JOURNAL OF SOCIAL SCIENCE
Printed ISSN: 2720-9938
Electronic ISSN: 2721-5202
jsss.co.id

Analysis of Light Vehicle Accident Data at PT Z Period 2018-2022 Using Human Factor Analysis and Classification System-Mining Industry Framework

Dimas Bayu Aji[1*], Indri Hapsari Susilowati[2]
University Indonesia, West Java, Indonesia[1*2]
Email: dimas.bayu.aji@gmail.com[1*], indri.susilowati@gmail.com[2]

ABSTRACT
The mining industry poses significant risks, heavily influenced by human factors contributing to workplace accidents. PT Z, a mineral mining company in Papua, Indonesia, operates complex operations involving underground mining and diverse production equipment. With a workforce exceeding 29,563 as of February 2023, the potential for accidents involving moving vehicles, particularly light vehicles, is notably high. From 2018 to 2022, there were 513 reported incidents involving light vehicles, prompting PT Z's focused attention on mitigating traffic-related risks. This study conducted at PT Z aims to analyze light vehicle accidents using the Human Factors Analysis and Classification-Mining Industry (HFACS-MI) framework. Over a five-year period, qualitative data from accident cases at PT Z were collected and classified based on incidents logged in the company's management system. The HFACS-MI framework was applied to categorize and analyze these accidents, revealing that 88% occurred in highland operational areas. The analysis identified multiple layers contributing to light vehicle accidents: organizational influence factors (106%), unsafe leadership (9%), precondition for unsafe acts (109%), and unsafe acts themselves (77%). These findings underscore the critical role of human factors in mining accidents and highlight the potential for reducing incidents through improved error management strategies. Ultimately, the HFACS-MI framework proves effective for structured analysis of mining accidents, emphasizing human factors' significant impact on safety within the industry.

Keywords: HFACS-MI; Mining Industry; Accidents; Light Vehicles

INTRODUCTION
PT Z is an affiliated mineral mining company of a mining company from the United States and the Indonesian Mining Industry Holding BUMN, which has been operating since 1972 in Mimika Regency, Central Papua Province (Prayogi, 2019). PT Z operates at an altitude ranging from 2,800-3,500 meters above sea level and employs more than 30,000 employees (Jutras et al., 2021). The mined ore is located at an altitude of more than 4,000 m above sea level in the Ertsberg and Grasberg areas in an area of 100 km (Leys et al., 2020). The ore produced from the mine is sent via downward vertical tunnels and conveyor belts to the Ore Processing Plant located in a narrow valley at an altitude of 2,800 m above sea level (Bustillo Revuelta & Bustillo Revuelta, 2018). At the Ore Processing Plant, valuable minerals such as copper, gold and silver are extracted using flotation techniques (Bakalarz, 2019). The foam is then collected into concentrate slurry and sent via pipeline to the Concentrate Drying Plant in the Amamapare Port area which is located about 120 km south of the Ore Processing Factory (Susanto, 2017). Drying is carried out by high pressure filtration (filter press) and heating. Dry concentrate in the form of fine black sand grains is PT Z's final product (Shirato et al., 2017).

According to the International Council on Mining and Metals (ICMM) report, "Safety Performance: Benchmarking Progress of ICMM Company Members in 2021", the total number of work-related deaths in the mining sector is relatively consistent with

2020, considering 43 deaths in 2021 compared to 44 deaths in the previous year. This occurred despite a 7% increase in the number of hours worked in the previous year (Bliese et al., 2017). In the past year, moving vehicles replaced rockfall as the most prolific killer of miners worldwide (Rosser & Massey, 2022). This last happened in 2018, when 15 deaths due to moving vehicles accounted for 30% of deaths in 2.3 billion hours worked. In 2021, moving vehicles accounted for 28% of deaths in 2.5 billion hours worked (Farmer, M., 2022). In Indonesia, based on data from the Ministry of Manpower of the Republic of Indonesia, in 2023 the number of work accident cases in Indonesia will be recorded at 370,747 cases (Udoikah et al., 2024).

