K3 Risk Assessment Using FMEA Method at PT Pertama Mina Sutra Perkasa Jember in Crushing Plan 1, Crushing Plan 2, Mine Quarry and Workshop Area

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Abstract This study aims to identify potential hazards, assess Occupational Safety and Health (OSH) risk levels, and provide recommendations for improving the risk management system at PT Pertama Mina Sutra Perkasa Jember. The research data were obtained through field observations, interviews with workers and related personnel, company documentation, and questionnaires. These data were used to identify workplace hazards, evaluate risk levels, and calculate the Risk Priority Number (RPN). The method employed was Failure Mode and Effect Analysis (FMEA), a risk assessment technique that determines RPN values based on severity, occurrence, and detection parameters. The calculated RPN values were then prioritized to determine which hazards required immediate mitigation. The results revealed several hazards with high RPN values, including falling from heights, being trapped in machinery at the crushing plant, and electrical panel fires in the workshop area. Pareto diagrams were applied to establish hazard mitigation priorities. Recommended improvements include strengthening supervision, enforcing the mandatory use of appropriate Personal Protective Equipment (PPE), and conducting regular inspection and maintenance of equipment. In conclusion, the application of FMEA effectively identifies OSH risks systematically, establishes priority scales for mitigation, and provides corrective measures to minimize potential workplace accidents. Implementing these recommendations is expected to enhance workplace safety and health while supporting company productivity.

Keywords: FMEA; Occupational Safety and Health (OSH); Risk Assessment; Limestone Mining; Risk Priority Number (RPN)

INTRODUCTION

The mining industry plays a vital role in economic development, but also carries a high level of occupational safety and health (OHS) risks. Activities such as drilling, material transportation, and the use of heavy equipment have the potential to cause workplace accidents, dust exposure, and hazards due to unstable terrain. BPJS Employment data shows that in 2024 there were 462,241 workplace accidents in Indonesia, an increase compared to 370,747 in 2023. Furthermore, PT Pertama Mina Sutra Perkasa Jember recorded 10 workplace accidents in 2024 and 7 in 2025, indicating the continued need for improved OHS implementation.

Occupational Safety and Health (OHS) is a workforce protection effort to prevent accidents and occupational diseases. Therefore, risk management is a crucial part of the OHS system to identify, analyze, and evaluate potential hazards before an incident occurs. One method that can be used is Failure Mode and Effect Analysis (FMEA). FMEA is a method for analyzing system or equipment failures and evaluating the effects of those failures (M Iqbal Firmansyah, 2021). The advantage of the FMEA method is that it provides evaluation and input for improving system capabilities. It measures the level of risk and determines the RPN (Risk Priority Number) with parameters S (severity) to determine the

severity of the hazard, O (occurrence) to determine the frequency of accidents, and D (detectability Rating) to determine failures before realizing their impact.

This study aims to identify potential occupational hazards and prioritize OHS risks in the operational activities of PT Pertama Mina Sutra Perkasa Jember using the FMEA method. It is hoped that the results of this study can serve as a basis for developing more effective risk control strategies, preventing recurrent workplace accidents, and improving occupational safety and health performance in the mining environment.

METHOD

This study was conducted to assess and understand the occupational safety and health (OHS) risks in the work environment of PT Pertama Mina Sutra Perkasa Jember, specifically in the Crushing Plant, quarry, and workshop areas. The approach used was descriptive qualitative, with a primary focus on hazard identification and risk assessment through the Failure Mode and Effect Analysis (FMEA) method. This method was chosen because it is able to provide a comprehensive overview of potential risks while helping to develop appropriate mitigation steps. FMEA is a SOD parameter from (Liu & Tsai, 2012).
The data used in this study was collected through several methods:
1. Field observation: directly observing work processes in the Crushing Plant, quarry, and workshop areas to identify potential hazards.
2. Interviews: conducted informally with workers and field supervisors to gather information about their experiences with workplace accidents and preventative measures.
3. Questionnaires: distributed to field supervisors and workers.
4. Documentation: data collected from internal company reports, photographs of field activities, and references from the company's sustainability report.

