Analysis of Accident Investigation Techniques at The Location of The Ore Hauling Road Location (ICAM Analysis Method)

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Abstract

ICAM (Incident Cause Analysis method) is one of the investigation techniques used to analyze accidents and PT XYZ uses ICAM (Incident Cause Analysis method). Based on accident data for the last 3 years at PT XYZ, there has been a significant increase in the number of accidents caused by work activities, namely in 2022-2023 an increase of 5 cases (2.7%) and 2023-2024 an increase of 4 cases (2.08%). The purpose of this study is to analyze the effectiveness of the Incident Cause Analysis Method (ICAM) method in investigating accidents at the location of the ore haul road at PT XYZ in 2023.This research uses qualitative descriptive with a case study approach. The research population was 8 cases. Subject research cases of accidents on ore hauling roads. The object of the research is the occurrence of accidents in the period of 2023. Secondary data sources from investigation reports. The results of the findings of this study highlight that there is an absence or failed defence 22% (DF04-Awareness-Supervision 37.5%), individual/team factors 20% (IT12-Errors or violations of work methods 37.5%), Human-Environmental Factors 17% (HF05-situational awareness 37.5%), Workplace environment 19% (TE05-Normal operating situations and TE12-routine/non-routine tasks 25%), Organizational Factors 22% (OR-Organization 62.5%). Research conclusions from 8 cases of accidents caused by factors Absent or failed defence (22%) and organizational factors (22%). company suggestions are required to fulfil field supervision competencies, companies make, implement and review work operational standards (SOPs), companies are required to repair roads or reduce road grades to make them safer, selective in labour selection, install signs in dangerous areas, evaluate SOPs, JSA and HIRA regularly and conduct training to all workers, supervisors are required to conduct coaching to workers who are their responsibility.

Keywords: Accident Investigation, ICAM Data Collection, ICAM Analysis, Occupational Health and Safety

INTRODUCTION

The level of work accidents is one indicator of work safety in a company or industry. An industry is said to be zero accident if there are no work accidents. The Zero Accident Award, which is part of the national OSH acculturation program, aims to motivate companies that have implemented OSH and achieved zero accidents within a certain period (Utami, 2023). Zero accident means being able to prevent work accidents in the workplace without losing time or working hours (Ariscasari, 2018).

A work accident is an undesirable event or incident that harms people, damages property or damages processes. An accident can also be defined as an unwanted and

unexpected event that can cause loss of life and/or property (Fa, Z, 2021). Accident investigation is an important part of occupational safety and health (OHS) management in various industries, including the mining industry. PT.XYZ (Jilcha & Kitaw, 2017).

This ICAM (Incident Cause Analysis Method) investigation uses the basic theory of the Swiss cheese model. The Swiss cheese model is a model used to analyze risk and risk management in human systems (Griffiths, 2021). This model includes a sequence of human failures that cause accidents or errors. It is likened to slices of Swiss cheese that are solid and side by side. This theory was proposed by British psychologist James Reason in 1990 (Health and Safety Executive United Kingdom, 2020). Accident investigation techniques are an effective approach to understanding the root causes of accidents and implementing appropriate preventive measures. One of the methods used in accident investigation techniques is the Incident Cause Analysis Method (ICAM) (Grant et al., 2018).

The stages of accident investigation techniques using ICAM (Incident Cause Analysis Method) consist of 6 parts, namely first, Immediate actions, namely mobilization to the scene, responding to emergency situations, securing the scene, appointing an investigation team, preparing investigation tools. Second, Investigation Planning is preparing an investigation meeting plan. Third, data collection, namely collecting PEEPO data (People, Environment, Equipment, Procedures, Organization) and some additional data and witness reports. Fourth, Data organization is preparing the incident and incident conditions chart and compiling using tools such as fall trees analysis or 5 ways. Fifth, Data Analysis is to analyze the findings, identification of defense failures/existence, identification of individuals/teams, identification of tasks/environmental conditions, identification of organizational factors and validation of organizational factors and ICAM (Incident Cause Analysis Method) element codes. Sixth, Recomended and report, namely providing recommendations for follow-up, control hierarchy, impact and potential assessment, payoff matrix, compiling findings reports and compiling case learning through short reports (Suma'mur PK, 2014) .

