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Occupational Health and Safety Risk Analysis Using JSA and FMEA in Fatty Acid Tank Maintenance at PT Bramindra Indotama Gresik

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ABSTRACT

This study aims to identify potential occupational hazards and assess the level of occupational health and safety (OHS) risks in the maintenance activities of the fatty acid tank at PT Bramindra Indotama Gresik using an integrated Job Safety Analysis (JSA) and Failure Mode and Effects Analysis (FMEA) approach.This research employs a qualitative descriptive approach, with data collected through direct observation, interviews, and questionnaires administered to maintenance workers and Health, Safety, and Environment (HSE) personnel. JSA was used to identify work steps and potential hazards, while FMEA was applied to evaluate risk levels based on Severity, Occurrence, and Detection, resulting in a Risk Priority Number (RPN). The results indicate that several activities fall into high-risk categories, particularly during Lock Out Tag Out (LOTO), tank cleaning and draining, and inspection of components inside the tank. The highest RPN values were associated with hazards related to residual energy, confined space conditions, and manual handling. The implementation of risk control measures based on the hierarchy of controls is expected to reduce workplace accident risks, improve compliance with safety procedures, and strengthen the OHS culture. Therefore, the integration of JSA and FMEA is proven to be an effective approach for identifying hazards and prioritizing risk control in maintenance activities.

Keyword: *Occupational Health and Safety, Job Safety Analysis, Failure Mode and Effects Analysis (FMEA), Hazard Identification, Risk Assessment*

ABSTRAK

Penelitian ini bertujuan untuk mengidentifikasi potensi bahaya kerja serta menilai tingkat risiko keselamatan dan kesehatan kerja (K3) pada aktivitas pemeliharaan tangki fatty acid di PT Bramindra Indotama Gresik dengan menggunakan pendekatan terintegrasi antara *Job Safety Analysis* (JSA) dan *Failure Mode and Effects Analysis* (FMEA).Penelitian ini menggunakan pendekatan deskriptif kualitatif, dengan teknik pengumpulan data melalui observasi langsung, wawancara, dan kuesioner yang diberikan kepada pekerja maintenance serta petugas *Health, Safety, and Environment* (HSE). Metode JSA digunakan untuk mengidentifikasi tahapan pekerjaan dan potensi bahaya, sedangkan metode FMEA digunakan untuk mengevaluasi tingkat risiko berdasarkan nilai *Severity*, *Occurrence*, dan *Detection* sehingga menghasilkan *Risk Priority Number* (RPN). Hasil penelitian menunjukkan bahwa terdapat beberapa aktivitas yang termasuk dalam kategori risiko tinggi, terutama pada pekerjaan *Lock Out Tag Out* (LOTO), pembersihan dan pengurasan tangki, serta inspeksi komponen di dalam tangki. Nilai RPN tertinggi ditemukan pada bahaya yang berkaitan dengan energi sisa, kondisi ruang terbatas (*confined space*), dan aktivitas *manual handling*.Penerapan pengendalian risiko berdasarkan hirarki pengendalian diharapkan dapat menurunkan tingkat kecelakaan kerja, meningkatkan kepatuhan terhadap prosedur keselamatan, serta memperkuat budaya K3 di lingkungan kerja. Maka, integrasi JSA dan FMEA terbukti efektif mengidentifikasi bahaya serta menentukan prioritas pengendalian risiko pada aktivitas pemeliharaan.