Incident Management System (IMS) data used at PT Z as a database for recording and managing incidents, there were 513 accidents involving light vehicles. Of the total light vehicle accidents, 88% occurred in highland areas (Podofillini et al., 2015).

The Swiss Cheese Model developed by James Reason in 1990 is a metaphor to describe how accidents or incidents occur (Howard & Dimick, 2024). This model can also be used to understand how latent dangers can emerge and develop in an organization (Long et al., 2022). In an organizational context, holes in a slice of Swiss cheese can represent various factors that contribute to latent dangers, such as procedural design flaws or poorly designed systems that can create gaps where latent dangers can hide. Human error, such as negligence or lack of knowledge can introduce latent dangers into the system (Woods et al., 2017). Inadequate asset maintenance can also contribute as a latent hazard, as lack of maintenance or inspection of equipment and infrastructure can cause undue wear and tear and damage that can ultimately lead to accidents (Hassan et al., 2017). An organizational culture that does not focus on safety or tolerate violations can also allow latent dangers to develop (Komljenovic et al., 2017).

Human Factors Analysis and Classification System (HFACS) is a framework used to analyze and understand human factors that contribute to accidents and incidents. HFACS was developed by Dr. Scott Shappell and Dr. Douglas Wiegmann based on an analysis of United States naval plane crash cases. This model was specifically created to describe active and latent failures in layers of a protection system, based on the concept of Reason's Swiss Cheese Model (da Cunha et al., 2022). Further developments in 2010 saw Patterson and Shappell develop a more specific framework for the mining sector known as the Human Factors Analysis and Classification System in Mining Industry (HFACS-MI). HFACS-MI has five levels, namely, outside factors, organizational influences, unsafe supervision leadership, preconditions for unsafe acts, and unsafe acts. HFACS-MI provides a systematic and comprehensive approach to analyzing incidents in the mining sector, with a focus on human and organizational factors (Joe-Asare et al., 2023).

PT Z in incident management uses the Root Cause Analysis Process (RCAP) method, which is a systematic method for identifying the basic causes of an incident or accident that occurs. The aim of this research is to analyze the contribution of human factors in light vehicle accidents at PT Z in the period between 2018 and 2022 using the HFACS-MI framework which will try to classify it into five predetermined levels. The author uses the HFACS-MI method because it was developed specifically for the mining industry and not only focuses on the direct causes of accidents but also on latent factors that can create an environment that is prone to accidents.

RESEARCH METHODS

In this study, the HFACS-MI framework is used to analyze accidents in the mining sector (Figure 1). HFACS-MI has 5 levels or layers for analyzing work accidents, consisting of Unsafe Acts, Preconditions for Unsafe Acts, Unsafe Leadership,

Organizational Influences, and Outside Factors. Overall HFACS-MI consists of 26 elements.

This research was conducted at PT Z which operates in Mimika Regency, Papua from April to June 2024. The type of research used was a case study with a semi-quantitative descriptive approach. This research aims to analyze light vehicle accidents at PT Z for the 2018-2022 period where the process of collecting or retrieving data and measuring variables is carried out at the same time. This research looks at the percentage of factors causing accidents from each category analyzed using the HFACS-MI method. Then this research also uses a cross-sectional methodology where data is collected at the same time as variable measurement. Research data was collected through literature reviews, interviews, and a triangulation process with safety practitioners at PT Z.

The research population is light vehicle accident information data at PT Z which has been verified and recorded in the incident management system for the period 2018 to 2022. Light vehicle accident investigations have been carried out systematically using the RCAP method and carried out by competent personnel in their field. In the research period, there were 513 accidents involving light vehicles at PT Z, of which 451 accidents occurred in the highlands (Highland/HL) and the remaining 62 accident cases occurred in the lowlands (Lowland/LL). The proportion and number of light vehicle accidents can be seen in Graph 1.

This research requires a thorough review of the contents of accident investigation reports. Data analysis uses a univariate analysis approach, where each processed data variable is examined individually to determine its characteristics. These findings are presented through descriptive statistics for independent and dependent variables, as well as frequency distributions, proportion measures and percentages.

Ethical assessment procedures have also been carried out for this research, and approval for research implementation was obtained with "registration number: Ket-504/UN2.F10. D11/PPM.00.02/2024".

