KESANS: International Journal of Health and Science
2808-7178 / 2808-7380
http://kesans.rifainstitute.com/index.php/kesans/index

Accident Prevention Program in the Nickel Mining Facility Construction Project at the Indonesia Growth Project (IGP), Pomalaa

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Article Information
Submitted: **04 April 2026**
Accepted: **10 April 2026**
Publish: **15 April 2026**

Keyword: Occupational Safety; Workplace Accidents; OHSMS; Mine Construction; Risk Management;

Abstract
Introduction: *Construction projects in nickel mining, such as the Indonesia Growth Project (IGP) Pomalaa, involve numerous workers and high-risk activities. Safety management is often reactive and administrative, limiting its effectiveness in preventing accidents.* ***Objective:*** *To analyze the factors causing workplace accidents, describe the implementation of accident prevention programs, and evaluate their effectiveness in improving safety performance at the IGP Pomalaa construction project.* ***Method:*** *A descriptive qualitative approach was used, supported by secondary quantitative data. Data were collected through field observations, interviews with safety personnel (managers, officers, supervisors, and workers), and document reviews of safety reports, accident records, and safe work procedures. Analysis followed reduction, presentation, and conclusion drawing to provide insight into OHS management implementation.* ***Results and Discussion:*** *Key causes of workplace accidents included insufficiently specific Job Safety Analyses, unsafe worker behaviors (non-compliance with protective equipment and housekeeping), weak supervision, and safety communication misaligned with field conditions. These factors interacted to form chains of causation consistent with accident prevention theory. Strengthening risk analysis, improving safety leadership, and implementing participatory, context-specific safety programs were identified as critical to enhancing safety culture.* ***Conclusion:*** *Targeted safety programs addressing identified hazards can significantly reduce workplace accidents and improve the overall safety culture in mining construction projects.*

How to Cite **Noor Faiz Achmad, Felixtianus Eko Wismo Winarto/Accident Prevention Program in the Nickel Mining Facility Construction Project at the Indonesia Growth Project (IGP), Pomalaa/Vol. 5, No. 7, 2026**
DOI https://doi.org/10.54543/kesans.v5i7.618
e-ISSN/p-ISSN **2808-7178 / 2808-7380**
Published by **CV. Rifainstitut/KESANS: International Journal of Health and Science**

Introduction

Occupational Safety and Health (OSH) has become a critical component of construction management worldwide due to the high exposure to physical hazards, mechanical risks, and operational uncertainty inherent in construction activities. The construction sector contributes over 30% of total occupational accidents globally, with injury rates higher than many other industrial sectors (ILO, 2020). This shows that workplace accidents are not merely labor issues but also strategic concerns affecting productivity, cost efficiency, and long-term project sustainability. In developing economies, rapid infrastructure growth often surpasses the readiness of safety systems, increasing project vulnerability. In Indonesia, construction activities typically involve multiple contractors, temporary labor, and dynamic field conditions, further elevating occupational risk.

At the national level, Indonesia faces challenges in consistently implementing occupational safety standards across construction projects. Data from BPJS Ketenagakerjaan show that construction-related accidents accounted for 31.9% of all workplace accidents in 2023, with major causes including falls from height (26%), impacts from hard objects (12%), and heavy equipment incidents (9%) (BPJS Ketenagakerjaan, 2023). These statistics underscore the need for strict and structured OSH management systems. Studies by Pratama and Hidayat (2023) indicate that many projects still exhibit weak compliance with formal safety procedures, while Badan Pusat Statistik reports that construction remains among sectors with persistently high accident rates (BPS, 2022).

The risk is even higher in mining-related construction, where operational hazards extend beyond conventional civil works. Workers face structural hazards, remote-site logistics, large-scale material handling, and coordination challenges involving thousands of personnel. Susanto and Utami (2021) explain that large mining infrastructure projects often involve multiple interacting hazards, particularly where heavy machinery, excavation, and chemical processing operate concurrently. Theoretically, effective accident prevention relies on comprehensive OSH principles, including hazard identification, risk assessment, risk control, and continuous worker training. Heinrich's (1931) accident triangle suggests that systematic intervention can prevent most incidents, while Geller (2001) emphasizes behavior-based safety approaches for reducing incident frequency in high-risk industries.

