HEURISTIC
Vol. 23, No. 1, April 2026
ISSN(p) 1693-8232
ISSN(e) 2723-1585

Mechanical Work Occupational Safety Risk Analysis Using JSA and HIRARC at PT ABB

Fannisha Aura Rifqo[1]*, Bintang Nidia Kusuma[2], Muhammad Ali Akbar[3]
[1, 2]Sekolah Tinggi Teknologi Wastukancana Purwakarta

***Corresponding Author**: fannisha2001@gmail.com

Article history:
Received: 9 July 2026
Accepted: 20 July 2026
Published: 28 July 2026

Keywords:
HIRARC;
JSA;
Mechanical Work;
Occupational Safety;
Work Risk

ABSTRACT

This study aims to identify potential hazards, assess occupational safety risks, and develop safety improvement recommendations for mechanical work at PT Arasindo Bina Bersama using the Job Safety Analysis (JSA) and Hazard Identification, Risk Assessment, and Risk Control (HIRARC) methods. This study employed qualitative and quantitative approaches through field observations, interviews, and documentation. JSA was used to identify potential hazards at each stage of the work process, while HIRARC was applied to assess risk levels and determine appropriate control measures based on the hierarchy of controls. The results identified three critical mechanical activities, namely hydraulic hose and pipe installation, axle component dismantling and installation, and hydraulic pipe and hose assembly, with a total of 26 identified hazards. The HIRARC risk assessment classified the hazards into 1 Very High Risk, 4 High Risk, 18 Medium Risk, and 3 Low Risk categories. Hazards classified as Very High Risk and High Risk were prioritized for immediate implementation of control measures. Meanwhile, Medium Risk hazards required additional controls to reduce the level of risk, whereas Low Risk hazards only required periodic monitoring. Safety improvement recommendations were developed based on the hierarchy of controls, including elimination, substitution, engineering controls, administrative controls, and personal protective equipment. This study demonstrates that the integration of JSA and HIRARC provides a systematic approach to hazard identification, risk prioritization, and the development of effective control strategies to improve occupational safety and promote a sustainable occupational health and safety culture.

INTRODUCTION

The rapid growth of industrial activities has increased the complexity of work processes involving workers, machinery, equipment, materials, and the working environment. As industrial operations become more complex, the potential for occupational hazards also increases, leading to a higher risk of workplace accidents if hazards are not systematically identified and controlled [1]. Mechanical work is considered one of the most hazardous industrial activities because it involves material handling, mechanical equipment operation, hydraulic systems, and the installation or dismantling of heavy equipment components. These activities expose workers to various hazards, including being struck by falling objects, caught between moving components,

falls from elevation, eye injuries, cuts from hand tools, and work-related musculoskeletal disorders [2], [3], [4]. Therefore, implementing Occupational Safety and Health (OSH) through hazard identification, risk assessment, and risk control is essential to minimizing workplace accidents while improving operational reliability and productivity [5], [6], [7].

A systematic risk management approach is required to identify hazards and evaluate risks throughout each stage of mechanical work. Among the available methods, Job Safety Analysis (JSA) is widely applied to identify potential hazards by breaking work activities into sequential tasks, allowing hazards to be recognized before accidents occur [8], [9]. Meanwhile, HIRARC provides a structured framework for evaluating risk levels based on the likelihood and severity of hazards and determining appropriate control measures [10], [11], [12]. The integration of JSA and HIRARC enables organizations to understand the relationship between work activities, hazard sources, and risk levels comprehensively, thereby supporting more effective decision-making in occupational risk management [13], [14].