RESULT AND DISCUSSION

Using the HFACS-MI framework, a total of 513 light vehicle accident cases were analyzed and classified at five standardized levels. This research seeks to analyze work accident data at PT Z from the perspective of the HFACS-MI framework. Because RCAP and HFACS-MI have categories and elements that are not exactly the same, the researchers carried out a "matching" process using the triangulation method. The researcher carried out this poleulation process by analyzing data with the support of observation and an interview process with the parties. Researchers conducted discussion and interview sessions with Safety Experts from representatives and the Mining Safety Division of PT Z and Safety Practitioners from one of the Divisions at PT Z. It was found that each level played a role and contributed to light vehicle accidents, but not at the Outside Factor level. The results of analysis and classification using the HFACS-MI framework can be seen in Table 1 and the contribution of each level each year can be seen in Graph 2.

Level Unsafe Acts

Based on data on light vehicle accidents at PT Z for the 2018-2022 period, it can be seen that the contribution of unsafe acts is quite significant every year. The highest contribution of unsafe acts appeared in 2019, reaching 92%, while the lowest contribution occurred in 2021, namely 59%. In 2018 unsafe acts contributed 73% to all accidents or contributed 101 of the 138 accident cases that occurred. For 2020, unsafe acts contributed 89% or 128 of the total 144 accident cases that year. Meanwhile, in

2022, the contribution of unsafe acts has decreased to 72% or accounts for 42 of the total 58 accident cases.

In the HFACS-MI framework, unsafe acts consist of two groups of variables, namely errors and violations. From the data we can conclude that the contribution to the occurrence of unsafe acts at PT Z is more caused by errors than by violations. The highest contribution of errors was in 2018 at 84% or 85 of the total 101 unsafe acts that occurred. The lowest contribution of errors was in 2019, which only contributed 59% or 70 of the total 119 unsafe acts recorded. The type of error that contributes the most each year comes from the decision error category, where each year the error contribution is more than 80%. The remainder is a contribution from skill based errors of 20% and during the research period no perceptual errors were identified. For the violation category, the highest contribution comes from routine violations, reaching more than 80% every year. Meanwhile, for exceptional violations, the highest contribution was only 17% in 2021, in fact it did not contribute at all (0%) in 2020 and 2022. To see more clearly, see Graph 3.

From the graph we can see that the number of Unsafe Acts appearing increased from 2018 to 2020. In 2021, PT Z succeeded in managing unsafe acts by reducing their occurrence by 80% compared to the previous year. However, in the following year, in the 2022 period, an increase in the occurrence of unsafe acts was identified by 60%. PT Z needs to note this in managing the emergence of unsafe acts in the coming year.

Level Preconditions for Unsafe Acts

The contribution of Preconditions for Unsafe Acts has a significant contribution trend exceeding 100% contribution every year. 2018 was the year with the highest contribution of preconditions for unsafe acts, reaching 122% or contributing 168 of the total 138 incidents that occurred. Meanwhile, the lowest contribution of preconditions for unsafe acts occurred in 2020, with a contribution of 100% or 144 of the total 144 accident cases that occurred. If we look at the three groups of variables that make up Precondition for Unsafe Acts, the Condition of Operators variable is the largest contributor with an average contribution of 72% each year. The second position of the largest contributor comes from the Environment Factors variable with an average contribution of 26% every year. The variable with the smallest contribution comes from Personnel Factors, which only contributes 2% each year. In the condition of operators variable, adverse mental state is the highest contributor, followed by physical/mental limitations, and adverse physiological state is the lowest contributor. For the environmental factors variable, the technical environment contributed more than the physical environment in the 2018 to 2020 period, but for the 2021 and 2022 periods conditions reversed, making the physical environment a superior contributor. Although the contribution between the technical environment and the physical environment is not too significantly different and is almost equal every year.

From graph 4, researchers see that PT Z's positive performance in suppressing the emergence of the Preconditions for Unsafe Acts variable started in the 2021 to 2022 period. PT Z succeeded in reducing Preconditions for Unsafe Acts by up to 64% in 2021 and succeeded in maintaining it in 2022.

