE including safety shoes, helmets, and gloves; avoid body contact with pinch points and sharp surfaces
		Damaged components/tools	Open wounds	4	3	12	Ensure tools are in good condition; use tools appropriate for the components being removed or installed
5	Operational testing	Incorrect operation	Electrical short circuit				Understand standard operating procedures
6	Clean-up	Untidy conditions	Tripping, slipping	2	1	2	Ensure consumables, hand tools, and special tools are clean and organized; implement the 5R procedure
		Falling, slipping	Foot injuries	2	2	4	Ensure there are no oil spills in the work area and clean them immediately
		Contamination	Skin irritation	2	1	2	Ensure hazardous waste is disposed of in appropriate locations

The results of the HIRADC table preparation serve as an initial assessment of the actual conditions of maintenance activities in the workplace. The conclusions from the analysis are explained as follows:

In the extreme risk category, there was one work activity identified, namely the removal and installation of components, which could result in severe injuries due to pinch points and sharp surfaces. This activity has a high-risk level because it involves direct interaction with heavy components and machine parts that may pinch or injure workers. Therefore, stricter control measures are required to reduce the risk, such as direct supervision, the use of complete personal protective equipment (PPE), and the implementation of more detailed work procedures.

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In the high-risk category, there were two activities identified, namely disconnecting or connecting batteries and operational testing. The risks in these activities are related to electrical hazards such as electric shock and short circuits. The risk level becomes high because procedural errors or unfit equipment conditions can seriously affect worker safety and damage the unit. Therefore, strict compliance with standard operating procedures (SOPs), inspection of cables and electrical systems, and improvement of operator competence are essential.

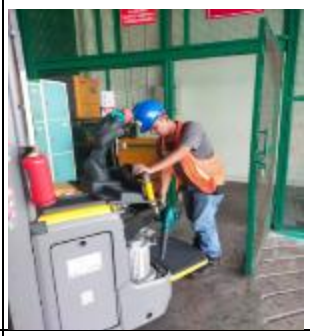
In the medium-risk category, there were three activities identified, namely carrying tools and equipment, parking units, and cleaning units. Risks in this category are generally caused by workplace environmental factors such as slippery floors, uneven work areas, and exposure to dust or particles during cleaning activities. Although the impacts are not considered severe, the potential for accidents still exists if workers do not comply with safety procedures. Therefore, consistent housekeeping practices, the use of PPE, and increased worker awareness are necessary to prevent risks from escalating to higher levels.

There were three activities categorized as low-risk work, namely general inspection, oil replacement, and clean-up activities. These activities have relatively low likelihood and severity levels because they are supported by clear work procedures and adequate control measures. Nevertheless, supervision and compliance with safety standards are still necessary to ensure that risks remain at a low level and do not develop into more serious hazards.

Risk Control

Based on the results of field observations, several risk control measures have been implemented in preventive maintenance activities, as described below:

Table 7. Risk Control Measures

No	Figure	Type of Control	Description
1		Personal Protective Equipment (PPE)	Workers use PPE to reduce risks during work activities.
2		Administrative Control	Safety talks are conducted before work begins to provide guidance regarding work procedures, potential hazards, and preventive measures.

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3		Administrative Control	The work area is maintained in a clean and organized condition to prevent slipping, tripping, or other workplace accidents.
4		Administrative Control	The work area is equipped with warning signs as visual information regarding potential hazards.
5		Administrative Control	Supervisors conduct monitoring to ensure workers comply with occupational safety procedures.

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6		Administrative Control	Work equipment is inspected beforehand to ensure it is in proper and safe condition for use.
7		Administrative Control	Basic occupational health and safety (OHS) training is provided to employees so that each worker understands the risks and impacts of the job.
8		Administrative Control	Ensuring that the fire extinguishers (APAR) available on the units are in proper condition and have not exceeded their expiration dates.
9		Administrative Control	Ensuring that the blue spot, camera, and buzzer on the unit are always functioning properly to minimize accident risks, particularly the risk of workers being struck in operational areas.