Based on a preliminary study of accident data for the last 3 years at PT XYZ, it is known that in 2021 there were 89 cases of incidents, in 2022 there were 94 cases and in 2023 there were 98 cases. Based on this data, there was a significant increase in the number of accidents caused by work activities ranging from exploration, construction, mining, transportation of ore materials. In 2021 to 2022 there was an increase of 5 cases (2.7), 2022 to 2023 there was an increase of 4 cases (2.08). In 2023 incidents at PT XYZ were dominated by incidents caused by driving traffic such as 32 cases of dump truck incidents, 15 cases of light vehicles (LV), 18 cases of heavy equipment, 3 cases of buses, 15 cases of support vehicles and 15 cases of tools.

Based on the classification of incidents, there are 39 cases of class 2 incidents (accidents that cause serious injuries) at PT XYZ (8 cases are the highest risk) to conduct in-depth investigations using accident investigation techniques using the Incident Cause Analysis Method (ICAM). In 2023, it is an important focus in the company's efforts to improve OHS standards and reduce the risk of work accidents and to develop work programs. Therefore, it is necessary to analyze accident investigation techniques at the location of the ore haul road at PT XYZ in 2023 using the ICAM (Incident Cause Analysis Method) method.

METHODS

This type of qualitative descriptive research uses an explanatory case study approach, which is a type of case study method used by researchers when they can no longer find or control the phenomenon being studied. So that researchers have the question "why" or "how" the phenomenon can no longer be controlled (Salma, 2023). The subject of the study was an accident case on an iron ore haul road. The object of the study was an accident incident in the period 2023. The research population was 8 accident cases in 2023. The research sample consisted of 7 DT driver aged 26-30 years and had worked for 1-3 years. The data source uses secondary data from the investigation report at PT XYZ. The instrument used is the ICAM Matrix. Data analysis uses qualitative descriptive data. To ensure the validity and reliability of research findings on accident investigation techniques at the ore haul road location at PT XYZ in 2023 using the ICAM Method, this study will use methodological triangulation by integrating the following data collection methods: Document Analysis: Review of internal accident reports, safety records, and ICAM investigation documents to collect comprehensive data on past incidents and investigation results. Using these multiple data sources, this study aims to provide a strong and comprehensive understanding of the effectiveness of the ICAM Method in accident investigation and to develop comprehensive recommendations for improving safety measures at PT XYZ. Multiple Perspectives: Triangulation allows for the incorporation of multiple perspectives from multiple stakeholders, ensuring a more balanced and nuanced analysis of the accident investigation process and outcomes.

RESULTS

Based on the results of secondary data analysis of interview results with 8 accident cases as follows:

Table 1. Informant characteristics based on secondary data from 8 cases

Characteristics Informant	Total (n=8)	Percentage (%)
Jobs		
DT Driver	**7**	**87,5**
LV Driver	1	12,5
Age		
21- 25 years old	1	12,5
26 - 30 years old	**6**	**75,0**
31 - 35 years old	1	12,5
Length of service		
<6 month	2	25,0
6-12 month	2	25,0
12-18 month	**4**	**50,0**
Shift		
Day shift	**4**	**50,0**
Night Shift	**4**	**50,0**

Based on table 1, it can be seen that 8 informants have jobs as DT drivers 87.5 and lv drivers 12.5. The age of informants tends to be between 26-30 years old by 75 and the length of work is between 12-18 years by 50. While the work shift is divided into day shift 50 and Night shift 50.