Keyword: Keselamatan dan Kesehatan Kerja, Job Safety Analysis, Failure Mode and Effects Analysis (FMEA), Identifikasi Bahaya, Penilaian Risiko

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1. Introduction

Occupational Health and Safety (OHS) is a strategic element in industrial activities, playing a critical role in protecting workers, maintaining equipment reliability, and ensuring the continuity of operational processes [1]. The increasing complexity of production systems and the use of advanced machinery are directly proportional to the rising potential for workplace hazards when not accompanied by systematic risk management [2]. Workplace accident data in Indonesia indicate an upward trend over recent years, with the majority of incidents caused by unsafe acts and unsafe working conditions [3]. This situation suggests that OHS implementation across many industrial sectors still requires significant strengthening, particularly in high-risk job activities. Machine maintenance activities are classified as high-risk work because they involve direct interaction with mechanical components, stored energy, manual handling of heavy loads, and work environments that may be slippery or confined [4]. Several studies have reported that occupational accidents during maintenance work are predominantly associated with pinch injuries, cuts and abrasions, slips, and musculoskeletal disorders resulting from non-ergonomic manual handling practices [5]. These risks are likely to increase when maintenance tasks are performed without a detailed hazard analysis at each stage of the work process.

PT Bramindra Indotama Gresik, as a company engaged in industrial construction and maintenance services, has implemented an OHS management system in its operational activities. However, based on workplace accident data from June to August 2025, recurring incidents were still recorded during the maintenance of the Fatty Acid Tank. The dominant types of accidents included injuries from sharp objects, entrapment by machine components, muscle injuries due to manual lifting, and slips caused by slippery floor conditions. The relatively consistent pattern of accidents indicates that existing risk control measures have not been fully effective in significantly reducing hazard levels. From a theoretical perspective, OHS risk management is conducted through the stages of hazard identification, risk assessment, and risk control, referring to the hierarchy of controls, namely elimination, substitution, engineering controls, administrative controls, and the use of personal protective equipment (PPE) [6]. One widely used method to support these stages is Job Safety Analysis (JSA). The JSA method focuses on breaking down work activities into more detailed task steps, allowing hazards to be identified more specifically and risk control measures to be designed in a more targeted manner [7].

Previous studies have demonstrated that the implementation of JSA can reduce workplace accident rates and improve workers' compliance with safety procedures. Research by Maritza in 2024 [8], found that the application of JSA in industrial machine maintenance activities reduced accident risks to moderate and low risk categories. Similar findings were reported by Anhar in 2023 [9], who showed that JSA is effective in identifying hidden hazards that are often undetected by general risk identification methods. Furthermore, Rezkyana in 2024 [10], emphasized that JSA is particularly applicable to high-risk work because it focuses on detailed work steps and actual worker behavior in the field. Nevertheless, many companies still apply macro-level risk identification methods, such as Hazard Identification, Risk Assessment, and Determining Control (HIRADC), without incorporating a detailed analysis of each work step. Such an approach is considered less optimal for machine maintenance activities, which are characterized by dynamic and task-specific hazards. Therefore, the application of JSA as a complementary method is necessary to provide a more operational and practical approach to enhancing the effectiveness of OHS risk control. In addition to Job Safety Analysis (JSA), a more comprehensive method is required to prioritize risks effectively. Failure Mode and Effects Analysis (FMEA) is widely used to evaluate potential failures based on Severity, Occurrence, and Detection values, resulting in a Risk Priority Number (RPN). This method enables the identification of critical risks that require immediate corrective actions.

Based on the above discussion, this study aims to identify potential workplace hazards, assess risk levels, and propose risk control measures for the maintenance activities of the Fatty Acid Tank at PT Bramindra Indotama Gresik integrates JSA and FMEA to provide a more comprehensive analysis of hazard identification and risk prioritization in fatty acid tank maintenance activities. This research is expected to contribute practically to improving the company's OHS performance and academically to the development of occupational health and safety studies in the context of industrial machine maintenance.

2. Methods

This study employed a qualitative descriptive approach supported by quantitative data to analyze occupational health and safety (OHS) aspects in the maintenance activities of the Fatty Acid Tank at PT

Bramindra Indotama Gresik. The descriptive approach was selected because the study aims to systematically describe the actual conditions of work processes, potential hazards, and risk levels at each stage of machine maintenance activities without manipulating research variables [11].