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10		Administrative Control	Before starting the unit, ensure that the battery cable is not pinched or obstructed by any object.

Cause-and-Effect Correlation

The analysis of causes and impacts was conducted to identify the main factors triggering potential hazards and workplace accidents during maintenance activities at PT XYZ. This analysis was developed based on the findings from hazard identification, risk factors, and hazard assessments using the HIRADC method. Workplace accidents occur due to the combination of various interrelated factors rather than a single cause. These factors include the following:

Human factors are the primary cause of workplace accidents. The results of the study indicate that some workers still do not fully comply with safety procedures, such as not using complete personal protective equipment (PPE), lacking awareness while working, and experiencing work fatigue that can reduce concentration levels. In addition, poor communication among workers may lead to coordination errors, especially in activities involving more than one worker. These conditions contribute to risks such as electric shock during the battery disconnect process, pinching injuries during component installation, and operational errors during operational testing.

Equipment factors (machine factors) also contribute to increasing the risk of workplace accidents. Based on the identification findings, it was revealed that some work equipment was no longer suitable for use or inappropriate for the type of work being performed. This condition may result in accidents such as open wounds caused by damaged tools, wrist injuries due to the use of impact wrenches, and the risk of being struck by components due to lifting equipment failures such as chain blocks. In remove-install component activities, equipment factors became one of the main causes of the high-risk value (R = 16), which falls into the high-risk category.

Work method factors (method factors) also play an important role in workplace accidents. Although the company already has standard operating procedures (SOPs), the implementation of these procedures in practice has not been consistently carried out in the field. The lack of systematic work methods, such as the suboptimal implementation of Job Safety Analysis (JSA), causes workers to have limited understanding of safe work procedures and the potential hazards involved in each activity. This situation may increase the likelihood of work errors, especially in activities with high-risk levels.

Environmental factors also influence the level of workplace accident risk. Narrow work areas, insufficient lighting, and the presence of oil or water spills causing slippery floors are among the factors contributing to workplace accidents. Hazardous work environments can increase the likelihood of incidents such as slipping, tripping, or falling, particularly during activities involving carrying equipment, unit inspections, and clean-up activities.

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Based on the explanation above, it can be concluded that the main causes of potential workplace accidents in preventive maintenance activities at PT XYZ are dominated by human factors, supported by suboptimal work methods, and reinforced by inadequate equipment conditions and unfavorable work environments. The combination of these factors increases the level of risk in several work activities, particularly those categorized as medium to high risk based on the HIRADC analysis results.

Therefore, an effective method is needed to clearly describe each work step in detail and identify potential risks at every stage so that the resulting impacts can be better controlled. Job Safety Analysis (JSA) was implemented as a follow-up effort to further develop the HIRADC analysis. JSA functions to identify hazards in greater detail at each stage of work activities and establish accurate control measures to be implemented in the field. Thus, the integration of HIRADC and JSA not only provides numerical risk assessments but also offers practical safe work guidelines that can be directly followed by workers.

The implementation of JSA in this study was focused on activities with the highest risk levels based on the HIRADC results, with the expectation of reducing the likelihood of workplace accidents and improving the performance of the Occupational Health and Safety (OHS) system at PT XYZ. Through this integrated analysis, the company can develop work procedures that are more structured, safer, and aligned with actual field conditions.

Job Safety Analysis

The Job Safety Analysis (JSA) method is used to identify potential hazards, evaluate risks at each stage of work activities, and determine appropriate control measures. This technique provides a more comprehensive explanation of the hazards that may occur during the maintenance process and serves as a source of information for workers so that tasks can be performed safely. The following JSA was developed based on activities categorized as having extreme and high-risk levels in the maintenance process.