One of Indonesia's major mining developments exemplifying these challenges is the Indonesia Growth Project (IGP) Pomalaa in Kolaka Regency, Southeast Sulawesi. This project involves national and international stakeholders developing a lateritic nickel processing facility using High-Pressure Acid Leach technology, projected to produce 120,000 tons of nickel and 15,000 tons of cobalt annually (PT Vale Indonesia Tbk., 2024). The project integrates tailings management, waste treatment, and environmental controls to support sustainable operations. However, advanced technology introduces additional operational risks that require highly controlled safety management. Despite its economic and technological significance, mining remains one of the sectors with the highest occupational accident risk, with incidents often caused by unsafe acts, inadequate supervision, improper personal protective equipment use, and weak adherence to safety procedures (Kementerian ESDM, 2025).

At the project level, IGP Pomalaa has implemented several safety programs, including General Induction Programs, Employee Safety Manuals, Permit to Work systems, Hazard Identification and Risk Assessment, Emergency Response Training, and

Behavior-Based Safety campaigns (PT Vale Indonesia Tbk., 2024b). Hazardous waste is also managed through the Waste Management Plan to minimize secondary risks (PT Vale Indonesia Tbk., 2024a). Nevertheless, safety performance depends not only on procedures but also on top management commitment, safety leadership, and active worker participation (Saputri *et al*., 2024). Multi-contractor environments introduce variations in work culture, labor experience, and safety understanding, challenging consistent implementation. Environmental management, including waste treatment and air emission control, also forms part of occupational risk control, linking operational safety with worker protection (PT Vale Indonesia Tbk., 2004).

Internal project data indicate that preventive systems require continuous evaluation. Recorded incidents include five minor personal injuries (N5 cases) and one low-potential environmental incident, serving as warning signals for daily operational risks. Despite formal compliance with regulations such as Government Regulation No. 50 of 2012 concerning SMK3 and Ministerial Decree No. 1827 K/30/MEM/2018 on Good Mining Practice, optimal safety system performance has not yet been achieved. Internationally, ISO 45001 emphasizes worker participation, safety culture, and continuous improvement (Bagaskara, 2022). This study examines whether accident prevention at IGP Pomalaa functions beyond administrative compliance, assessing its effectiveness in controlling risks, protecting workers, and supporting the project's zero-accident and sustainable development objectives.

Method

This study employed a project-based applied research approach using descriptive qualitative methodology because the research objective was to examine directly how accident prevention programs were implemented in an actual industrial construction environment. According to Sahir (2022), descriptive qualitative research is appropriate when the objective is to generate contextual understanding of managerial practices, technical implementation, and behavioral interaction within a real operational setting. The research was conducted in the nickel mining facility construction area of the Indonesia Growth Project Pomalaa located in Kolaka Regency, Southeast Sulawesi, Indonesia. This site was selected because it represents a large-scale strategic industrial project involving complex construction activities, multiple contractors, and high occupational risk exposure. Through this applied design, the study not only evaluated the current safety management condition but also aimed to generate practical recommendations that may strengthen accident prevention strategies in future mining construction projects.

The study was conducted during the period from December 2025 to March 2026, covering field observation, interview activities, document review, and analytical interpretation of collected findings. During this period, the researcher observed project routines, safety meetings, permit systems, and operational control procedures in order to understand the actual implementation of occupational safety systems under real working conditions. The research subjects consisted of individuals directly involved in project safety implementation, including the HSE Manager, Safety Officers or Safety Inspectors, field supervisors, and workers such as operators, technicians, and foremen from several contractor companies. Informants were selected using purposive sampling because only personnel with direct experience and operational involvement in safety implementation were considered capable of providing relevant information. This sampling technique allowed the researcher to prioritize depth of information rather than numerical representation. The object of the research specifically focused on the implementation of

accident prevention programs and occupational safety management system performance as reflected through internal SMK3 audit outcomes within the nickel mining facility construction project.