Table.2 Characteristics of ICAM (*Incident Cause Analysis Method)*

Characteristics ICAM (*Incident Cause Analysis Method)*	**Total (n=8)**	**Percentage (%)**
Absent or Failed Defenses		**22,0**
DF05- Awareness - Work Instructions/Procedures	2	25,0
DF02 Awareness - Communication	2	25,0
DF11 Control & Recovery - Procedures	1	12,5
DF04 Awareness - Supervision	**3**	**37,5**
Individual/team		20,0
IT03- Operating Speed	1	12,5
IT10- Hazard Recognation/Perception	2	25,0
IT01- Supervisory Error or Violation	2	25,0
IT12 Work Method Error or Violation	**3**	**37,5**
Environmental Factors - human		17,0
HF18- Behavioural Beliefs	1	12,5
HF01- Complacency/ Motivation/Desensitization to Hazard	2	25,0
HF04- Fatigue		
HF05- Situational Awareness	1	12,5
HF16- Experience/Knowledge/skills for task	**3**	**37,5**
	1	12,5
Workplace environment		19,0
TE02 Hazard Analysis/Job Safety Analysis/HIRAC	1	12,5
TE05- Abnormal operational situation	**2**	**25,0**

Characteristics ICAM (*Incident Cause Analysis Method)*	**Total (n=8)**	**Percentage (%)**
TE12- Routine/Non-Routine Task	**2**	**25,0**
TE22- Surface Gradient/Conditions	1	12,5
TE24- Other Factor	**2**	**25,0**
Organizational factors		**22,0**
OR- Organization	**5**	**62,5**
TR- Training	1	12,5
CO- Comunication	1	12,5
PR- Procedures	1	12,5

The assessment of ICAM characteristics in table 2 is based on the assessment of the ICAM Code Matrix *(Incident Cause Analysis Method)* as follows:

Based on table 2 ICAM characteristics and characteristics of the ICAM code matrix, the cause of the ICAM analysis that accidents at PT XYZ at the location of the ore haul road in 2023 were caused by incompetent supervision (Awareness - Supervision) as much as 37.5. work methods or violations of work methods (Work Method Error or Violation) as much as 37.5. changes in situation (Situational Awareness) as much as 37.5. The workplace environment caused by changes in the operating situation (Abnormal operational situation) as much as 25, routine/non-routine activities (Routine/Non-Routine Task) as much as 25, and other factors not in the matrix (Other Factor) as much as 25. The organizational factor (Organization) was 62.5. Overall, this study shows that inadequate supervision, incorrect work methods, low situational awareness, routine or non-routine tasks, and ineffective training are the main factors that need to be considered in efforts to improve work safety.

Table 3. ICAM *(Incident Cause Analysis Method)* Code Matrix

Absent or Failed Defenses			
Code	**Contributing Factor Types**	**Code**	**Contributing Factor Types**
DF01	Awareness - hazard identification	DF07	**Detection - aural warning systems**
DF02	Awareness – Communication	DF08	**Detection - speed/movement detectors**
DF03	Awareness - Competence / knowledge	DF09	**Detection - vigilance / fatigue**
DF04	Awareness – Supervision	DF10	**Detection - gas / substance**
DF05	Awareness - Work **Instructions/Procedures**	DF11	**Control and Recovery – procedures**
DF06	**Detection - visual warning systems**		

Individual / Team Action			
Code	**Contributing Factor Types**	**Code**	**Contributing Factor Types**
IT01	Supervisory error or violation	IT 08	**Equipment/materials handling error**
IT02	Operating authority error or violation	IT 09	**Horseplay / thrill seeking error or Violation**
IT03	Operating speed	IT10	**Hazard recognition / perception**
IT04	Equipment use error or violation	IT11	**Hazard management error or violation**
IT05	PPE use error or violation	IT12	**Work method error or violation**
IT06	Procedural compliance	IT13	**Occupational hygiene practices**

Individual / Team Action			
Code	**Contributing Factor Types**	**Code**	**Contributing Factor Types**
IT07	Change management error	IT14	**Other**