RESULTS AND DISCUSSION

Identification was conducted through field observations, interviews, and questionnaires distributed to 16 respondents in the work areas of crushing plant 1, crushing plant 2, the mining quarry, and the workshop. Data validity and reliability testing will then be conducted. After the questionnaire is declared valid and reliable, a risk assessment will be conducted. The formula used to calculate the RPN is:

$$\text{RPN} = \textit{severity rating x occurance rating x detection rating}$$
$$= S \times O \times D$$

Table 1. severity scale

Criteria	Description	scale
Very Low	No risk at all	1
Low	No injuries, just near miss	2
	Minimal injury, just a small cut and no treatment required	3
Intermediate	Very minor injury (minor treatment) and no lost work days	4
	Minor injury, loss of 1-3 days of work	5

Criteria	Description	scale
	Mild moderate injury, loss of 4-10 days of work	6
High	Moderate injury, loss of 11-30 days of work	7
	Serious injury, loss of >30 working days	8
Very High	Very serious injury, permanent disability and unable to return to work	9
	Impact of worker deaths	10

Source: (Liu & Tsai, 2012)

Table 2. *Occurance* scale

scale	Criteria	Category	Description
1	*Insignificant*	Never happened	Never happened
2	*Minor*	Rarely happening	Occurs once a year
3	*Moderate*	Sometimes it happens	Occurs 1-3 times in 3 months
4	*Mayor*	Often occur	Occurs 1-3 times in 1 month
5	*Catastrophic*	Happens very often	Occurs >1x a week

Source: (Ayu Nurjanah et al., 2023)

Table 3. *Detection* scale

Detection	Description	scale
Almost impossible	Using supervision, work procedures, it is almost impossible for risks to be detected.	10
Very rarely	Using supervision, work procedures, the possibility of risk being detected is very rare.	9
Seldom	Using supervision, work procedures, the possibility of risks being detected is rare.	8
Very low	Using supervision, work procedures, the possibility of risk being detected is very low.	7
Low	Using supervision, work procedures, the probability of risk being detected is low.	6
Currently	Using supervision, work procedures, the likelihood of risk being detected is moderate.	5
Rather high	Using supervision, work procedures, the probability of risk being detected is quite high.	4
high	Using supervision, work procedures, the possibility of high risk being detected.	3

Detection	Description	scale
very high	Using supervision, work procedures, the possibility of risk being detected is very high.	2
Almost certainly	Using supervision, work procedures, the probability of risk being detected is almost certain.	1

Source: (Mahardhika et al., 2023)

1. Risk Assessment

A risk assessment was carried out using FMEA parameters based on data obtained in the field:

Table 4. FMEA Assessment *(Failure Mode And Effect Analysis)*

No	Area	Activity	Cause	Hazard	Risk	S	O	D	RPN
1.	*Crushing plant 1*		Operation of the Marton PE 710 jaw crusher is carried out every day (7 working hours)	There is Noise	Hearing disorders	3,75	5	1	18,75
2		Sizing Material	Operation of wheelloader equipment	Exposure to dust	Respiratory Disorders	3,75	5	1	18,75
3			Peeled/damaged cables, Overhead	Jaw crusher panel short circuit	Operator electrocuted, Electrical panel caught fire, Fire	9,81	1,81	6	106,71
4				Hammer crusher panel short circuit	Operator electrocuted, Electrical panel caught fire, Fire	9,81	1	6	58,88
5	*crushing plant 2*		Raymond 400 Roll mill machine activity	There is Noise	Hearing disorders	4,25	5	1	21,25
6		Sizing Material		There is exposure to dust	Respiratory Disorders	4,25	5	1	21,25
7			Peeled/damaged cables, Overhead	Rollmill panel short circuit	Operator electrocuted, Electrical panel caught fire, Fire	9,69	1,94	6	112,62