Table 8. Job Safety Analysis

Job Safety Analysis	
Task Name	**Preventive Maintenance**
JSA Prepared By	
JSA Reviewed By	
Customer	
Location	
Personnel	
Required Equipment	Toolbox, Extension Cable, Blower
Required PPE	Safety Shoes, Helmet, Gloves

Table 9. Job Safety Analysis Control Measures for Maintenance Activities

Work Step	**Potential Hazard**	**Control Measures**
Remove and install components	Pinch points / sharp surfaces	1. Pay attention to hand positioning and use anti-slip gloves.
		2. Ensure the tools used are in proper condition and suitable for the task.
		3. Do not place hands or other body parts near sharp or narrow areas and avoid pinch points.
		4. Provide OHS knowledge and clear SOPs for the work process.
		5. Conduct regular safety talks to remind workers about hazard risks.

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Disconnect or connect battery	Pinch points / sharp surfaces and battery short circuit	1. Ensure the unit is turned off before work begins.
		2. Install positive and negative labels on the battery plug.
		3. Conduct inspections on cable conditions.
		4. Provide training regarding work procedures and electrical hazards.
		5. Use electrical safety gloves.
Operational testing	Incorrect operation	1. Avoid testing units in worker traffic areas.
		2. Restrict the area using barriers during testing activities.
		3. Implement standard operating procedures (SOPs) for unit testing.
		4. Operators must possess an official operating license (SIO).
		5. Conduct inspections before testing activities.

The findings indicate that occupational risks in preventive maintenance activities at PT XYZ are mainly shaped by the interaction of work procedures, worker behavior, equipment condition, and workplace environment. The use of HIRADC provides a structured basis for classifying risk levels, while JSA strengthens the analysis by breaking down high-risk activities into specific work steps and practical controls. This supports previous studies showing that JSA is effective for task-based hazard identification but becomes stronger when combined with systematic risk assessment and control prioritization (Ghasemi et al., 2023; Haristama et al., 2023; Faizah et al., 2021).

The highest risk was found in removing and installing components, particularly due to pinch points, sharp surfaces, and direct interaction with heavy mechanical parts. This confirms that maintenance work, although routine, may still contain serious hazards when workers handle heavy components or damaged tools without adequate controls. Similar findings were reported by Purbarani (2024) and Rahardja (2023), who emphasized that maintenance and technical operations require detailed hazard identification because mechanical and electrical hazards often occur during direct interaction with equipment. Therefore, this activity requires stricter controls, including detailed work procedures, equipment inspection, supervision, and complete PPE use.

Battery disconnection/connection and operational testing were also identified as high-risk activities because they involve electrical shock, short circuit, and operational error. These risks show that procedural compliance is essential, especially in activities involving energy sources and unit testing. Benson et al. (2024) and Kineber et al. (2023) emphasized that effective OHS implementation depends on the integration of training, equipment readiness, inspection, supervision, and management commitment. In this context, PT XYZ should strengthen energy isolation procedures, battery cable inspection, restricted testing areas, and competency-based training for technicians.

Medium- and low-risk activities, such as carrying tools, parking units, cleaning units, general inspection, oil replacement, and clean-up, should not be ignored because minor hazards can escalate when combined with fatigue, poor housekeeping, limited space, or low worker awareness. Studies by Dodoo and Al-Samarraie (2023), Firmansyah et al. (2024), and Sunaryo and Ratriwardhani (2022) show that occupational accidents are often influenced by unsafe behavior, environmental conditions, fatigue, and weak safety implementation. Therefore, housekeeping, pedestrian pathways, lighting improvement, tool organization, and routine monitoring remain important to prevent recurring incidents.

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Human factors were found to be one of the dominant causes of occupational risk, especially incomplete PPE use, fatigue, lack of awareness, and poor communication. However, these issues should not be interpreted only as individual worker negligence. Amoadu et al. (2023) and Schulte et al. (2022) explain that worker safety is strongly influenced by organizational safety climate, communication, and management support. Thus, improving safety performance requires not only worker discipline but also stronger supervision, regular safety talks, fatigue management, and worker involvement in hazard reporting.

