Type of Contribution:
Research Paper
Review Paper
Case Study

ENERGY: JURNAL ILMIAH ILMU-ILMU TEKNIK
Vol. 15, No. 2 (2025) pp 335-344
DOI: 10.51747/energy.v15i2.15217

E-ISSN: 2962-2565

This article contributes to:

Risk Factors Causing Occupational Accidents Using the FMEA and Fishbone Methods in the Particle Board Division of PT. Kutai Timber Indonesia

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Abstract

Occupational Health and Safety (OHS) is an essential aspect of industrial operations, aimed at preventing workplace accidents and maintaining a safe and productive environment. The Particle Board Division of PT. Kutai Timber Indonesia faces high accident risks due to heavy machinery and high-temperature processes. This study evaluates potential occupational hazards using the Failure Mode and Effects Analysis (FMEA) and Fishbone Diagram methods. FMEA is used to prioritize risks based on the Risk Priority Number (RPN), while the Fishbone Diagram identifies the root causes of critical hazards. The highest identified risk is the absence of an emergency response team in each shift (RPN = 148.5). Other major risks include inadequate monitoring of corrective actions, poor documentation systems, low employee involvement in hazard identification, and insufficient technical controls. Recommendations include forming emergency response teams, conducting regular safety training, improving documentation systems, and enhancing technical and administrative controls. Implementing these measures is expected to reduce accident rates and strengthen the safety culture in the company.

Keywords: FMEA; Fishbone Diagram; Occupational Health and Safety; Risk Analysis; Workplace Accidents.

Article Info
Submitted: 2025-10-20
Revised: 2025-11-07
Accepted: 2025-11-29
Published: 2025-11-30

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Publisher
Universitas Panca Marga

1. Introduction

Occupational Health and Safety (OHS) plays a fundamental role in industrial activities to ensure a safe, healthy, and productive working environment [1].

Consistent implementation of OHS helps prevent occupational accidents and work-related illnesses while supporting business continuity [2]. In the manufacturing sector, OHS implementation is particularly vital due to production activities involving large-capacity machinery, high-temperature processes, and flammable materials all of whichh contribute to a higher risk of accidents [3].

PT. Kutai Timber Indonesia is a wood-processing company with one of its production units being the Particle Board Division. The production process in this division includes several critical stages: grinding, drying, pressing, and cutting. These processes pose potential hazards such as heat exposure, noise, and fire. Based on company data from 2022–2024, there were 14 reported workplace incidents, consisting of 10 near-miss events and 4 fire incidents, indicating a relatively high level of risk that requires comprehensive analysis and control.

The purpose of this study was to determine the risk of workplace accidents using the Failure Mode and Effects Analysis (FMEA) and Fishbone analysis methods. The FMEA method includes risk priority levels using the Risk Priority Number (RPN) derived from Severity, Occurrence, and Detection. A higher RPN value indicates a more critical risk that should be prioritized [4]. Fishbone, on the other hand, identifies the root causes of risks based on five main factors: human, machine, method, material, and environment [5].

2. Methods

This research was conducted in the Particle Board Division of PT Kutai Timber Indonesia over a period of four months, from February to May 2024. The study utilized internal company documents and supporting references, including occupational accident reports from 2022 to 2024, to analyze the recorded workplace incidents. In the data collection process, interviews were employed as the primary method. In the data collection process, this study used the interview method as the main instrument. The criteria for selecting informants for data collection were based on several main considerations, namely the informant had direct experience of more than 10 to 15 years in the production process and implementation of K3 in the Particle Board Division, the informant also held a position that had authority and responsibility related to the implementation of K3 and the entire production process, and the informant was directly involved in the implementation of K3 programs and operational activities [6]. Based on these considerations, interviews in this study were conducted with the Assistant Head of Section, Head of Production Section, and Safety Officer because the informants had knowledge, experience, and direct involvement that was relevant to this study. The interview instrument consisted of 40 questions related to risk assessment, as presented in **Table 1** on the Risk Assessment Instrument.

Table 1. Risk Assessment Instrument

Classification type	Question Number	Total Question
Emergency Response and Procedures	Q1, Q2, Q3, Q4, Q7, Q8, Q15, Q16,	8
Accident Reporting and Documentation	Q5, Q14, Q23, Q24, Q25	5
Training and Readiness	Q10, Q11, Q12, Q13, Q20	5
Preventive Actions and Controls	Q31, Q33, Q35, Q36, Q37, Q38	6
Risk Inspections and Hazard Identification	Q9, Q21, Q22, Q32, Q34	5
HSE and Organizational Actions	Q6, Q17, Q18, Q19	4
Compensation and Welfare	Q26, Q27, Q28, Q29, Q30	5
Workplace Environment	Q39, Q40	2

After all the data was collected, the next stage was data processing. This process began with hazard identification, which identified various potential hazards based on direct field observations and historical accident data. The next stage was risk assessment using the FMEA method, where each potential hazard was scored based on Severity (S), Occurrence (O), and Detection (D). The Risk Priority Number (RPN) value is then calculated using the following formula:

$$RPN = S \times O \times D \quad (1)$$

A high RPN value indicates that the risk is critical and requires immediate mitigation [7].