Previous studies have demonstrated that the integration of JSA and HIRARC has been successfully applied in various industrial sectors, including civil and electrical departments, fabrication workshops, manufacturing processes, construction projects, and pipeline installation activities to identify workplace hazards and assess occupational risks [4], [10], [11], [15], [16], [17]. These studies consistently showed that the combined application of both methods effectively supports hazard identification, risk assessment, and the development of occupational safety measures. However, the majority of previous studies were conducted in general manufacturing, fabrication, construction, or pipeline installation environments, with limited attention given to mechanical work involving hydraulic systems and heavy equipment components. Moreover, most studies primarily emphasized hazard identification and risk classification, whereas the prioritization of risk control measures based on the Hierarchy of Controls has not been comprehensively addressed [2], [7], [18]. Therefore, practical guidance for establishing risk control priorities in mechanical work activities, particularly hydraulic hose and pipe installation, axle component dismantling and installation, and hydraulic pipe and hose assembly, remains insufficient.

PT Arasindo Bina Bersama performs various mechanical activities involving hydraulic systems and heavy equipment components, where each stage of the work process presents different hazard characteristics and risk levels. Although previous studies have demonstrated the effectiveness of integrating JSA and HIRARC in various industrial settings, limited evidence is available regarding their application for establishing prioritized risk control strategies in these specific mechanical activities. Consequently, it remains unclear which work activities present the highest occupational risks and how appropriate control priorities should be established to improve workplace safety. Therefore, this study integrates Job Safety Analysis (JSA) and Hazard Identification, Risk Assessment, and Risk Control (HIRARC) to identify potential hazards, assess occupational safety risks, and develop prioritized safety improvement recommendations based on the Hierarchy of Controls for mechanical work at PT Arasindo Bina Bersama [19], [20], [21].

The findings of this study are expected to provide a practical framework for prioritizing occupational risk control in mechanical work involving hydraulic systems and heavy equipment components. By integrating hazard identification, risk assessment, and risk control prioritization within a single framework, this study contributes to more effective occupational safety decision-making and supports the implementation of appropriate control measures based on the Hierarchy of Controls. Furthermore, the

proposed approach may serve as a reference for future studies on integrated occupational risk assessment in mechanical work environments [2], [12], [17].

MATERIALS AND METHODS

This study employed a mixed-methods approach by combining qualitative and quantitative analyses to identify occupational hazards, assess risk levels, and develop risk control recommendations for mechanical work activities at PT Arasindo Bina Bersama. The research focused on three mechanical work activities, namely hydraulic hose and pipe installation, axle dismantling and installation, and hydraulic pipe and hose assembly. Qualitative analysis was used to identify work activities, potential hazards, and existing control measures, whereas quantitative analysis was applied to determine the likelihood, severity, and risk level of each identified hazard using the HIRARC method.

Data were collected through direct observations, structured interviews with supervisors and experienced mechanics, field documentation and company documents. The research instruments consisted of JSA worksheets, HIRARC assessment forms, the risk assessment matrix, and the Hierarchy of Controls framework.

The research began with a preliminary study to determine the scope of the mechanical work activities, followed by field observations to understand the work process. Each activity was then broken down into sequential work steps using the JSA approach to facilitate systematic hazard identification. Potential hazards, possible consequences, existing control measures, likelihood, and severity were recorded using standardized JSA and HIRARC assessment forms. Risk values were subsequently calculated using the risk assessment matrix and classified into Very High Risk, High Risk, Medium Risk, and Low Risk categories. Based on the obtained risk level, appropriate control measures were developed according to the Hierarchy of Controls.

The collected data were analyzed to evaluate occupational hazards and determine the corresponding level of risk for each work activity. Risk scores were obtained by multiplying the likelihood and severity values for every identified hazard and were subsequently classified according to the established risk matrix. Hazards categorized as Very High Risk and High Risk would receive the highest priority for corrective actions, while Medium Risk hazards would require additional risk reduction measures and Low Risk hazards would be monitored periodically to maintain an acceptable level of risk.

Finally, risk control recommendations were formulated by applying the Hierarchy of Controls, including elimination, substitution, engineering controls, administrative controls, and personal protective equipment. The proposed control measures were developed according to the priority of each risk category to provide practical recommendations for improving occupational safety during mechanical work activities. The overall methodology provides a systematic and reproducible framework that can be applied to similar mechanical work environments.