The research context also involved understanding the organizational characteristics of the companies operating within the project. The construction activities examined were carried out under collaboration between PT Vale Indonesia Tbk. and PT Leighton Contractors Indonesia as part of the Indonesia Growth Project Pomalaa industrial development program. As a large-scale nickel facility construction project, this environment presents high-risk operational characteristics involving heavy equipment, hazardous materials, open construction zones, and mechanical installation works. Consequently, effective occupational safety and health management becomes essential not only to protect workers but also to maintain operational continuity. At the project level, several safety systems have already been implemented, including HIRADC for high-risk activities, mandatory personal protective equipment use, hazard signage installation, daily toolbox meetings, safe work permit systems, and emergency response readiness through Fire Emergency Services teams. However, preliminary observation also identified several challenges, including fluctuating worker compliance, limited supervision coverage across wide work areas, incomplete incident digitalization, and low worker participation in hazard reporting.

To ensure analytical clarity, the operational focus of this study was defined through twelve major elements of occupational safety management implementation derived from the national SMK3 framework. These elements were used to guide field observation, interview construction, and document analysis so that findings could be systematically interpreted. The operational framework is showed in Table 1.

Table 1
Operational Definition

Unit of Analysis	Operational Definition	Indicators
Implementation of Occupational Safety and Health Management System (SMK3)	The process of planning, implementing, monitoring, and improving occupational safety and health systems in construction projects according to established standards	(a) Commitment development and maintenance; (b) Preparation and documentation of safety plans; (c) Contract control, design, and review; (d) Document control; (e) Procurement and product control; (f) Safe working practices; (g) Monitoring standards; (h) Reporting and corrective action; (i) Material handling and lifting management; (j) Data collection and utilization; (k) SMK3 inspection; (l) Skill and competency development

The success indicators were further interpreted through evidence such as reduction of incidents and near misses, internal and external audit compliance, systematic monthly safety reporting, and active worker participation in safety programs showd through attendance records and documented engagement. In this study, safety success was not

interpreted merely from documentation completeness but also from the emergence of sustainable safe work culture in daily project operations.

In qualitative research, the researcher served as the primary instrument because data interpretation required direct interaction with field realities, social behavior, and managerial processes. However, several supporting instruments were also used to improve data consistency and traceability. Semi-structured interview guides were prepared using open exploratory questions aligned with SMK3 indicators in order to obtain in-depth perspectives from informants regarding practical safety implementation. Observation sheets were used to record field situations such as personal protective equipment usage, procedure supervision, toolbox meetings, and worker compliance during operational tasks. Documentation review sheets were also used to examine internal project records including safety policy documents, risk assessment reports, training needs analysis, training schedules, safe work permits, audit reports, incident alerts, and emergency response procedures. The combination of interviews, observation, and documentation created methodological triangulation that improved the credibility of findings.

The research process was implemented through several structured stages beginning with preliminary problem identification through initial field observation, early interviews, and literature review. After defining the research focus, the researcher prepared data collection instruments based on project conditions and SMK3 indicators. Data collection was then conducted directly at the project site using triangulation methods involving interviews with project managers, HSE officers, supervisors, and workers, direct observation of field practices, and review of supporting documents such as risk assessments, standard operating procedures, and internal audit reports. After collection, data were reduced and organized into thematic categories to simplify analytical interpretation. The analysis followed the Miles and Huberman approach consisting of data reduction, data display, and conclusion drawing, enabling identification of recurring patterns across interviews, observations, and documentation. Conclusions and recommendations were formulated to evaluate the effectiveness of accident prevention programs and to propose applicable improvements for strengthening occupational safety performance in the IGP Pomalaa project environment.

