

Evaluation of Coal Mining Operation Performance by Frequency and Severity Rate of Accidents

Karina Shella Putri¹, Ihsan Noor^{1*}, Andi Afdal Givar Ramadhan², Salma Saharani², Rizka Trisna Laili², Muhammad Irgi Fahrezi², Najwa Radila Adnyza², Dinda Junita Ningtias²

¹ Mining Engineering Study Program, Faculty of Engineering, Lambung Mangkurat University, Jalan Ahmad Yani KM.34, Banjarbaru, South Kalimantan, Indonesia (70712).

² Mining Engineering Study Program (Student Group-1), Faculty of Engineering, Lambung Mangkurat University, Jalan Ahmad Yani KM.34, Banjarbaru, South Kalimantan, Indonesia (70712).

* Author correspondence email: ihsan.noor@ulm.ac.id

Abstract. A coal mining operation is a high-risk activity with higher accident rates. Occupational health and safety in coal mining is essential and urgent for proper handling. The performance of occupational health and safety (OHS) in mining operations is carried out by analyzing the ratio of frequency (IFR) and severity (ISR) in each period. For the case of JBG coal mining in South Kalimantan Province from 2017 to 2022, the data obtained showed no fatalities or serious (major) injuries recurring more than once in 2018, 2021, and 2022. Minor injuries occurred only once in 2018. This study aims to determine the performance of OHS in coal mining operations in South Kalimantan, Indonesia, by evaluating the statistical performance report of IFR and ISR.

Keywords. Occupational Health and Safety, Injury Frequency Rate, Injury Severity Rate

1. Introduction

Occupational health and safety (OHS) is an essential operational component that must be adequately managed and properly supported to ensure safe and effective mining production. Mining operations are high-risk activities with possibilities for accidents to occur. OHS factors are one of the decision-making determinants in coal mining operations. Coal mining employs two primary methods: the open-pit method and the underground mining method. (Oparin et al., 2018; Savon et al. 2019; Suhernomo et al., 2023).

The decision to select a mining method not only considers occupational safety and health but also takes into account convenience, capability, environmental issues, and cost. Coal mining activities in Indonesia generally employ the open-pit method, as the coal reserves are in shallower areas, the rock structure is relatively unstable, and it is easier to excavate using heavy equipment. The open-pit mining method requires the involvement of heavy equipment and personnel to operate and supervise the machinery used in these mining activities. (Namin et al., 2011; Noor et al., 2024).

The selection of the v. Specifically, the formation of acid mine drainage, which must be managed to meet the quality standards for mining liquid waste before being released into public waters. Acid mine water management can be carried out through active treatment, which generally involves the use of chemicals to neutralize the low pH value of liquid wastewater, a relatively expensive process. Water is also managed through passive treatment, a process that utilizes natural methods to treat acid mine water

by releasing it into an area, followed by phytoremediation of the land (Noor et al., 2023; Triwibowo et al., 2025)

1.1. Mining OHS Regulation

Mining OHS regulations (Number 1) in Indonesia were officially issued in 1970, although historically, OHS in Indonesia has been implemented since 1847 at a sugar cane factory in East Java. This law requires the implementation of the OHS program in mining operations by implementing the regulations and their standard operating procedures (SOPs) (Adiratna et al. 2022).

The OHS regulations ensure that every worker in the mining sector has the right to protection for their safety while carrying out work, thereby promoting the welfare of life and increasing national productivity. Every person in the workplace needs to have their safety guaranteed, and every source of production needs to be used safely and efficiently by creating norms for a protective working environment. Fostering these norms needs to be realized in regulations and general provisions regarding work safety in accordance with developments in society, industrialization, engineering, and technology (Ependi and Nur 2018; Nayak et al. 2022).

Mining OHS programs aim to control all forms of potential hazards that exist in the workplace environment. If all potential risks have been controlled and meet safety standard limits, these programs will provide a safe and healthy work environment, introducing calmness for workers. Over time, mining OHS programs have become a significant concern due to several work-related accidents in mining activities. Therefore, hopefully, other companies will identify and analyze any hazardous factors at work. (Coleman and Kerkering 2007; Savon et al. 2019).

The OHS program should begin with the most fundamental aspect, namely, establishing a culture of OHS. The OHS program's functionality and effectiveness are determined by the communication of the program to all individual workers. The mining industry poses relatively significant risks. However, these risks can be minimized by implementing preventive measures through work culture formation activities, one of which is the OHS program. (Bai et al., 2022; Li et al. 2023).