Next, a root cause analysis is performed using a Fishbone Diagram to identify the root causes of the risk with the highest RPN value [8]. At this stage, causal factors are grouped into five main categories: human, machine, method, material, and environment. The final stage is the formulation of improvement recommendations, which compile various corrective and preventive action proposals based on the results of the FMEA and Fishbone analysis, with the aim of minimizing risk and strengthening the company's safety culture [9].

3.Results and Discussion

3.1 Failure Mode and Effects Analysis (FMEA)

An FMEA analysis is conducted to identify potential failures that could lead to workplace accidents. Each potential hazard is evaluated based on three parameters: Severity (S), Occurrence (O), and Detection (D). The values of these three parameters were obtained from the assessments of three informants and then averaged to determine the Risk Priority Number (RPN) [10], as presented in **Table 2**, which shows the results of the FMEA calculation.

Table 2. FMEA Calculation Results

No	S	O	D	RPN	No	S	O	D	RPN
Q1	6.00	2.67	5.33	85.33	Q21	8.00	5.67	4.67	211.56
Q2	8.67	5.67	4.33	212.81	Q22	5.33	4.00	5.67	120.89
Q3	8.67	5.67	4.67	229.19	Q23	7.67	7.00	4.33	232.56
Q4	7.33	6.33	4.67	216.74	Q24	7.33	5.00	5.00	183.33
Q5	7.00	4.67	5.67	185.11	Q25	8.33	6.00	4.67	233.33
Q6	6.67	6.67	5.00	222.22	Q26	9.00	5.67	4.67	238.00
Q7	7.33	7.00	5.33	273.78	Q27	7.67	5.67	4.67	202.74
Q8	6.67	7.00	3.33	155.56	Q28	6.67	4.67	5.67	176.30
Q9	7.00	4.67	5.33	174.22	Q29	7.33	5.33	5.33	208.59
Q10	7.00	6.33	4.00	177.33	Q30	7.33	5.67	4.67	193.93
Q11	8.00	3.67	6.67	195.56	Q31	7.33	6.33	5.00	232.22
Q12	6.00	4.33	6.67	173.33	Q32	7.67	5.33	5.67	231.70
Q13	8.00	4.67	5.67	211.56	Q33	8.00	6.67	5.00	266.67
Q14	5.67	4.33	6.33	155.52	Q34	8.33	4.00	6.33	211.11
Q15	7.67	3.67	6.67	187.41	Q35	6.00	4.00	6.67	160.00
Q16	4.50	2.50	9.00	101.25	Q36	8.00	4.67	6.00	224.00
Q17	7.67	6.67	4.00	204.44	Q37	5.67	4.33	6.00	147.33
Q18	8.67	7.33	3.67	233.04	Q38	8.00	4.00	6.33	202.67
Q19	8.00	6.67	3.00	160.00	Q39	6.00	4.33	6.33	164.67
Q20	5.00	4.33	6.67	144.44	Q40	7.67	6.67	4.00	204.44

The FMEA analysis for the Particle Board Division of PT. Kutai Timber Indonesia identifies critical occupational risks, with the highest priority being the absence of an emergency response team on each shift (RPN = 273.78). Other major risks include late first aid (RPN = 229.19), lack of emergency procedures (RPN = 212.81), and insufficient emergency communication systems (RPN = 155.56). These risks are mainly driven by human factors (e.g., inadequate training) and system failures (e.g., poor documentation and risk monitoring). Recommendations include forming emergency response teams, improving first aid training, ensuring clear evacuation routes, and enhancing technical and administrative controls to reduce accidents and strengthen safety protocols.