Levels of Unsafe Leadership

Unsafe leadership in this research did not make a significant contribution. This can be seen from the largest contribution of this variable which is only 19% or 11 out of a total of 58 cases of light vehicle accidents that occurred in 2022. The lowest unsafe leadership contribution occurred in 2019, where only 1 unsafe leadership was recorded or if we look at the percentage contribution only about 0.8%. Unsafe leadership in the HFACS-MI framework consists of four variables, namely Inadequate Leadership, Planned

Inappropriate Operations, Failure to Correct Known Problems, and Leadership Violations. Based on the research results, during the period 2018 to 2022 not a single Planned Inappropriate Operations variable was identified. However, if we look at the trend, the Leadership Violations variable has the greatest contribution, dominating for 3 years, namely the 2018, 2021 and 2022 periods.

From graph 5, we can see that the contribution of Unsafe Leadership is relatively small and insignificant when compared to the total incidents that occur each year. However, attention needs to be paid, researchers see an upward trend starting in 2019. This needs attention from PT Z to pay more attention to this variable, so that it does not become a bigger contributor in the future.

Organizational Influence Level

Based on data analysis, the Organizational Influences factor has a very significant contribution. This is shown by the organizational influences variable which contributes more than 100% every year in the period 2018 to 2022. The highest contribution of organizational influences occurred in 2021 amounting to 109% or 41 of the total 48 accident cases that occurred in that year. Meanwhile, the lowest contribution from organizational influences was in 2019, namely 102% or the equivalent of 132 of the total 129 cases of light vehicle accidents that occurred in that year. In the HFACS-MI conceptual framework, Organizational Influences consists of three sub-sections, namely Resource Management, Organizational Climate, and Organizational Process. Based on research conducted at PT Z in the period 2018 to 2022, it can be identified that the Organizational Process factor is the largest contributor to the Organizational Influences variable, with an average contribution of 85%. Meanwhile, the Resource Management and Organizational Climate factors have relatively the same contribution to the Organizational Influences variable, with an average contribution of 10-11%.

From graph 6, we can conclude that Organizational Influences at PT Z experience fluctuations every year, where in the research period 2020 was the highest year and 2021 was the lowest year for the number of organizational influence variables in light vehicle accident cases. It is hoped that PT Z can reduce the emergence of negative factors from organizational processes in the workplace which are the main contributors so that in the end it can reduce the Organizational Influences variable. Meanwhile, the Resource Management & Organizational Climate factors can be managed well by PT Z as shown by the frequency of occurrence which is relatively small and tends to decrease every year.

Outside Factor Levels

Based on the analysis carried out by researchers on data on light vehicle accidents at PT Z in the period 2018 to 2022, no variables were found that could be included in the Outside Factor either in terms of Regulatory Factors or Other Factors.

CONCLUSION

Based on the results of the analysis of light vehicle accident data at PT Z for the 2018-2022 period using the HFACS-MI method, several conclusions can be drawn as follows: No outside factors were found in the analysis of light vehicle accident data; Preconditions for Unsafe Acts are more dominant than Unsafe Acts; Preconditions for Unsafe Acts that contribute most to light vehicle accidents are Adverse Mental States, such as mental/psychological abilities, mental or psychological stress, and inappropriate motivation/behavior. Meanwhile, Technical Environment, includes inadequate guards or barriers, inadequate or inappropriate protective equipment; defective/damaged tools, equipment or materials; and inadequate warning systems; At the organizational level, Organizational Process factors dominate as a cause of accidents. Organizational

processes include communication issues, change risk management, and inspections/audits.

Based on the results of research on accident data and the results of interviews, discussions and triangulation processes, there are several recommendations that need to be carried out, namely that in PT Z's accident data system (IMS), there are still many duplicate data and incomplete data found. The author still sees room for improvement, especially the quality of data input and analysis in the future; The RACP used by PT Z has less potential to explore outside factors and management control. The code selection at the management control layer (section 9) contains normative words and tends to use positive sentences (cannot be blamed). This can actually bias the results of the investigation, especially if there are recommendations that are related at the organizational level; Based on the results of this research, psychological, behavioral and stress factors contribute quite significantly to light vehicle accidents. Further research needs to be done regarding these factors to prevent accidents in the future; Based on the results of this research, at the organizational level the issues of communication, change risk management, and inspections/audits need to receive more serious attention from PT Z to obtain better K3 performance in the future.