1.2. Mining OHS Statistical Performance Report

Based on the Ministry of Energy and Mineral Resources Regulation Number 3 of 1998 concerning Accident Reporting and Procedures Evaluation, it is explained that management or employers are required to report every accident that occurs in the workplace. After receiving an accident report, an inspection and study of the accident is carried out. Information known at the time of inspection is recorded in the work accident report. All information in either the work accident logbook or the work accident report form needs to be analyzed as part of the management data. One form of monitoring can be presented through work accident statistics. (Coleman and Kerkering 2007; Gammarano 2020).

Work accident statistics, as determined by the ILO (1989), include incident rate, frequency rate, and severity rate. Work accident statistics also aim to assess the effectiveness of OHS performance programs. The statistical data can be used to provide input to management regarding the level of work-related accidents and various factors that can serve as a basis for preventing such accidents. The obligation to measure OHS performance is outlined in the Occupational Health and Safety Assessment Series (OHSAS) 18001:2007, which addresses performance monitoring and measurement.

2. Methodology

This research used a descriptive method to objectively, systematically, factually, and accurately describe the facts studied. Based on the method used, this study was observational because it involved collecting data, and it was a cross-sectional study conducted over a single period. (Gammarano 2020).

2.1. Location and Research Period

The data used in the analysis are from the coal mining activities of JBG coal mining in Jorong District, Tanah Laut Regency, South Kalimantan Province, Indonesia (as shown in Figure 1). The data used are OHS performance statistics for the period from 2017 to 2022, inclusive. The data collected are

the types of accidents that occur, and the statistical report calculates the frequency and severity rate of work accidents.

2.2. Data Compilation and Analysis

A compilation of data was conducted from accident reports in coal mining activities by classifying the types of accidents based on a reference, namely, the Minister of Energy and Mineral Resources Regulation No. 1827 of 2018. The research data were collected and processed to determine the injury frequency rate (IFR) and injury severity rate (ISR). To analyze work accidents, the IFR and ISR were calculated using the following formula:

$$\text{Injury Frequency Rate (IFR)} = \frac{\text{Total accidents}}{\text{Total working hour}} \times 1,000,000 \quad \dots\dots\dots 1$$

$$\text{Injury Saverity Rate (ISR)} = \frac{\text{Total working days loss}}{\text{Total working hour}} \times 1,000,000 \quad \dots\dots\dots 2$$

$$\text{Accident Probability (P}_x\text{)} = t^x e^{-t/x!} \dots\dots\dots 3$$

Where: P_x = Probability 1st, 2nd, 3rd etc.
 t^x = total accidents/12 (total accidents per year)
 e = 2.718

3. Results and Discussion

3.1. Data on Accident Category

The data obtained from 2017 to 2022 include information on the types of accidents that have occurred, as presented in Table 1. There were no fatality accident reports during the period from 2017 to 2022; however, major accidents occurred in 2017, 2019, and 2020, while minor accidents and dangerous incidents occurred in 2018.

Table 1. Summary of Accident Categories from 2017 to 2022

Category of Accident	Total accidents per year					
	2017	2018	2019	2020	2021	2022
Fatality	0	0	0	0	0	0
Major Accident	1	0	1	1	0	0
Minor Accident	0	1	0	0	0	0
Dangerous Incident	0	1	0	0	0	0
First Aid	7	8	12	5	10	6
Total	8	10	13	6	10	6

The highest number of first aid category accidents was 12 incidents in 2019, and the lowest was five incidents in 2020. The highest number of property damage incidents was 48 in 2020, and the lowest was 24 in 2017. Near misses should be higher, with the lowest being 4 in 2018 and the highest being 8 in 2017. These two categories were excluded from the calculation of the number of accidents that occurred during a specific period.

3.2. Statistical Data of IFR and ISR

According to the data processing that has been carried out to calculate the frequency of work accident injuries (IFR) and the ratio of the severity of injuries (ISR) from 2017 to 2022, the highest IFR value is

obtained, namely, 0.46 in 2017, and the lowest is 0 in 2021 and 2022. The highest level of severity (ISR) was 62.50 in 2019, and the lowest was 0 in 2021 and 2022, as presented in Table 2. The company successfully reduced the frequency and severity of accidents in 2021 and 2022.