The existing controls at PT XYZ are mostly administrative controls and PPE, including safety talks, warning signs, supervision, housekeeping, equipment inspection, and OHS training. These controls are useful but still depend heavily on worker compliance. Ajslev et al. (2022) emphasized that the hierarchy of controls should prioritize stronger controls before relying on PPE. Therefore, PT XYZ should gradually improve engineering and physical controls, such as machine guarding, safer tool design, traffic separation, battery protection, and designated operational testing zones. This is also consistent with Botti et al. (2022), who stated that participatory and preventive safety approaches are needed to improve workplace safety culture.

The integration of HIRADC and JSA is appropriate for preventive maintenance activities because it combines numerical risk prioritization with detailed task-level control planning. This approach can help PT XYZ move from reactive accident prevention toward a more proactive OHS system. In addition, systematic OHS implementation may also improve productivity by reducing accidents, downtime, and unsafe work interruptions, as supported by Iavicoli et al. (2022), Lari (2024), and Shabani et al. (2023). Therefore, periodic evaluation, worker participation, updated JSA documents, and stronger implementation of the hierarchy of controls are essential to ensure safer and more sustainable preventive maintenance practices.

Conclusion

Based on the results of the study on the implementation of Job Safety Analysis (JSA) using the Hazard Identification, Risk Assessment, and Determining Control (HIRADC) approach in the preventive maintenance process at PT XYZ, it can be concluded that each stage of maintenance activities has different potential hazards and risk levels. The identified risks include mechanical hazards, exposure to hazardous chemicals, improper use of work equipment, and worker negligence in following established work procedures. The results of hazard identification and risk assessment using the HIRADC method indicate that several work activities fall into the high to extreme risk categories, particularly in remove-install component activities, disconnect-connect battery activities, and operational testing. These conditions indicate that preventive maintenance activities involve significant risk levels and therefore require appropriate and sustainable control measures to prevent workplace accidents.

The implementation of Job Safety Analysis (JSA) integrated with the HIRADC approach is considered capable of providing a more detailed analysis of each work step, including activity identification, potential hazards, and risk control recommendations. Through the implementation of this method, workers can better understand the potential hazards that may occur during each work activity, thereby increasing awareness of the importance of occupational health and safety. In addition, the control recommendations developed based on the hierarchy of controls, including elimination, substitution, engineering controls, administrative controls, and the use of personal protective equipment (PPE), are considered more systematic and effective in reducing occupational risk levels. Therefore, the integration of JSA and HIRADC methods can serve as an effective approach to improving Occupational Health and Safety (OHS) implementation, reducing the potential for workplace accidents, and

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creating a safer and more productive working environment in preventive maintenance activities at PT XYZ.

Based on the results of this study, the company is recommended to consistently implement the Job Safety Analysis (JSA) method and integrate it with the HIRADC approach in all work activities, especially those with high-risk levels. In addition, the company should regularly evaluate and update work procedures to ensure they remain aligned with actual operational conditions and the development of potential workplace risks. This step is important to ensure that the risk control system can operate effectively and sustainably.

The company is also advised to improve training programs and socialization related to occupational health and safety for all employees, particularly regarding hazard identification, the use of personal protective equipment (PPE), and the implementation of safe work procedures. By increasing workers' knowledge and awareness of occupational risks, it is expected that compliance with safety procedures will improve, thereby minimizing the potential for workplace accidents. Furthermore, supervision of the implementation of standard operating procedures (SOPs) in the field should be strengthened through routine monitoring by supervisors and management to ensure that every work activity is carried out in accordance with established safety procedures. Through consistent supervision, the company can create a more disciplined and safer work culture that supports the overall improvement of occupational health and safety performance.

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