Task / Environment Conditions-Workplace			
Code	**Contributing Factor Types**	**Code**	**Contributing Factor Types**
TE01	Task Planning / Preparation / manning	TE13	Routine / non-routine task
TE02	Hazard Analysis/Job Safety Analysis /Take 5	TE14	Fire and/or explosion hazard
TE03	Work Procedures availability and suitability	TE15	Lighting
TE04	Permit to work availability and suitability	TE16	Equipment / material temperature / conditions
TE05	Abnormal operational situation/condition	TE17	Noise
TE06	Tools / equipment condition / availability	TE18	Ventilation
TE07	Materials availability and suitability	TE19	Gas, dust or fumes
TE08	Equipment integrity	TE20	Radiation
TE09	Housekeeping	TE21	Chemical
TE10	Weather conditions	TE22	Wildlife
TE11	Congestion / restriction / access	TE23	Surface Gradient/Conditions
TE12	Routine / non-routine task	TE24	Reduced/restricted visibility

Task / Environment Conditions - Human factors			
Code	**Contributing Factor Types**	**Code**	**Contributing Factor Types**
HF01	Complacency / motivation / desensitization to hazard	HF14	Personal issues
HF02	Drugs/Alcohol influence	HF15	Distraction / pre-occupation
HF03	Familiarity with task	HF16	Experience / Knowledge / Skill for task
HF04	Fatigue	HF17	Competency
HF05	Situational awareness	HF18	Behavioural beliefs (gains > risks)
HF06	Time / productivity pressures	HF19	Personality/attitude
HF07	Peer pressure / supervisory example	HF20	Poor communications
HF08	Physical capabilities	HF21	Poor shift patterns & overtime working
HF09	Mental capabilities	HF22	Passive tolerance of violations
HF10	Physical stress	HF23	Perceived license to bend the rules
HF11	Mental stress	HF24	Change of routine
HF12	Confidence level	HF25	Reliance on undocumented knowledge
HF13	Secondary goals	HF26	Other Human Factors

Organizational Factors			
Code	**Contributing Factor Types**	**Code**	**Contributing Factor Types**
HW	Hardware	RM	Risk Management
TR	Training	MC	Management of Change
OR	Organization	CM	Contractor Management
CO	Communication	OC	Organizational Culture
IG	Incompatible Goals	RI	Regulatory Influence
PR	Procedures	OL	Organizational Learning
MM	Maintenance Management	VM	Vehicle Management

Organizational Factors			
Code	**Contributing Factor Types**	**Code**	**Contributing Factor Types**
DE	Design	MS	Management Systems

DISCUSION

Based on the factor analysis of accidents at PT XYZ, the cause of the Absent or Failed Defences factor (22), especially in DF04 Awareness - Supervision (37.5), which is related to failed supervision. Supervisors of wrong actions or violations of supervision rules can result in accidents (Ye, 2018) that are currently unable to carry out supervisory duties and functions because supervisors in the field do not master the job or upgrade positions from operators to supervisors without any training in accordance with worker competencies (Jiang, W, 2020). So that many of the supervisors only carry out the role of food delivery drivers without ensuring the location of the work area, standard operating procedures and briefings are running. The appointed supervisor has not been certified in accordance with the regulations of the minerba. Analysis of organizational factors (22): Organizational factor (22), namely OR-Organization (62.5), namely the company's organization must have a commitment to implementing a work safety system and setting appropriate standards related to work safety (Wang, Y, 2021). In the organizational factor, there is no strong commitment from site management to implement corrective actions as recommended in the investigation report so that the accident is repetitive or repeated (Yufahmi et al, 2021). This includes not only work system improvements, such as technical or infrastructure improvements, but also encouraging safety behavior in the workplace (Yufahmi et al, 2021) management and related departments to ensure that recommended improvements can be implemented effectively (Sulistyowati dan Sukwika, 2022). Analysis of factor IT12 Work Method Error or Violation (37.5) based on the analysis that the procedures that have been prepared are incomplete Errors or violations of supervision (Wiegmann, D. A, 2021) and or not updated in the last 3 years according to the location of the work area currently being worked on, resulting in several violations of unsafe actions such as not using low gear on descents or on inclines using low gear to go uphill, resulting in a higher potential for accidents (Joe-Asare, 2020)