RESULTS AND DISCUSSIONS

Results

1. Identification of Work Activities

This study focused on three major work activities performed in the Mechanical Department of PT ABB: Hydraulic Hose and Pipe Installation, Axle Component Dismantling and Installation, and Hydraulic Pipe and Hose Assembly. These activities were selected because they involve high-risk operations requiring interaction between

workers, equipment, materials, and the work environment, thereby increasing the potential for occupational accidents.

The identification of work activities served as the initial stage for understanding the overall work process before conducting potential hazard identification using the JSA and HIRARC methods.

2. Work analysis using Job Safety Analysis (JSA)

JSA was performed by breaking down each work activity into sequential job steps to systematically identify hazards associated with every stage of the operation. The analysis included the identification of work activities, job breakdown, potential hazards, possible consequences, and existing control measures.

This systematic breakdown enabled hazards to be identified at each stage of the work process before conducting risk assessment. The detailed JSA results for Hydraulic Hose and Pipe Installation, Axle Component Dismantling and Installation, and Hydraulic Pipe and Hose Assembly are presented in Tables 1–3.

Table 1. JSA Hydraulic Hose and Pipe System Installation Work

No	Job Steps	Potential Hazards	Impact/Risk	Control Measures
1	Preparation of pipes, hoses, and materials	Leakage or failure of the hydraulic system due to equipment damage/ non-conformance to specifications	Burns, eye injuries, and skin injection	Ensure all pipes, hoses, and materials comply with standard specifications and conduct inspections before use.
2	Lifting of pipes, hoses, and materials	Unrecommended material lifting load	Back and waist muscle injuries	Use proper lifting techniques, avoid unsafe working postures, and perform lifting according to the worker's capacity.
3	Preparation of work tools	Non-standard or damaged tools (wrenches)	Hand bone fractures and joint dislocation	Use tools that comply with standards and are in good condition, and pay attention to hand positioning while orking.
4	Installation of hoses and pipes	a. Non standard/damaged tools	Pinched	Use work tools according to standards, check tool conditions before use, and keep hands away from pinch points.
		b. Not using an appropriate ladder	Falls	Use a proper, stable, and standard-compliant work ladder.
		c. Not using a safety body harness	Falls	Use a safety body harness correctly and ensure the anchorage point is secure before working.

No	Job Steps	Potential Hazards	Impact/Risk	Control Measures
5	Testing of the hydraulic system (tipping hydraulic)	Power pack malfunctioning	Fractures and impact injuries	Ensure the power pack is functioning properly before use and perform routine equipment inspections.
6	*Housekeeping (cleaning of the work area)*	a. Messy work area	Tripping	Clean the work area after tasks are completed and keep the work area tidy.
		b. Oil-contaminated waste	Slipping	Clean up oil spills immediately using the provided sawdust and dispose of the waste into the appropriate container according to procedures.

Table 2. JSA Dismantling and Installation of Axle Components

No	Job Steps	Potential Hazards	Impact/Risk	Control Measures
1	Preparation of axle components	Unrecommended material lifting load	Back and waist muscle injuries	Avoid unergonomic working postures and limit the maximum lifting load to 20–25 kg; if it exceeds this limit, the use of lifting assistive devices is mandatory.
2	Preparation of work tools	Non-standard or damaged tools (wrenches)	Hand bone fractures and joint dislocation	Use tools that comply with standards and are in good condition, and pay attention to hand positioning while working.
3	Disassembly and installation of axle	a. Non - standard/damaged tools	Pinched	Use work tools according to Standards and keep hands away from pinch points.
		b. Errors in the disassembly/installation process	Crushed / Struck by	Perform disassembly and installation carefully in accordance with applicable work procedures.
4	Housekeeping (cleaning of the work area)	a. Messy work area	Tripping	Clean the work area after tasks are completed and keep the work area tidy.
		b. Oil/lubricant-contaminated waste	Slipping	Clean up oil/lubricant spills immediately using the provided sawdust and dispose of the waste into the appropriate container according to applicable procedures.