Table 3. Workplace Accident Risk Assessment Results Based on RPN Values

Rank	No	Question	Average			RPN
			S	O	D	
1	Q7	If no emergency response team is available on each shift, how great is the potential delay in incident handling?	6	2.67	5.33	273.78
2	Q33	If no technical or administrative controls are implemented, how likely is an accident to occur?	8.67	5.67	4.33	266.67
3	Q26	If the company does not cover accident medical expenses, how significant is the impact on workers' welfare?	8.67	5.67	4.67	238

Based on the analysis presented in **Table 3**, the highest RPN value is associated with the statement "If no emergency response team is available on each shift", with an RPN of 273.78 derived from a Severity (S) score of 6, an Occurrence (O) score of 2.67, and a Detection (D) score of 5.33. The second-highest RPN value is linked to the statement "If no technical and administrative controls are implemented for the risks", which has an RPN of 266.67, calculated from S, O, and D scores of 8.67, 5.67, and 4.33 respectively. The third-highest risk, with an RPN value of 238, corresponds to the statement "If the company does not cover accident medical expenses", derived from S, O, and D scores of 8.67, 5.67, and 4.67.

3.2. Visualization of Risk Priority Number (RPN) Values

To clarify the comparison between risks, the results of the RPN calculation are visualized in the form of a histogram in Figure 1. The histogram in Figure 1 visualizes the Risk Priority Number (RPN) values for the various risks identified in the study. The X-axis represents the rank of each risk (from 1 to 40), while the Y-axis shows the frequency of each RPN value, indicating the severity of the risks.

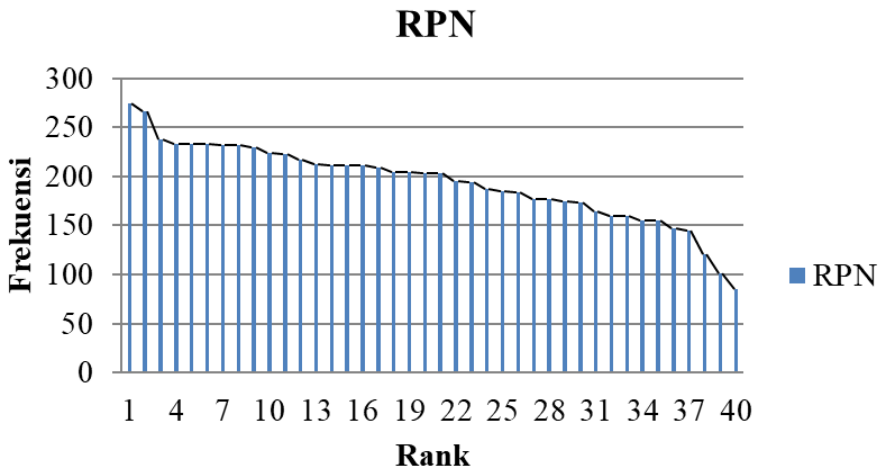

Figure 1. Histogram of Workplace Accident Risk RPN Values

The graph demonstrates that the highest-ranked risks (at the beginning of the chart) have significantly higher RPN values, with a sharp drop as the rank increases. The steep initial decline suggests that a small number of risks pose much greater threats, while the remaining risks have lower RPN values, indicating they are less critical. This visualization highlights which risks need immediate attention and prioritization based on their RPN values, guiding the company's efforts in improving safety and addressing potential hazards.

3.3. Risk Root Cause Analysis Using a Fishbone Diagram

After conducting the hazard identification process and visualizing it using a histogram, three work accident risks were identified with the highest RPN values based on the FMEA method. These three risks were then further analyzed using a Fishbone Diagram to explore the root causes of each risk in more depth. This analysis aims to understand all factors contributing to work accidents by grouping the causes into several main categories.

