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Hazard Identification, Assessment and Control of OHS Risks in Nickel Mining Operations in Batu Putih District

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ABSTRACT

This study evaluates the implementation of Occupational Safety and Health (OHS) in nickel mining operations in Batu Putih District using the Hazard Identification, Risk Assessment, and Risk Control (HIRARC) method. The mining industry inherently carries high risks due to the use of heavy equipment, extreme work environments, and exposure to physical, mechanical, chemical, and environmental hazards. This study focuses on identifying and assessing these risks, as well as developing strategies to minimize them. Through a combination of literature review, field observation, and direct data collection, this study identified significant hazards in mining operations, including equipment failure, unsafe working conditions, and inadequate use of personal protective equipment (PPE) by workers. The application of the HIRARC method in this study enabled risk prioritization, allowing control measures to be focused on activities with the highest risk. The study's findings emphasize the importance of systematic OHS management, with clear recommendations for improving safety practices and reducing occupational accidents in the mining sector. This research contributes to improving the overall safety culture in the mining industry by providing applicable insights for risk mitigation and continuous safety improvement.

INTRODUCTION

Occupational Safety and Health (OHS) is an essential aspect of industrial operations, particularly in the mining sector, which carries a high level of occupational risk. Mining activities involve the use of heavy equipment, work in extreme environments, and exposure to physical, mechanical, chemical, and environmental hazards that have the potential to cause workplace accidents and occupational diseases (Andersen et al., 2019). Therefore, the implementation of a systematic OHS management system is fundamental to ensuring workforce safety and the sustainability of mining company operations (Magalhães et al., 2022).

Every industrial activity inherently carries the risk of occupational accidents, the severity of which is influenced by the type of work, the technology used, the working environment, and the effectiveness of the implemented risk controls (Jaafar et al, 2018; Sousa et al, 2014). An occupational accident is defined as an undesired event occurring as a result of work or during the performance of work, which can result in injury, material loss, and operational disruption (Attwood et al, 2006; Khahro et al, 2020). In general, the causes of workplace accidents are classified into two main factors: unsafe acts committed by workers and unsafe conditions in the work environment (Baldissone et al, 2019). The interaction between these two factors is often the primary trigger for accidents in the mining industry (Yuliana & Ardhyaksa, 2019).

The mining industry, particularly open-pit mining, still exhibits a relatively high rate of workplace accidents compared to other industrial sectors (Timofeeva et al., 2020). Operational complexity, dynamically changing field conditions, and production target pressures are key challenges in managing occupational health and safety (Kasap & Subaşı, 2017). Therefore, a comprehensive and structured approach is needed to identify hazards and effectively control occupational risks.

One internationally recognized OSH management framework is a system aligned with OHSAS 18001 and ISO 45001, which emphasize a risk-based approach to occupational health and safety management (ISO, 2018). Within this framework, the Hazard Identification, Risk Assessment, and Risk Control (HIRARC) method is a widely used method for identifying potential hazards, assessing risk levels based on likelihood and impact, and determining appropriate control measures (Ahmad et al., 2016; Wong et al., 2022). The HIRARC method enables companies to prioritize risks so that control resources can be focused on hazards with the highest risk levels.

Various studies have shown that consistent application of the HIRARC method can reduce workplace accident rates and improve safety performance in high-risk industrial sectors, including mining (Syaifullah et al., 2025). Furthermore, HIRARC plays a crucial role in building a culture of safety by raising awareness of potential hazards in the workplace (Kabul, 2022). Therefore, the application of the HIRARC method is a strategic tool for preventing workplace accidents and sustainably improving the OHS management system in the mining sector.

RESEARCH METHODS

Literature Study

A literature study is conducted by gathering information from various relevant sources, such as books, journals, scientific articles, and company data related to the research objectives. This stage is conducted before and during the research to deepen the theory and basic information that supports the activities carried out in the field. The literature study aims to broaden insight regarding the research topic and provide a strong theoretical foundation for conducting more applicable research.

Field Observation

At this stage, research activities involve direct observation of field conditions related to the research object. This observation aims to obtain factual data regarding the situation in the field. This process includes observations of the work environment, operational conditions, and interactions between various elements in the field, which will then serve as the basis for further data collection.

Research Implementation

Research implementation includes the activities of directly collecting and collecting data related to the object being studied. The data obtained during this research is used to analyze the situation in the field, including identifying problems or potential hazards at the research site. All of these activities are carried out to explore the existing problems in more detail and provide solutions based on the theories learned during the literature study stage.

Field Data Collection

Field data collection was conducted through interviews, direct observation, and documentation obtained during the research. The data collected came from several sources, namely:

a. Primary Data

Primary data was obtained directly from the field through interviews with relevant parties and direct observation related to potential hazards, risk assessments, and risk controls within the company.

b. Secondary Data

Secondary data was collected from pre-existing information, such as company profiles, employee data, and related reports provided by the company. This data provided additional context useful for further analysis.

c. Documentation

Documentation produced during the research included drawings or photographs of field conditions and activities. This documentation helped clarify the situation encountered in the field and provided visual evidence to support the analysis and findings.