The initial stage of the research began with a preliminary study through direct observation at the workplace to obtain a general overview of the machine maintenance process and the surrounding working environment [12]. Based on the observation results, problem identification and formulation were conducted, particularly concerning the high potential for occupational accidents in machine maintenance activities. Subsequently, the research objectives were determined to guide the direction of data collection and analysis.

Data collection was carried out using two approaches, namely a literature review and a field study [13]. The literature review aimed to establish a relevant theoretical foundation, including concepts of occupational health and safety (OHS), Job Safety Analysis (JSA), hazard identification, risk assessment, and risk control based on the hierarchy of controls [14]. The field study was conducted to obtain empirical data through direct observation of machine maintenance activities, documentation of working conditions, interviews with maintenance workers and Health, Safety, and Environment (HSE) personnel, and the distribution of questionnaires to respondents directly involved in the machine maintenance process. This study employs an integrated approach combining Job Safety Analysis (JSA) and Failure Mode and Effects Analysis (FMEA). JSA was used to systematically identify work steps and potential hazards in each maintenance activity. Subsequently, FMEA was applied to evaluate and prioritize risks by calculating the Risk Priority Number (RPN), which is obtained from the multiplication of Severity (S), Occurrence (O), and Detection (D). The RPN values were used to determine the priority level of each hazard and to support the development of appropriate risk control strategies.

The primary data collected included the sequence of work stages in the maintenance of the Fatty Acid Tank, potential hazards at each work stage, and assessments of the likelihood and severity (consequence) of each identified hazard. Risk assessment was conducted using the Job Safety Analysis (JSA) method by combining likelihood and consequence values to determine the risk rating [15]. The values used in the analysis were based on the mode of the questionnaire responses, reflecting the most dominant risk perceptions in the field [16], After hazard identification, risk assessment was performed by assigning likelihood (L) and severity or consequence (S) values using a 1–5 risk matrix scale [17], The risk rating (R) was calculated by multiplying the likelihood and severity values, resulting in a risk score ranging from 1 to 25, representing risk levels from the lowest to the highest..

3. Results and Discussion

Based on field observations, hazard identification was conducted at each stage of the fatty acid tank maintenance activities. The results of the hazard identification are presented in Table 1.

The identified hazards were further analyzed using the Job Safety Analysis (JSA) method to determine the risk level associated with each work activity. A summary of the analysis results is presented in Table 2.

After determining the risk matrix values, risk levels were classified by applying color codes to each category according to the risk matrix classification. The results were then applied to each stage of the Fatty Acid Tank maintenance process. The assessment of accident severity was obtained through questionnaires completed by seven respondents at PT Bramindra Indotama Gresik, consisting of one HSE personnel and six field workers, serving as the basis for workplace risk analysis.

Risk assessment in the production area of PT Bramindra Indotama Gresik was conducted through interviews and questionnaire responses from seven respondents, including one HSE Coordinator and six production operators representing each work process stage. Respondents assessed the likelihood and consequence of each identified hazard using a scale of 1–5, with the final value determined based on the most frequently occurring score (mode). The risk value was calculated using the formula $R = L \times C$ to determine risk levels, which were subsequently used to establish hazard control priorities and improve workplace safety performance.