Results and Discussion

1. Result

Occupational Safety and Health Management System (SMK3) Audit Performance

The Occupational Safety and Health Management System (SMK3) audit at the Indonesia Growth Project Pomalaa was conducted using the twelve audit elements established under Government Regulation No. 50 of 2012. The audit applied a checklist-based evaluation covering 166 sub-criteria distributed across all SMK3 elements. Compliance was calculated using the percentage of fulfilled criteria relative to total assessed criteria. Audit findings were classified into three categories: conforming, minor non-conformity, and major non-conformity. Minor findings show limited deviations without immediate accident potential, whereas major findings represent significant deviations requiring corrective action.

The audit result showed that 140 out of 166 criteria (84.34%) were fulfilled, while 26 criteria (15.66%) remained non-conforming, consisting of 20 minor findings and 6 major findings. This showsthat SMK3 implementation at the project has reached a generally good level, although several areas still require systematic improvement. Three

audit elements achieved full compliance (100%), namely contract design and review control, purchasing and product control, and internal SMK3 inspection. Meanwhile, document control and competency development recorded the lowest fulfillment rates, indicating weaknesses in administrative consistency and training sustainability. The element with the highest number of criteria was work safety implementation under SMK3, which contained 41 sub-elements and still generated four findings requiring follow-up.

Table 2
SMK3 Audit Results

No	Audit Element	Criteria	Fulfilled (%)	Minor	Major	Non-Conformity (%)
1	Commitment Development and Maintenance	26	88.46	2	1	11.54
2	Safety Planning and Documentation	14	78.57	2	1	21.43
3	Design Control and Contract Review	8	100	0	0	0
4	Document Control	7	71.43	2	0	28.57
5	Purchasing and Product Control	9	100	0	0	0
6	Safe Work Practices under SMK3	41	90.24	3	1	9.76
7	Monitoring Standards	17	76.47	3	1	23.53
8	Reporting and Corrective Action	9	77.78	2	0	22.22
9	Material Handling and Movement	12	75.00	2	1	25.00
10	Data Collection and Use	6	83.33	1	0	16.67
11	SMK3 Inspection	3	100	0	0	0
12	Skill and Competency Development	14	71.43	3	1	28.57
Total	12 Elements	166	84.34	20	6	15.66

A more detailed review of the audit records shows that strong performance was found in formal safety commitment, contract safety integration, procurement verification, and internal inspection mechanisms. Written safety policies were available, regularly reviewed, and supported by monthly HSE reporting systems. Contractor and vendor management also showd strong compliance because safety requirements had already been embedded in procurement specifications, technical reviews, and supplier qualification procedures. In addition, internal audit activities were conducted periodically by certified safety personnel, ensuring that audit findings were formally distributed and monitored.

However, several non-conformities remain important. In document control, outdated revisions and incomplete update distribution were still found in several operational records. In competency development, annual training needs analysis existed, but not all training programs were fully aligned with field hazard priorities. Major findings were also identified in manual SMK3 updating, hazardous chemical labeling, and environmental monitoring coverage. Specifically, some environmental monitoring parameters had not yet comprehensively covered physical, chemical, biological, ergonomic, and psychosocial exposure dimensions. Similar implementation gaps in mining-related occupational safety systems have been reported in previous industrial

safety evaluations where documentation maturity often develops slower than operational control performance (Sahir, 2022).

At the operational level, the strongest implementation appeared in work permit systems, PPE availability, equipment certification, hazard signage, emergency preparedness, and maintenance scheduling. Nevertheless, supervision consistency remains an issue, especially in ensuring corrective actions are closed promptly after inspections. Several minor findings also emerged in emergency simulation documentation and worker consultation dissemination. Although these findings do not immediately threaten project safety, they may reduce long-term system reliability if not continuously improved.

Implementation of Occupational Safety, Health, and Environmental Accident Prevention Programs

The accident prevention program implemented at the Indonesia Growth Project Pomalaa shows a structured Occupational Safety, Health, and Environment (K3L) management approach adapted to the high-risk characteristics of nickel mining facility construction. The project has established multiple preventive mechanisms that combine permit control, hazard assessment, worker competency development, operational supervision, and emergency preparedness. These programs are integrated into daily field activities and supported by both management and contractor participation. Field observations showed that most preventive activities are already institutionalized in routine project operations, although implementation quality varies across programs. Some systems function effectively at the procedural level but still face delays, inconsistency, or limited worker engagement during practical execution.