Report Preparation

After the research activities were completed, a report was prepared based on the results of the activities and the issues identified in the field. This report would include an in-depth analysis of field conditions, findings related to potential hazards, and recommendations for risk control. The preparation of the report is carried out in accordance with the methodology that has been applied during the research activities and aims to provide a clear understanding of the conditions in the field and the solutions that can be implemented.

RESULTS AND DISCUSSION

Occupational Safety and Health Evaluation Using the HIRARC Method

The results of the occupational safety and health evaluation using the HIRARC method indicate that most activities carried out at this company have significant potential hazards. These potential hazards generally focus on the mining front, involving activities such as the use of swing excavators that stray from the land clearing path, as well as interactions between excavator buckets operating close together. Furthermore, the use of dump trucks also carries potential hazards, particularly related to adverse environmental factors such as weather or slippery road conditions.

Based on direct observations, workers' lack of awareness regarding the use of personal protective equipment (PPE) significantly increases the potential for workplace accidents. Therefore, implementing strict risk controls and using adequate personal protective equipment is crucial to prevent potential workplace accidents.

Based on the evaluation and direct field observations, the following personal protective equipment must be worn by workers:

a. Vests

Safety vests are used to clearly identify workers and increase their visibility in busy and high-risk work areas, such as areas used for mining and heavy equipment operation.

b. Mask

Masks protect workers from hazardous particles they may inhale during work, such as dust and smoke. Masks also provide protection from air pollution and chemicals that can harm workers' health.

c. Safety Helmet

A safety helmet is used to protect workers' heads from impacts that may occur when working in areas with a high risk of falling hard objects. This helmet is crucial for preventing fatal head injuries.

d. Safety Shoes

Safety shoes protect workers' feet from injuries caused by sharp objects, falling heavy objects, or other risks that can occur while working in harsh and hazardous environments.

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e. Ear Plugs
   Ear plugs are used to protect workers' hearing from excessive noise in the work environment, such as in areas with heavy machinery and mining equipment, which can cause permanent hearing loss if not properly protected.
f. Safety Gloves
   Safety gloves are hand protection worn to protect workers from the risk of injury from chemicals, heavy equipment, or sharp objects they may encounter during work in the field.
g. Safety Glasses
   Safety glasses protect workers' eyes from the risk of dust, particles, or objects entering the eyes, as well as from excessive light or chemical splashes that can damage vision.

Hazard Identification at Mining Frontage

At the mining frontage site, several potential hazards frequently arise. These hazards were identified through direct observation and interviews with workers and the site manager. Some of the main potential hazards in this area are:

a. Excavator Swinging Off the Land Clearing Track
   This potential hazard arises from a lack of focus on the excavator operator. The excavator can veer off the land clearing track, risking collision with other equipment or workers.
b. Excavator Buckets Operating Close to Each Other
   Excavators operating too close together can collide, especially if the distance is too narrow. This risks damage to the equipment or even causing injury to workers.

Figure 1. Excavator Buckets Operating Closely

c. Workers Close to Excavator Buckets
   Workers who are too close to excavator buckets in operation are at risk of being struck. This occurs due to a lack of attention from workers in the work area.

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Figure 2. Workers near the Excavator Bucket

d. Workers Struck by Dump Trucks
   Workers can be struck by dump trucks if they are not careful about heavy equipment traffic. This is due to workers' lack of awareness of the equipment movement around them.

Risk Assessment in Mining Operations

In every mining process, potential risks must be analyzed to ensure worker safety and smooth operations. This assessment is conducted using a risk matrix, which considers two main factors: the likelihood of an accident occurring and its severity. The following is a risk assessment of potential hazards in the mining operation:

a. Excavator Swing Departure from Land Clearing Path
   Risk Level: 4 (Very Low)
   Likelihood of Occurrence: 21% - 40%, or 1-2 times per period (usually per year).
   During the land clearing phase, an excavator operator may lose focus and cause the equipment to deviate from its designated path. However, the likelihood of this occurring is quite small. However, if an accident does occur, the impact is likely to be minor, such as minor damage to the equipment or surrounding materials. Therefore, this risk is categorized as very low.
   Solution: To mitigate this risk, it is important to provide additional training for excavator operators on the importance of focus and proper procedures when operating heavy equipment. Furthermore, close supervision throughout the operation will significantly contribute to keeping the equipment on a safe path.

b. Collisions Between Excavator Buckets Operating Close to Each Other
   Risk Level: 8 (Low)
   Likelihood of Occurrence: 61% - 80%, or 4-5 times per year.
   In the mining process, excavator buckets operating too close together can collide. This usually occurs due to a lack of coordination between operators or because the work area is too narrow. Although these accidents occur quite frequently, the impact is relatively minor, such as damage to the equipment or minor injuries to the operator.
   Solution: Maintaining a safe distance between heavy equipment is essential to avoid collisions between equipment. Better communication between operators through communication devices or

stricter field supervision can help minimize these accidents. Regular maintenance and inspections of heavy equipment can also reduce the risk of damage.