No	Area	Activity	Cause	Hazard	Risk	S	O	D	RPN
8	*Quarry Tambang*	*Loading* Material	Damage to the hydraulic system on the excavator, operator negligence	*Dump truck hit by material*	Dump truck cabin damaged, dump truck operator suffered minor injuries	3,13	2	3,63	22,66
9		*Hauling* material	Operator negligence, hauling route not up to standard, damage to DT	*Dump truck overturned*	*Dump truck damaged, operator suffered minor injuries, hauling lane closed*	5,25	1	10	53
10			Operator negligence, Excessive tonnage	Operator negligence, Excessive tonnage	Dump truck operator suffered serious injuries/fatality, damage to dump truck, closure of hauling route	9,75	1	10	98
11	*Work shop*	Welding	Mechanic smoking near gas cylinder, Gas cylinder leak	Gas cylinder explosion	Workers suffered burns and even fatalities, Fire	9,88	1	10	98,75
12		*Service Unit*	Mechanical negligence, Mechanic does not work according to SOP	Hit by heavy equipment spare parts	Mechanic suffered serious injuries/fatality	9,06	2,25	10	203,91
13		*Heavy Equipment Maintenance*	Changing oil on heavy equipment	Oil spill	Fall/slip	3	3	0,06	0,56
14		*Service units*	Kelalaian mekanik	Hit by DT tub	Causes serious injury/fatality	10	1	10	100

No	Area	Activity	Cause	Hazard	Risk	S	O	D	RPN
15		Workshop Warehouse	*Vibrating ground*	The workshop building has cracks	Death	10	1	10	100

Source: Research Data

Table 5. Risk Level Criteria

RPN	Risk Level
>60	Low
60-80	Currently
80-100	High
>100	Critical

Source: Research Data

2. Mitigasi Risiko

Based on the results of the analysis that has been carried out and the RPN value and risk level category have been obtained, mitigation improvements will be carried out based on the highest risk level and risk control hierarchy:

Table 6. Mitigation Repair Priorities

No	Hazard	Risk Mitigation
1	Hit by heavy equipment spare parts	Use of APD, use of lifting aids such as chain blocks, cranes, hydraulic jacks during dismantling and installation processes, use of jack stands when removing large spare parts such as cylinders, providing training to mechanics.
2	Roll mill panel short circuit	Use of electrical components according to SNI, designing waterproof and dust-resistant panels, carrying out preventive maintenance, using electrical APD when inside the panel, and providing fire extinguishers near the electrical panel.
3	Jaw crusher panel short circuit	Use of electrical components according to SNI, designing waterproof and dust-resistant panels, carrying out preventive maintenance, using electrical APD when inside the panel, and providing fire extinguishers near the electrical panel.
4	Hit by DT tub	Use of safety lock when lifting the body, prohibiting entry under the dump truck without safety, use of APD, providing training to mechanics.
5	The workshop building has cracks	Conduct regular inspections, strengthen structures and make repairs to prevent cracks from getting bigger.
6	Gas cylinder explosion	Carrying out safe storage of welding tubes, installing pressure regulators and flashback arresters to prevent fire from entering the gas tube, providing training to workers, using APD, providing no-smoking signs in the workshop area, and conducting routine inspections.

No	Hazard	Risk Mitigation
7	Collision between DT's	Installing 360• cameras, limiting maximum speed, conducting training for operators, conducting P2H before heavy equipment is used.

Source: Research Data

CONCLUSION

Based on the research results, it can be concluded that:

1. 15 potential failures have been identified in the crushing plate 1, crushing plan 2, mining quarry, and workshop areas.
2. The discussion revealed five risks with the highest RPN (Reduced Precipitation) of 203.91: the highest risk was the risk of being struck by heavy equipment spare parts, and the lowest RPN was 0.56, for the risk of oil spills.
3. Risk mitigation measures are listed based on the risk criticality level (>50%), including: the use of lifting equipment such as chain blocks, cranes, and hydraulic jacks during dismantling and assembly, providing fire extinguishers near electrical panels, conducting preventative maintenance, using safety locks, conducting regular inspections, providing no-smoking signs in the workshop area, and limiting speeds.

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