Table 3
Main Accident Prevention Programs at IGP Pomalaa

No	Program	Current Implementation	Main Improvement Needed
1	Safe Work Permit (SWP)	Applied for hot work, confined space, height work, and energy isolation	Permit digitalization and field verification
2	Risk Assessment (HIRAC/IBPR)	Available for routine work, weaker in non-routine activities	Standardized risk assessment library
3	Job Safety Analysis (JSA)	Conducted before work, but quality inconsistent	More specific and visual JSA format
4	Safety Training	Induction and technical safety training implemented regularly	Training needs analysis update
5	Management of Change (MOC)	Applied for design and method changes	Simplified reporting for minor changes
6	Stop Work Authority (SWA)	Policy available, limited practical use	Strengthen reporting culture
7	Daily Toolbox Meeting	Highly consistent and widely accepted	More varied and task-specific content
8	Safety Inspection and CAPA	Routine inspections conducted	Faster corrective-action closure
9	Emergency Drill	Fire and emergency drills implemented	More regular subcontractor participation

Among all programs, the Safe Work Permit system remains one of the strongest operational controls because it is mandatory for all high-risk activities, including hot work, confined space entry, lifting operations, and work at height. Permit documents

already include hazard identification, required personal protective equipment, and supervisor authorization before work begins. However, field observation identified delays during peak working hours, particularly when multiple permits were processed simultaneously. In several cases, generic permit forms did not fully reflect task-specific hazards, especially during non-routine activities.

Risk assessment and Job Safety Analysis are also routinely used before work execution. Hazard Identification, Risk Assessment, and Control (HIRAC) documents are available for most standard construction activities, using a 5×5 probability-severity matrix to classify risk levels. Nevertheless, non-routine work often leads to rapidly prepared assessments with limited field detail. Similar limitations were observed in JSA preparation, where some documents remained too general and did not adequately describe actual hazards present during execution. Despite this, supervisors and workers generally understand the procedural requirement, indicating that the main issue lies in document quality rather than acceptance of the system itself.

The most consistently implemented program identified by respondents was the daily toolbox meeting. This activity takes place before each work shift and is led by supervisors to discuss daily hazards, planned tasks, recent incidents, and required protective equipment. Workers considered toolbox meetings the most effective communication channel because they directly connect safety messages with immediate field conditions. Attendance records were consistently maintained, and participation was high across work groups. However, repeated content and insufficient adaptation to specific daily tasks were still observed, indicating the need for more dynamic communication methods.

Behavior-based programs such as Stop Work Authority and Management of Change remain less mature compared with procedural controls. Although every worker formally has the authority to stop unsafe work, practical application is still influenced by hierarchical hesitation, particularly among subcontractor personnel. A similar pattern was observed in Management of Change procedures, where major changes were documented, but smaller operational adjustments were not always formally reported. This shows that cultural safety maturity has not yet fully reached proactive worker behavior. Strengthening positive reinforcement, supervisor response, and practical simplification may improve participation in both systems.

Emergency preparedness and safety inspection systems are functioning but still show uneven consistency. Emergency drills covering fire response, chemical spills, evacuation, and first aid are conducted periodically, yet subcontractor participation is not always complete. Safety inspections are performed using standardized checklists, and findings are recorded through corrective and preventive action mechanisms. However, some corrective actions remain open beyond target deadlines, especially in wide operational zones.

Questionnaire Based Evaluation of K3L Program Effectiveness

The effectiveness of Occupational Safety, Health, and Environmental (K3L) programs at the Indonesia Growth Project Pomalaa was assessed using a five-point Likert scale to capture worker perceptions regarding field implementation. The scoring system classified effectiveness into five categories ranging from very ineffective to very effective.