Table 3. JSA Hydraulic Pipe and Hose Assembly Work

No	Job Steps	Potential Hazards	Impact/Risk	Control Measures
1	Preparation of work tools	Non-standard or damaged tools	Hand bone fractures and joint dislocation	Use tools that comply with standards and are in good condition, and pay attention to hand positioning while working.
2	Lifting of materials	a. Unrecommended material lifting load	Back and waist muscle injuries	Use proper lifting technique and avoid unsafe working postures.
		b. Material falling / Struck by material	Crushed / Struck by	Use safety gloves and ensure a secure grip on materials during lifting.
3	Cutting of pipes and hoses	a. Damaged cutting equipment (cutting wheel)	Burns	Perform routine equipment inspections and ensure tools are in proper working condition.
		b. Not using PPE	Burns	Use PPE such as face shields or safety glasses, heat-resistant gloves, aprons, and hearing protection.
		c. Fire extinguisher (APAR) unavailable	Burns	Provide a fire extinguisher (APAR) in the work area, install a fire blanket, and keep flammable materials away.
4	Hose and pipe crimping process	Crimping machine malfunctioning	Pinched	Ensure the crimping machine is in good condition, pay attention to hand positioning near pinch points, and use PPE.
5	Pipe flushing	Not using PPE properly	Eye injuries	Use safety glasses and masks, and direct the airflow to a safe area.
6	Pipe painting	Not using PPE properly	Eye injuries	Use safety gloves, masks, and safety glasses.
7	Housekeeping (cleaning of the work area)	a. Messy/dirty work area	Tripping	Clean the work area after tasks are completed.
		b. Oil/lubricant-contaminated waste	Slipping	Dispose of waste into hazardous waste (B3) containers according to procedures and clean up oil spills immediately using the provided sawdust.

3. Risk Assessment Using the HIRARC Method

Following potential hazard identification through the JSA, each identified potential hazard was evaluated using the HIRARC risk assessment method. Risk levels were determined by combining Likelihood and Severity scores based on the risk matrix to classify each hazard into Low, Medium, High, or Very High Risk categories. The risk assessment results provide the basis for determining control priorities. The complete risk assessment results are presented in Table 4.

Table 4. Risk Level Assessment Using the HIRARC Method

Activity	Job Steps	Potential Hazards	Code	Risk	L	S	Risk Value	Risk Matrix
Hydraulic Hose and Pipe System Installation	Preparation of pipes, hoses, and materials	Leakage or failure of the hydraulic system due to equipment damage/non-conformance to specifications	A1	Burns, eye injuries, and skin injection	3	3	9	**M**
	Lifting of pipes, hoses, and materials	Unrecommended material lifting load	A2	Back and waist muscle injuries	3	2	6	**M**
	Preparation of work tools	Non-standard or damaged tools (wrenches)	A3	Hand bone fractures and joint dislocation	3	2	6	**M**
	Installation of hoses and pipes	a. Non standard/ damaged tools	A4	Pinched	4	2	8	**M**
		b. Not using an appropriate ladder	A5	Falls	3	3	9	**M**
		c. Not using a safety body harness	A6	Falls	4	5	20	**E**
	Testing of the hydraulic system (tipping hydraulic)	Power pack malfunctioning	A7	Fractures and impact injuries	2	3	6	**M**
	Housekeeping (cleaning of the work area)	a. Messy work area	A8	Tripping	3	1	3	**L**
		b. Oil-contaminated waste	A9	Slipping	4	2	8	**M**