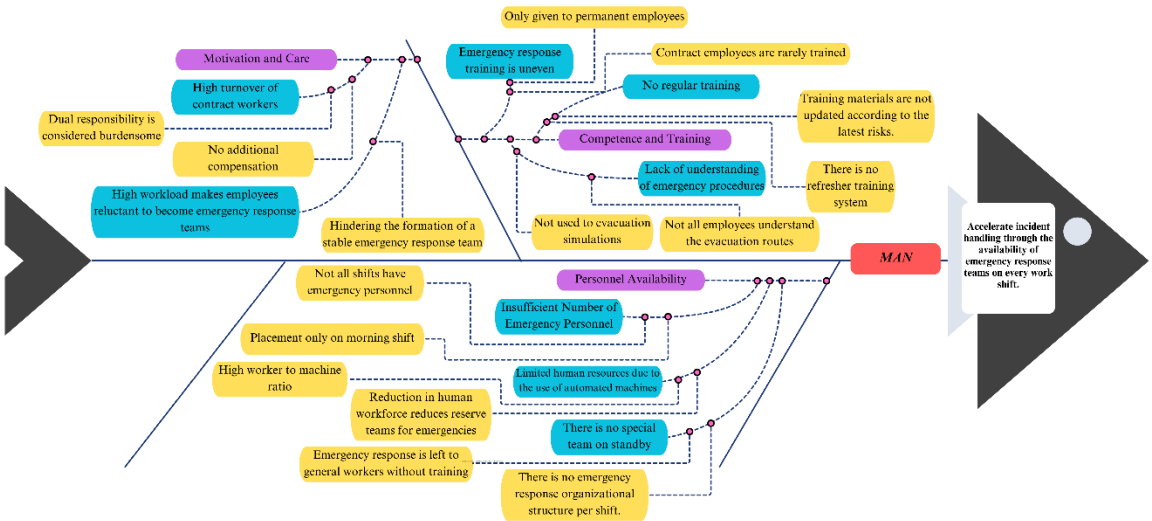

Figure 2. Fishbone diagram risk 1

A Fishbone Diagram itself resembles a fishbone, with the head representing the effect or event being analyzed, while the bones extending to the sides represent the cause categories. In this study, five main elements were used as the basis for grouping: Human, Machine, Method, Material, and Environment. This helps systematically map the source of the problem so that the root cause of each risk can be identified, as shown in **Figure 2**.

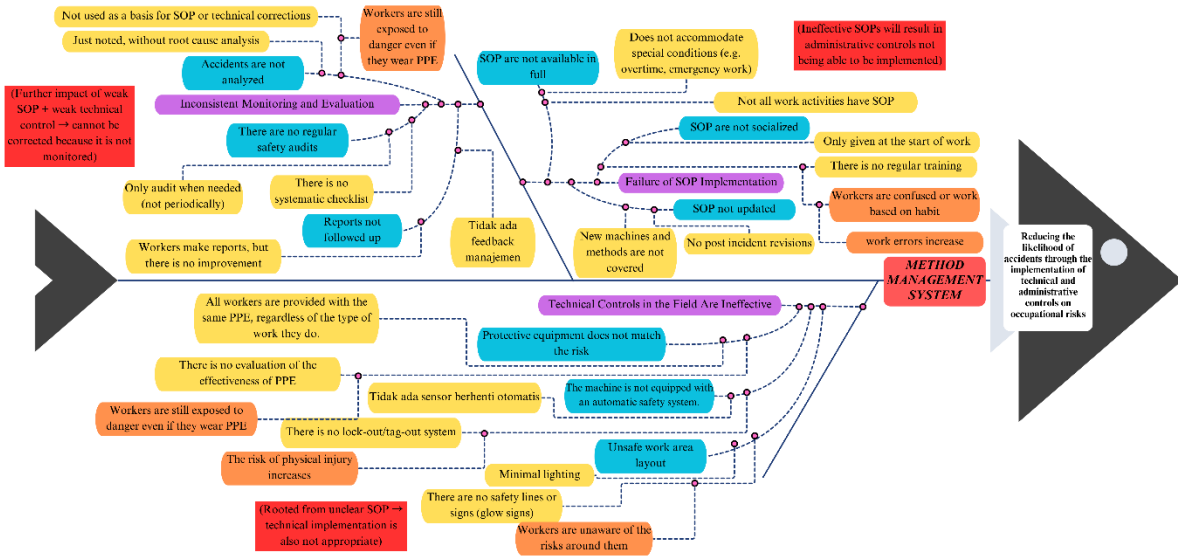

Figure 3. Fishbone diagram risk 2

Based on **Figure 2**, it was found that the main problem in the human aspect (Man) was the delay in handling incidents due to the lack of adequate emergency response teams on each shift. This condition was exacerbated by a lack of trained personnel, uneven and infrequent emergency training, and low worker motivation to participate in emergency teams due to high workloads and minimal compensation. The absence of an emergency response structure per shift also hampered coordination when incidents occurred. This combination of factors resulted in slow incident response, necessitating equal distribution of training, additional trained personnel on each shift, and increased support for emergency response team members.

Based on **Figure 3**, risk two arises from weak technical and administrative controls, particularly due to the lack of routine safety monitoring and evaluation, the absence of checklists, and the absence of root cause analysis for each incident, resulting in no SOP improvements or technical actions. SOP implementation also fails because it is incomplete, not updated, socialization is minimal, and workers rely more on habits than procedures. Technical controls in the field are also ineffective: PPE is not risk-adjusted, not evaluated, machines lack automatic safety guards, work areas are poorly organized, and safety signs are minimal. This combination of weak

SOPs, supervision, and technical controls makes accident prevention less effective, so the occupational safety management system requires a comprehensive overhaul to effectively reduce risks.