Table 4
Effectiveness Score Classification

Score	Response	Category	Mean Range
5	Strongly Agree	Very Effective	4.21-5.00
4	Agree	Effective	3.41-4.20
3	Less Agree	Moderately Effective	2.61-3.40
2	Disagree	Ineffective	1.81-2.60
1	Strongly Disagree	Very Ineffective	1.00-1.80

This classification was consistently applied to interpr*et al*l questionnaire results and determine the perceived performance of each safety program.

Table 5
Questionnaire Results (n = 20)

Program Aspect	Mean Score	Category
Overall K3L consistency	4.05	Effective
Safe Work Permit (SWP)	4.00	Effective
Risk Assessment	3.70	Effective
Job Safety Analysis (JSA)	3.65	Effective
Training and Development	3.90	Effective
Management of Change (MOC)	3.50	Moderately Effective
Stop Work Authority (SWA)	3.90	Effective
Daily Toolbox Meeting	4.25	Very Effective
Near-miss reporting	3.55	Moderately Effective
Overall accident prevention	3.95	Effective
Overall Mean Score	3.85	Effective

The overall effectiveness score of 3.85 showsthat the K3L program is generally perceived as effective by field workers. Daily toolbox meetings obtained the highest score (4.25), making them the strongest component of the current safety system. Respondents showd that direct daily communication before work begins provides immediate relevance because hazards discussed are directly related to planned tasks. Supervisor presence during these meetings also increases worker attention and understanding. Safe Work Permit implementation and overall safety consistency also received strong evaluations, indicating that procedural controls are functioning reliably in routine project activities. Stop Work Authority was rated positively, suggesting that workers understand their right to stop unsafe work, although practical use remains influenced by field hierarchy. The lowest scores were found in Management of Change and near-miss reporting. These findings suggest that procedural awareness related to operational changes and proactive hazard reporting remain weaker compared with daily operational controls. Limited reporting culture and concern about negative consequences still affect worker willingness to report unsafe conditions. This showsthat behavioral safety maturity remains an important area for further improvement.

Occupational Accident Data and Causal Analysis

During the observation period (December 2025-March 2026), five occupational incidents were recorded at the project site. All cases were classified as First Aid Cases (FAC), with no Lost Time Injury, Medical Treatment Case, or fatal accident reported during the study period.

Table 6
Recorded Occupational Accidents

Date	Work Area	Accident Type	Immediate Cause	Main Root Cause
14 Dec	Welding workshop	Minor burn	Welding spark contact	Incomplete JSA and PPE non-compliance
27 Dec	Steel erection area	Minor cut	Sharp steel edge contact	Lack of arm protection
9 Jan	Pipe rack installation	Muscle strain	Manual lifting posture	No ergonomic briefing
18 Jan	Civil foundation area	Foot injury	Nail stepped on	Poor housekeeping
5 Feb	Pump installation area	Hand pinch injury	Alignment process	Generic JSA and poor coordination

Although all incidents were minor, repeated patterns reveal important weaknesses in field-level safety control. Most incidents were directly associated with incomplete hazard anticipation and inconsistent application of preventive measures. Three dominant patterns emerged from accident analysis. First, unsafe acts were identified in several cases, particularly involving incomplete personal protective equipment use and unsafe work habits. Second, Job Safety Analysis quality was insufficient in most cases because documents were often too generic and failed to identify specific hazards such as pinch points, sparks, sharp edges, or manual handling risks. Third, communication gaps during task execution contributed to incidents where workers lacked clear coordination during shared activities.

Supervisory inconsistency also appeared as an important contributing factor. In several cases, PPE verification and end-of-task safety checks were not fully conducted before work started or after work ended. This showsthat existing safety systems are present procedurally but not always reinforced consistently in real field execution. Using Herbert William Heinrich domino theory and James Reason Swiss Cheese Model concepts, these incidents can be interpreted as failures across multiple defensive layers occurring simultaneously. In each case, accident occurrence was not caused by a single unsafe act alone, but by the combined failure of hazard identification, briefing quality, supervision, and behavioral control. If one protective layer had functioned properly, the incident could likely have been prevented.