Analysis of accident occurrence factors at PT XYZ from HF05- Situational Awareness (25) That is, the perpetrators involved in accidents often fail to identify the location of the work area because they are new workers working at the mining area location so that sensitivity and knowledge do not yet understand the work process and hazards in the work area. By integrating all these aspects, companies can achieve a safer, more productive and sustainable work

environment. Limitations in obtaining accurate information from witnesses or related parties are an obstacle in the investigation process (Zulkarnaen, W, 2020). Analysis of accident occurrence factors at PT XYZ from TE05- Abnormal operational situation (25), namely changes in the design of the work site caused by road maintenance activities resulting in changes in safety designs that become unsafe such as trenches for deep drainage that cause units to fall and are not given adequate signage (Joe-Asare, T, 2021).

Analysis of accident occurrence factors at PT XYZ from TE12- Routine/Non-Routine Task (25), namely routine activities that are often done and become monotonous so that operators feel accustomed and result in indifference to field situations that have changed (Ministry of Energy and Mineral Resources, 2024).

Analysis of accident occurrence factors at PT XYZ from TE24- Other Factor (25) Witnesses or injured persons may have different perspectives on the events that occurred, and ensuring the accuracy of information from various sources is a challenge (Manpower, 2022) for example, when carrying out activities, they do not ensure that they are ready to work or joke too much in operating the vehicle.

Based on the total accidents in 2023, there were 96 incident cases at PT XYZ. PT XYZ classifies accidents into 5 classes, namely class 3 as many as 57 cases, potential class 2 as many as 36 cases, class 2 as many as 2 cases, potential class 1 as many as 0 cases and class 1 as many as 1 case. The accident trend in the ore hauling area has the potential for high accidents because it is the main activity for transportation activities from the mine to processing with extreme road conditions and inexperienced operators. Accident investigation analysis using ICAM (Incident Cause Analysis Method) on the ore haul road at PT XYZ as many as 8 cases are SPI (Serious potential incidents) and thoroughly investigate the causes of accidents, but also on their ability to produce recommendations that have a positive impact on future accident prevention efforts (Tri Handari dan Qolbi, 2021). Based on the theory (Heinrich, 1980) states that accidents caused by direct action (unsafe act/unsafe condition) contribute 70-80%. Based on the theory of the three main factors causing accidents, it emphasizes that work accidents are caused by 3 factors, namely equipment, environment and human factors. Unsafe acts according to (James Reason, 1990) are classified into several groups, namely human error and violation. Human error itself consists of several parts, namely skill-based errors, rules-based errors and knowledge-based errors. Meanwhile, violations consist of routine violations and extraordinary violations (Al., 2022). Meanwhile, for analysis on the ICAM (Incident Cause Analysis Method) Swiss cheese model is a model used to analyze risk and risk management in human systems (Furszyfer Del Rio et al., 2022).

This model includes a sequence of human failures that cause accidents or errors. It is likened to slices of Swiss cheese that are solid and side by side. This theory was proposed by British psychologist James Reason in 1990 (Health and Safety Executive United Kingdom, 2020) and utilizes adequate technology and information systems to support the investigation process and report investigation results in a more structured and efficient manner (Nwankwo, C. D, 2022). so that the benefits of this investigation technique can be maximized for occupational safety and health in the company (Putera dan Harini, 2017). Based on the ICAM (Incident Cause Analysis Method) investigation analysis, the company needs to repair the road or reduce the road grade to make it safer, be selective in the selection of labor, install signs in dangerous areas, evaluate SOPs, JSA and HIRA regularly and conduct training to all workers, supervisors are required to conduct coaching to workers who are their responsibility.

CONCLUSIONS

Factors causing accidents based on 8 cases over the past 3 years at PT XYZ using the ICAM method obtained that the dominant factor that became the cause of the accident was organizational factors (22) which triggered the largest accident was organizational factors (OR) as much as 62.5 and the missing defense factor (22) which was the most dominant trigger for the accident was DF-04 Awareness supervision which was 37.5.

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