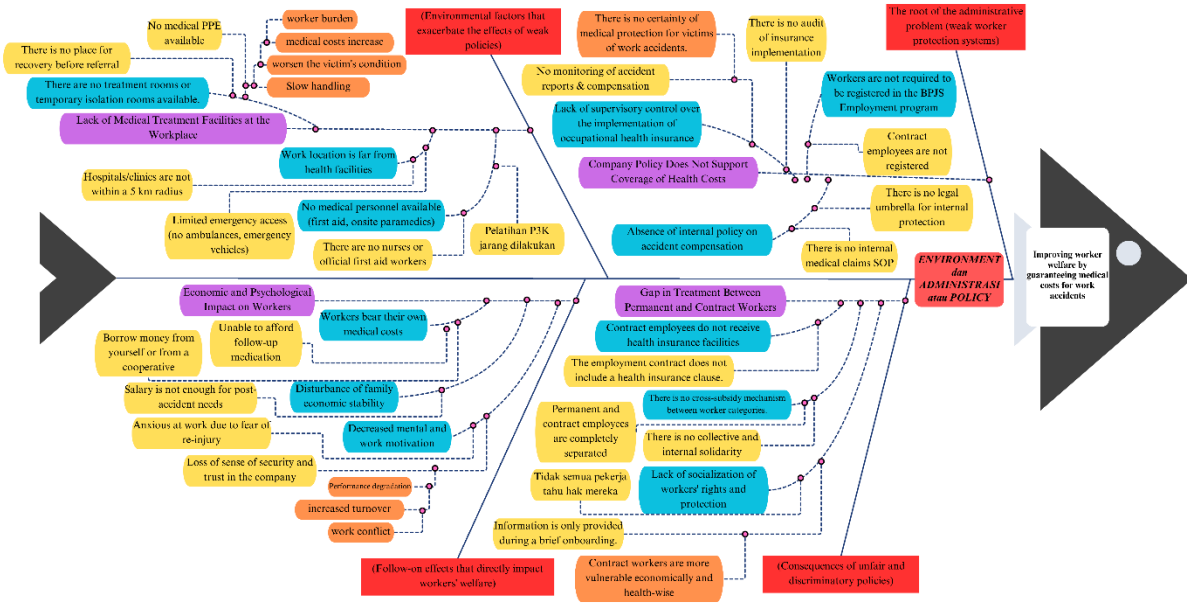

Figure 4. Fishbone diagram risk 3

Fishbone analysis of risk 3, in **Figure 4**, indicates that the primary problem lies in the lack of coverage for work-related medical expenses due to weak company policies and administrative oversight. Minimal control over the implementation of health protection, the absence of standard operating procedures for medical claims, and the lack of auditing mean that workers, especially those on contract, are not registered with BPJS Ketenagakerjaan and do not receive adequate healthcare. This situation is exacerbated by the lack of basic medical facilities at the workplace, such as medical PPE, recovery rooms, first aid personnel, or adequate emergency access. As a result, workers bear their own medical expenses, experience economic and psychological burdens, and decrease motivation and performance. The unequal treatment between permanent and contract workers creates a sense of injustice. Overall, this situation confirms that job security is highly dependent on fair company policies, adequate medical facilities, and a protection system that ensures the well-being of all workers regardless of contract status.

4. Conclusion

The research conducted in the Particle Board Division of PT. Kutai Timber Indonesia, using the FMEA and Fishbone Diagram methods, revealed several key conclusions. The potential risks of workplace accidents were found to stem from various factors, including inadequate emergency preparedness, insufficient technical and administrative controls, a weak accident documentation system, and limited worker involvement in hazard reporting and identification. Through the

FMEA method, risks were prioritized based on severity, frequency of occurrence, and ease of detection. The top risks identified were the lack of an emergency response team on each shift (RPN 273.78), the absence of technical and administrative controls for workplace risks (RPN 266.67), and the company's failure to cover accident medical expenses (RPN 238). Root cause analysis using the Fishbone Diagram pointed to several fundamental issues, including the absence of an active emergency team structure, outdated SOPs, insufficient training and socialization, an unintegrated documentation system, and a lack of Nearmiss reporting culture. These findings highlight the need for strengthening the company's OHS management system in terms of structure, technical measures, and organizational culture.

Authors' Declaration

Authors' contributions and responsibilities - The authors made substantial contributions to the conception and design of the study. The authors took responsibility for data analysis, interpretation, and discussion of results. The authors read and approved the final manuscript.

Funding - No funding information from the authors.

Availability of data and materials - All data is available from the authors.

Competing interests - The authors declare no competing interest.

Additional information - No additional information from the authors.

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