c. Worker Hit by Excavator Bucket Working Near Piles of Material
Risk Level: 15 (High)
Likelihood of Occurrence: 81% - 99%, or 4-5 times per year.
This potential hazard occurs when workers are too close to an excavator bucket operating near a pile of material. Workers who fail to maintain a safe distance from heavy equipment risk being struck by the moving bucket. This accident can cause serious injury to workers, especially if the bucket strikes directly. Therefore, the risk level is very high.
Solution: Repositioning workers so they are not near the operating heavy equipment is crucial. Furthermore, clearly marking the work area and strict supervision are essential to ensure workers remain safe. Safety training and an understanding of this hazard need to be regularly disseminated.

d. Worker Struck by Dump Truck
Risk Level: 20 (Very High)
Likelihood of Occurrence: 61% - 80%, or 5 times in a single period (a year).
Workers in the same area as a dump truck are at risk of being struck if they are not paying attention to the vehicle's movement. A dump truck moving through a work area without proper supervision can cause fatal accidents. Due to the high likelihood of occurrence and the significant impact if it does occur, this potential hazard is considered the highest risk of all the identified hazards.
Solution: Implementing a more structured traffic system between heavy equipment and workers is the first step to reducing this risk. Every worker must wear proper personal protective equipment (PPE), and a traffic control system with clear signs should be implemented. Training workers on the importance of safety when working in busy areas and using active communication between operators and workers can help prevent these accidents.

Risk Control at the Mining Front End

Every hazard found at the mining front end must be controlled to reduce the likelihood of an accident. These risk controls follow a hierarchy of controls, starting with administrative steps and ending with the use of personal protective equipment (PPE). The following are risk controls based on identified potential hazards:

a. Excavator Swing Departing the Land Clearing Path
   1) Administrative
      - Work permits for excavator operators must be checked to ensure they have valid permits and follow proper procedures.
      - SOP
        Ensure excavator operators follow standard operating procedures (SOPs) properly and correctly.
      - JSA
        Conduct a job risk analysis to evaluate potential hazards that may arise during excavator operation.
      - Operator Inspection
        If an accident occurs, the operator must be inspected to ensure there was no negligence.

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2) PPE
Operators must wear a safety vest, helmet, mask, safety shoes, and gloves to protect against injuries caused by heavy equipment and dust.

b. Collision Between Excavator Buckets Operating Close Together
1) Administratively:
- Work permits for excavator operators must be checked and the equipment must be used according to procedures.
- SOP
  Ensure operators maintain a safe distance between heavy equipment operating in the same area.
- JSA
  Conduct an analysis to ensure there is no potential for collisions between heavy equipment.
- Operator inspection
  Operators must be inspected to ensure there is no negligence.

2) PPE
Operators must wear a helmet, mask, safety shoes, safety glasses, and a safety vest to protect themselves from potential hazards.

c. Worker Injured by Excavator Bucket Working Near Piles of Material
1) Administratively
- Work permits for operators and workers operating near heavy equipment must be checked.
- SOP
  Ensure that workers are not in risky areas and that operators maintain a safe distance from workers.
- JSA
  Conduct a job risk analysis to ensure the safety of workers around heavy equipment.
- Operator inspection
  Operators are inspected when an accident occurs.

2) PPE
Workers near heavy equipment must wear a helmet, mask, safety shoes, safety glasses, and a safety vest for maximum protection.

d. Worker Struck by Dump Truck
1) Administrative
- The work permit of the dump truck operator must be confirmed and verified.
- SOP
  Regulate vehicle and heavy equipment traffic in the work area to keep workers out of the vehicle's path.
- JSA
  Conduct a risk analysis to identify potential accidents caused by dump truck traffic.
- Operator Inspection
  An inspection of the dump truck driver is conducted to ensure there is no negligence.

2) PPE
Workers must wear a helmet, safety shoes, safety gloves, safety glasses, and a safety vest for protection when working in high-risk areas.

CONCLUSION

The results of an evaluation of occupational safety and health using the Hazard Identification, Risk Assessment, and Risk Control (HIRARC) method at the mining site revealed many potentially hazardous activities. Four hazards were identified: excavator swings leaving the land clearing path, collisions between excavator buckets operating close together, workers being struck by excavator buckets and struck by debris, being hit by dump trucks, and adverse environmental conditions. The risk assessment levels for the four potential hazards were: very low (indicated by blue), low (indicated by green), medium (indicated by light yellow), high (indicated by dark yellow), and very high (indicated by red). Risk control was implemented in accordance with the hierarchy of control, including administrative measures and the use of personal protective equipment (PPE).

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