Table 1. Hazard Identification in Fatty Acid Tank Maintenance Activities

No.	Activity	Potential Hazard	Risk
1.	Area and Equipment Preparation	Incorrect hazard identification prior to work	Workers exposed to unidentified hazards, minor to severe injuries, chemical exposure, equipment damage, and rework
		Loss of balance while carrying work tools	Slips or falls, bruises, minor fractures, muscle or joint injuries, and open wound
2.	Implementation of LOTO	Residual energy not fully isolated	Sudden equipment movement, entrapment, partial amputation, severe injury, or fatality
		Incorrect installation of LOTO locks/tags	Personnel entering while the system is still energized, electrical shock, mechanical injury, and serious accidents
3.	Tank Cleaning and Draining	Injury due to lifting hoses or heavy equipment	Musculoskeletal injuries and work-related fatigue
		Slips caused by slippery floors during the draining process	Slipping, bruises, back injuries, and limb fractures
4.	Inspection of Components Inside the Tank	Entrapment by machine components or parts	Bruises or lacerations, fractures, and partial amputation
		Contact with sharp surfaces inside the tank	Cuts and risk of infection if not properly treated
5.	Component Replacement / Repair	Inhalation of dust or debris during cleaning	Respiratory tract irritation and respiratory diseases with repeated exposure
		Falling tools or equipment	Impact injuries, head injuries, fractures, and lacerations
6.	Finishing and Machine Testing	Untidy work area causing tripping hazards	Minor injuries, sprains, and other work-related injuries

Table 2. Risk Matrix

SCALE		*Consequences*				
Likelihood		*Insignificant*	*Minor*	*Moderate*	*Major*	*Catastrophic*
		1	2	3	4	5
Rare	1	1	2	3	4	5
Unlikely	2	2	4	6	8	10
Moderate	3	3	6	9	12	15
Likely	4	4	8	12	16	20
Almost	5	5	10	15	20	25
Very High Risk						
High Risk						
Medium Risk						
Low Risk						

Table 3. Questionnaire Results on Risk Severity

Process	Identified Potential Hazard	(Likelihood)	(Consequence)
Area and Equipment Preparation	Incorrect hazard identification prior to work	3	6
	Loss of balance while carrying work tools	2	4
Implementation of LOTO	Residual energy not fully isolated	2	8
	Incorrect installation of LOTO locks/tags	2	6
Tank Cleaning and Draining	Injury due to lifting hoses or heavy equipment	3	9
	Slips caused by slippery floors during the draining process	3	6
Inspection of Components Inside the Tank	Entrapment by machine components or parts	3	9
	Contact with sharp surfaces inside the tank	3	6
Component Replacement / Repair	Inhalation of dust or debris during cleaning	2	6
	Falling tools or equipment	2	4
	Cuts or abrasions	3	6
Finishing and Machine Testing	Untidy work area causing tripping hazards	2	6

Based on the calculated likelihood and consequence values, risk levels were assessed using a risk matrix approach. The results of the risk assessment are presented in Table 4.

Table 4. Risk Assessment Based on the Risk Matrix

Activity	Potential Hazard	Risk	R	Category
Area and Equipment Preparation	Incorrect hazard identification prior to work	Workers exposed to unidentified hazards, minor to severe injuries, chemical exposure, equipment damage, and rework	6	*Medium*
	Loss of balance while carrying work tools	Slips or falls, bruises, minor fractures, muscle or joint injuries, and open wounds	4	*Low*
Implementation of LOTO	Residual energy not fully isolated	Sudden equipment movement, entrapment, partial amputation, severe injury, or fatality	8	*High*
	Incorrect installation of LOTO locks/tags	Personnel entering while the system is still energized, electrical shock, mechanical injury, and serious accidents	6	*Medium*

Activity	Potential Hazard	Risk	R	Category
Tank Cleaning and Draining	Injury due to lifting hoses or heavy equipment	Musculoskeletal injuries and work-related fatigue	9	*High*
	Slips caused by slippery floors during the draining process	Slipping, bruises, back injuries, and limb fractures	6	*Medium*
Inspection of Components Inside the Tank	Entrapment by machine components or parts	Bruises or lacerations, fractures, and partial amputation	9	*High*
	Contact with sharp surfaces inside the tank	Cuts and risk of infection if not properly treated	6	*Medium*
Component Replacement / Repair	Inhalation of dust or debris during cleaning	Respiratory tract irritation and respiratory diseases with repeated exposure	6	*Medium*
	Falling tools or equipment	Impact injuries, head injuries, and fractures	4	*Low*
	Cuts or abrasions	Lacerations	6	*Medium*
Finishing and Machine Testing	Untidy work area causing tripping hazards	Minor injuries, sprains, and work-related injuries	6	*Medium*

To further prioritize the identified hazards, an FMEA analysis was conducted. The results of the Risk Priority Number (RPN) calculation are presented in Table 5.