Analysis of Contributing Factors, Impacts, and Improvement Actions Based on SMK3 Elements

Based on the SMK3 audit findings and accident causation analysis, several non-conformities were identified across key safety management elements at the Indonesia Growth Project Pomalaa. These findings show that the main weaknesses are not located in the absence of safety procedures, but rather in implementation consistency, documentation quality, worker participation, and competency control. The observed gaps directly influence field-level accident prevention performance and therefore require targeted preventive and corrective responses.

Table 7
Main Non-Conformity Analysis by SMK3 Element

SMK3 Element	Main Gap Identified	Safety Impact	Recommended Improvement
Worker involvement and consultation	No structured routine consultation forum	Limited safety communication to field workers	Appoint safety representatives in each work zone
Annual and monthly safety planning	Safety plans not fully communicated to contractors	Program targets not fully implemented	Integrate safety plans into contractor induction
Document control	SWP and JSA numbering incomplete	Risk of outdated document use	Digital document control system
JSA and permit execution	JSA often generic; SWP delayed	Contributed to minor incidents	HSE verification before permit approval
Routine inspection	Uneven inspection frequency	Unsafe conditions remain undetected	Zone-based inspection schedule
Near-miss reporting	Low reporting participation	Learning opportunities lost	QR-based simple reporting system
Material handling control	Incomplete operator certification	Lifting risk remains significant	Mandatory certification verification
Training and competency	Training needs analysis not regularly updated	Uneven worker competence	Six-month competency review

Three dominant root factors explain most implementation gaps. First, documentation and administrative systems remain partially manual, making document control slower and less reliable. Second, worker participation in proactive safety systems such as hazard reporting remains limited because reporting culture is not yet fully internalized. Third, technical competency for special-risk activities still varies among contractors and subcontractors, especially in lifting operations and task-specific hazard recognition. These three factors interact across multiple SMK3 elements, meaning that weaknesses in one area often amplify vulnerability in others. For example, incomplete documentation affects permit quality, while limited competency reduces the practical effectiveness of otherwise adequate procedures.

Recommended K3L Improvement Programs

Based on integrated findings from audit results, questionnaire responses, and accident pattern analysis, six priority improvement programs were formulated as strategic recommendations for strengthening accident prevention performance in mining facility construction projects.

Table 8
Priority Improvement Programs

Recommended Program	Main Rationale	Target Outcome	Responsible Unit
Digital Safety Management System (DSMS)	Manual document control remains inefficient	Full digital SWP, JSA, HIRAC within 6 months	HSE Manager & IT Unit
Safety Leadership Training	Supervisor influence affects weak MOC and reporting	All supervisors trained within 3 months	Training Unit & Project Manager
Hazard Reporting Reward Program	Near-miss reporting remains low	50% reporting increase in 3 months	HSE Officer
Visual JSA Improvement	Generic JSA linked to FAC cases	Visual JSA for all high-risk work	HSE Supervisor
Competency Certification Program	Special work skills uneven	100% certified operators and riggers	Training Department
Safety Culture Maturity Program	Behavioral safety still reactive	Shift from calculative to proactive culture	Project Director & HSE Manager

Among these recommendations, the Digital Safety Management System represents the most systemic intervention because it directly addresses several weaknesses simultaneously, including document control, permit speed, hazard traceability, and audit readiness. By digitalizing Safe Work Permit, JSA, and HIRAC processes, administrative delays can be reduced while improving document accuracy. Safety Leadership Training is equally important because several weak-performing programs-particularly Management of Change and near-miss reporting are strongly influenced by supervisor behavior in daily field control. Leadership quality determines whether safety procedures remain administrative or become operational.

The Visual JSA Improvement Program directly responds to the five recorded First Aid Cases, where hazard identification repeatedly failed to capture task-specific exposure. Visual formats are expected to improve worker comprehension, especially in multi-contractor environments where literacy levels and practical interpretation vary. The broader behavioral transformation is addressed through the Safety Culture Maturity Program based on E. Scott Geller Behavior-Based Safety principles, which emphasize active worker engagement, peer observation, and proactive hazard recognition. This approach aims to shift safety practice from compliance-based behavior toward internalized preventive culture.