Table 2. Statistical Data of IFR and ISR from 2017 to 2022

Safety Statistic	Total accidents per year					
	2017	2018	2019	2020	2021	2022
Injury Frequency Rate (IFR)	0.46	0.39	0.32	0.33	0	0
Injury Severity Rate (ISR)	27.40	1.16	62.50	2.01	0	0

Considering the data reported for the period from 2017 to 2022, the results obtained using the probability formula are shown in Table 3. The probability of one conceivable accident occurring at any time is 30.0-37.0%, while the probability of two work accidents occurring is 8.0-20.0%. For events 3, 4, and 5, the odds are 1.3-7.2%, 0.16-1.9%, and 0.02-0.15%, respectively.

Table 3. Accident Probability Data (accident category)

Accident Probability	Accident probabilities for each year					
	2017	2018	2019	2020	2021	2022
1	0.3400	0.3600	0.3700	0.3000	0.3600	0.3000
2	0.1100	0.1500	0.2000	0.0800	0.1500	0.0800
3	0.0250	0.0420	0.0720	0.0130	0.0420	0.0130
4	0.0042	0.0087	0.0194	0.0016	0.0087	0.0016
5	0.0006	0.0015	0.0042	0.0002	0.0015	0.0002

4. Discussion

The application of technology to coal mining activities is highly complex and poses a significant risk to employees and the mining operations. (Savon et al. 2019). Data on accident types that have occurred have become management's input for taking the next steps for evaluation to avoid recurring incidents. The company's ability to avoid and prevent fatalities results from collaboration between all parties, which suppresses and reduces OHS events at a lower level, such as the number of severe or minor incidents, including property damage, first aid, and near misses. The effort implemented deserves appreciation for the company's concern for the safety of its operations and employees. (Namin et al., 2011; Savon et al. 2019).

Coal mining activities have their own definitions in accordance with the Minister of Energy and Mineral Resources Regulation Number 1827, namely, (1) Actual occurrences, (2) Injury to mining workers, (3) Caused mining activities, (4) Occurring during working hours, and (5) Occurring in mining activity areas. Every accident that occurs shall be evaluated in reference to the criteria that determine whether it is a mining accident (Zhang et al., 2020).

The following types of accidents are grouped into minor injuries, major injuries, and fatalities. Minor injuries are injuries resulting from mining accidents, where mining workers are unable to return to their duties for more than one day to less than three weeks, including weekends or holidays. Significant injury is an injury resulting from a mining accident that renders a mining worker unable to return to their duties for more than three weeks, including weekends and other holidays. It causes a permanent disability to a mining worker. Fatality is an injury where the miner loses his life within 24 hours of an accident. (Coleman and Kerkering 2007; Li et al. 2023).

An example of a minor accident occurred in 2018 when a mechanic installed the left wheel of a dump truck, causing the index finger of his left hand to be pinched. This incident is classified in the injury category because the mechanic returned to work on his original duties within three weeks after the incident. An example of a significant accident happened to an employee in a workshop with the position

of a mechanic assistant. The mechanic assistant tidies up the drum to collect used oil in the workshop. When tidying up the drum that collected the used oil, it was too heavy to move, so the used oil drum pinched the ring finger of her left hand, causing the knuckle of the lower end of her ring finger to become permanently deformed. (Adiratna et al. 2022; Li et al. 2023; Nayak et al. 2022).

Statistical data reports for each incident are crucial in the management of OHS in mining, as they provide valuable information about the effectiveness of OHS management in the work area. Increasing one's knowledge and level of caution when performing work is a crucial process for preventing OHS incidents in mining. The company's performance in the field of OHS mining is relative because there has never been an OHS mining activity that has achieved a better score. Statistical data serve as a reference for future improvements, allowing for the development of a standard to measure performance using the ratio of severity and frequency as a target or success criterion for assessments through IFR and ISR. (Bai et al., 2022; Leemans et al. 2023; Nayak et al. 2022).

To reduce the accident level the program to be apply are continuous improvement in the level of mining mechanization, increased emphasis on health and safety by mining companies, work that used to be done by contractors is increasingly being done by permanent workers, Consolidation of mines by large companies – smaller, less hazardous operations, Improvements in mining system and design (Stemn & Krampah, 2023).

5. Conclusion

Coal mining activities are complex and involve high risks. Each observation period of the OHS mining performance can be seen from the IFR and ISR values. The tendency of companies to reduce the time lost by workers is an encouraging result. IFR and ISR values over time can be reduced, allowing for maximum results to be achieved. The level of accidents can be reduced by evaluating the safety and health program for employees.

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