Table 5. Summary of Risk Assessment Results

No	Activity	Hazard	S	O	D	RPN	Priority
1	LOTO	Residual energy	4	3	2	24	High
2	Cleaning	Slippery floor	3	3	2	18	Medium
3	Inspection	Entrapment	4	3	3	36	High

The results indicate that hazards related to residual energy and confined space activities have the highest RPN values, indicating the need for immediate corrective actions. To provide an overview of the distribution of risk levels, a summary of the risk assessment results is presented in Table 6.

Table 6. Summary of Risk Assessment Results

No	Risk Level	Risk Level
1	High Risk	3 activities
2	Medium Risk	7 activities
3	Low Risk	2 activities

Risk assessment was carried out by combining Likelihood and Consequence values using the risk matrix. The results showed that there were three activities classified as high risk, seven activities classified as medium risk, and two activities classified as low risk. High-risk activities were primarily associated with the implementation of LOTO, confined space work, and manual handling tasks involving heavy loads. These findings support the study by Khoiriyah [18], which stated that accident frequency has a significant influence on overall risk levels. Activities with moderate severity but recurring frequency may still generate cumulative negative impacts on occupational safety and workforce productivity. Conversely, prioritizing only the highest severity risks may result in the neglect of recurring latent risks. The integration of JSA and FMEA provides a more comprehensive analysis compared to using a single method. JSA identifies hazards at each work step, while FMEA prioritizes risks quantitatively based on RPN values. This combination enhances decision-making in determining effective risk control strategies.

Risk control measures were formulated based on the Hierarchy of Controls. The proposed controls include engineering controls such as the use of mechanical lifting aids, improved ventilation systems, and machine safeguarding; administrative controls through the refinement of standard operating procedures (SOPs), implementation of work permit systems, and regular toolbox meetings; and the use of appropriate personal protective equipment (PPE) according to job characteristics. This control strategy aligns with the Hierarchy of Controls concept, which prioritizes engineering and administrative controls over the use of PPE. the systematic and consistent application of JSA can effectively reduce accident potential in machine maintenance activities. Therefore, the findings of this study support existing theories and previous research, reinforcing the importance of integrating JSA and FMEA into industrial occupational health and safety management systems.

4. Conclusions and Recommendations

This study confirms that fatty acid tank maintenance at PT Bramindra Indotama Gresik contains significant occupational hazards across all work stages. The application of Job Safety Analysis (JSA) systematically identified task-level hazards, while the integration with Failure Mode and Effects Analysis (FMEA) enabled quantitative prioritization through Risk Priority Number (RPN). The results reveal three high-risk, seven medium-risk, and two low-risk activities, with the highest risks concentrated in LOTO implementation, confined space work, and manual handling. FMEA indicates that hazards related to residual energy, entrapment, and confined space conditions yield the highest RPN values, marking them as critical priorities. Overall, the combined use of JSA and FMEA provides a robust and complementary framework for precise hazard identification and evidence-based risk prioritization in industrial maintenance contexts.

Based on these findings, it is recommended that the company prioritize controls on high-RPN hazards through engineering measures (e.g., verified energy isolation for LOTO, machine safeguarding, and mechanical lifting aids), reinforced by administrative controls (detailed SOPs, permit-to-work systems, and targeted safety training) and strict PPE compliance. In addition, routine integration of JSA and FMEA into the OHS management system is essential to institutionalize continuous risk review, ensure timely corrective actions, and strengthen safety culture. This targeted approach is expected to reduce incident rates, improve procedural compliance, and enhance overall OHS performance in maintenance operations.

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