2. Discussion

The results of this study show that the Occupational Health, Safety, and Environmental (K3L) system implementation at the Indonesia Growth Project Pomalaa, operated by PT Vale Indonesia Tbk, has achieved a relatively high level of compliance, with SMK3 fulfillment reaching 84.34% and an overall program effectiveness score of 3.85 (Effective). Despite this, gaps remain that must be addressed to achieve the company's zero-accident target. The five recorded First Aid Cases (FAC) revealed a pattern of systemic weaknesses, particularly the lack of synergy between supervisors, workers, and procedural systems. Supervisors failed to verify personal protective equipment (PPE), workers did not fully follow established procedures, and Job Safety Analyses (JSA) were often too generic to capture specific hazards. These findings align with Fauzi *et al*. (2024), who emphasized that successful K3 implementation in large-

scale projects requires integrated collaboration between management, field supervisors, and workers. The persistence of these minor incidents shows that even high compliance scores cannot fully prevent accidents if operational execution is inconsistent.

Further, this study corroborates Muhammad and Susilowati (2021), who reported that safety implementation in Indonesia often emphasizes administrative compliance over behavioral change. Evidence from the questionnaire supports this claim, as low scores for Management of Change (MOC = 3.50) and near-miss reporting (3.55) show a significant gap between written procedures (paper compliance) and actual field practices (field compliance). The results suggest that formal documentation alone does not ensure effective risk mitigation if workers and supervisors do not internalize safety principles. This gap is particularly critical in mining construction environments, where small deviations from procedure can result in serious incidents

The Behavior-Based Safety (BBS) approach proposed in this study is supported by Geller (2001) and Sukma & Sanuddin (2025), who argue that behavior-focused supervision can significantly reduce near-miss events by increasing workers' hazard awareness and proactive risk management. The recommended Safety Culture Maturity Program, anchored in BBS principles, is expected to catalyze the transformation of K3L culture at the IGP Pomalaa project from reactive to proactive. By integrating BBS into daily operations, workers are encouraged to take ownership of safety, report hazards without fear, and reinforce safe behaviors consistently. This approach complements administrative systems such as DSMS and JSA by addressing human factors-the layer most susceptible to failure in construction safety management. Moreover, BBS fosters continuous learning and reinforcement, which can enhance the long-term sustainability of the safety culture.

From the perspective of Reason's Swiss Cheese Model (1990), interventions such as the Digital Safety Management System (DSMS) and Visual JSA Improvement are designed to strengthen system layers and prevent alignment of weaknesses that could allow accidents to occur. Meanwhile, the Safety Leadership Training program focuses on enhancing human defenses, which are the most critical yet vulnerable layer in mining construction K3L systems. Together, these programs create complementary layers of defense-administrative, behavioral, and supervisory designed to close gaps identified during the audit and accident analysis. By combining procedural rigor, technological support, and proactive behavioral reinforcement, the project can reduce the likelihood of incidents and move closer to its zero-accident goal.

Conclusion

The study identifies that workplace accidents at the IGP Pomalaa project are primarily caused by insufficiently specific Job Safety Analyses, unsafe worker behaviors, weak supervision, and limited alignment of safety communication with actual field conditions, forming chains of causation consistent with the Swiss Cheese Model. Although the project has established a comprehensive K3L system, gaps remain between formal compliance and effective field implementation, particularly in areas such as skills development, hazard observation, and near-miss reporting.

These findings show the critical importance of strengthening occupational health and safety management beyond administrative procedures. Effective accident prevention requires enhancing supervisory leadership, promoting proactive safety culture, and integrating participatory, context-specific programs that engage workers in risk identification and control. Implementing digital safety tools, competency verification,

behavior-based safety initiatives, and continuous training can transform the K3L system from a compliance-driven framework into an effective, proactive risk management and worker protection strategy.

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