REFERENCE

Bakalarz, A. (2019). Chemical and mineral analysis of flotation tailings from stratiform copper ore from lubin concentrator plant (SW Poland). *Mineral Processing and Extractive Metallurgy Review*, *40*(6), 437–446.

Bliese, P. D., Edwards, J. R., & Sonnentag, S. (2017). Stress and well-being at work: A century of empirical trends reflecting theoretical and societal influences. *Journal of Applied Psychology*, *102*(3), 389.

Bustillo Revuelta, M., & Bustillo Revuelta, M. (2018). Mineral resource extraction. *Mineral Resources: From Exploration to Sustainability Assessment*, 311–421.

da Cunha, D. T., Hakim, M. P., Soon, J. M., & Stedefeldt, E. (2022). Swiss Cheese Model of food safety incidents: Preventing foodborne illness through multiple layers of defence. *Food Control*, *139*, 109053.

Hassan, Z. F. A., Ali, A. S., Chua, S. J. L., & Baharum, M. R. (2017). Building pathology, maintenance and refurbishment. In *Building Design, Construction and Performance in Tropical Climates* (pp. 188–217). Routledge.

Howard, R., & Dimick, J. B. (2024). Human Factors and Principles of Patient Safety: The James Reason Model. *Principles of Perioperative Safety and Efficiency*, 3–15.

Joe-Asare, T., Stemn, E., & Amegbey, N. (2023). Causal and contributing factors of accidents in the Ghanaian mining industry. *Safety Science*, *159*, 106036.

Jutras, J., Naik, R. K., Jawad, Z., Razvi, J., Wang, M., Rameshwarsingh, S., Fan, K., Nehdi, A. N., Sochan, L., & Hasija, A. (2021). *The Ongoing Evolution of Air Travel*.

Komljenovic, D., Loiselle, G., & Kumral, M. (2017). Organization: A new focus on mine safety improvement in a complex operational and business environment. *International Journal of Mining Science and Technology*, *27*(4), 617–625.

Leys, C., Schwarz, A., Cloos, M., Widodo, S., Kyle, J. R., & Sirait, J. (2020). *Grasberg copper-gold-(molybdenum) deposit: Product of two overlapping porphyry systems*.

Long, J. A., Webster, C. S., Holliday, T., Torrie, J., & Weller, J. M. (2022). Latent safety threats and countermeasures in the operating theater: a national in situ simulation-based observational study. *Simulation in Healthcare*, *17*(1), e38–e44.

Podofillini, L., Sudret, B., Stojadinovic, B., Zio, E., & Kröger, W. (2015). *Safety and reliability of complex engineered systems: ESREL 2015*. CRC press.

Prayogi, I. A. (2019). Media Convergence In Welcoming Industrial Era 4.0. *Book of*

Abstracts, *62*.
Rosser, N., & Massey, C. (2022). Rockfall hazard and risk. In *Landslide Hazards, Risks, and Disasters* (pp. 581–622). Elsevier.
Shirato, M., Murase, T., Iritani, E., Tiller, F. M., & Alciatore, A. F. (2017). Filtration in the chemical process industry. In *Filtration* (pp. 299–423). Routledge.
Susanto, A. (2017). Design of Information Management for Environmental Performance Management based on ISO 14001: 2015 in Concentrating Division PT Freeport Indonesia. *Graduate Program Thesis, Institut Teknologi Bandung, Bandung*.
Udoikah, J. M., Nwuzor, C. I., Nwambe, S. N., Nwokwu, P. M., Ogo, E. D., Nkwede, V. I., Nwoba, M. O. E., & Ndu, M. U. (2024). Challenges of Developing Appropriate Manpower Plans in the Nigerian Local Government System. *Nigerian Journal of Social Psychology*, *7*(1).
Woods, D., Dekker, S., Cook, R., Johannesen, L., & Sarter, N. (2017). *Behind human error*. CRC Press.