Dismantling and Installation of Axle Components	Preparation of axle components	Unrecommended material lifting load	B1	Back and waist muscle injuries	3	2	6	**M**
	Preparation of work tools	Non-standard or damaged tools (wrenches)	B2	Hand bone fractures and joint dislocation	3	2	6	**M**
	Disassembly and installation of axle	a. Non - standard/damaged tools	B3	Pinched	3	3	9	**M**
		b. Errors in the disassembly/installation process	B4	Crushed / Struck by	3	4	12	**H**
	Housekeeping (cleaning of the work area)	a. Messy work area	B5	Tripping	3	1	3	**L**
		b. Oil/lubricant-contaminated waste	B6	Slipping	4	2	8	**M**
Hydraulic Pipe and Hose Assembly Work	Preparation of work tools	Non-standard or damaged tools	C1	Hand bone fractures and joint dislocation	3	2	6	**M**
	Lifting of materials	a.Unrecommend d material liftin load	C2	Back and waist muscle injuries	3	2	6	**M**
		b. Material falling / Struck by material	C3	Crushed / Struck by	3	3	9	**M**
	Cutting of pipes and hoses	a. Damaged cutting equipment (cutting wheel)	C4	Burns	3	4	12	**H**
		b. Not using PPE	C5	Burns	3	3	9	**M**
		c. (APAR) unavailable	C6	Burns	3	4	12	**H**
	Hose & pipe crimping process	Crimping machine malfunctioning	C7	Pinched	3	4	12	**H**
	Pipe flushing	Not using PPE properly	C8	Eye injuries	4	2	8	**M**
	Pipe painting	Not using PPE properly	C9	Eye injuries	3	3	9	**M**
	Housekeeping (cleaning of the work area)	a. Messy/dirty work area	C10	Tripping	3	1	3	**L**
		b. Oil/lubricant-contaminated waste	C11	Slipping	4	2	8	**M**

4. Determining Risk Priority

The risk assessment results were further analyzed to determine the priority of risk control using the HIRARC risk matrix in Table 5.

Table 5. Risk Assessment Matrix

		Severity				
		Negligible (1)	**Minor (2)**	**Moderate (3)**	**Major (4)**	**Extreme (5)**
Likelihood	**Almost Certain (5)**	0	0	0	0	0
	Likely (4)	0	A4, A9, B6, C8 & C11	0	0	A6
	Possible (3)	A8, B5 & C10	A2, A3, B1, B2, C1 & C2	A1, A5, B3, C3, C5 & C9	B4, C4, C6 & C7	0
	Unlikely (2)	0	0	A7	0	0
	Rare (1)	0	0	0	0	0

The overall risk priority distribution is summarized and illustrated in Figure 1. The assessment identified a total of 26 potential hazards, consisting of 1 Very High Risk, 4 High Risk, 18 Medium Risk, and 3 Low Risk hazards.

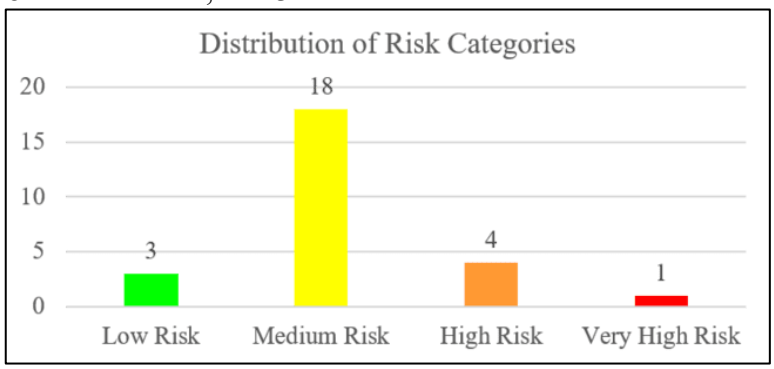


Figure 1. Distribution of Risk Categories

The results indicate that hazards classified as Very High Risk and High Risk require the highest priority for immediate implementation of control measures because of their significant potential to cause serious injury or fatality. In contrast, Medium Risk hazards require additional control measures to reduce the risk level, whereas Low Risk hazards can be managed through periodic monitoring and continuous supervision.
These priorities provide the basis for developing safety improvement recommendations using the Hierarchy of Controls.

5. Safety Improvement Recommendations

Based on the HIRARC assessment, safety recommendations were developed using the Hierarchy of Controls. High and very high-risk hazards were prioritized for immediate control measures due to their critical threat levels. Meanwhile, medium-risk hazards require controls to mitigate risk and prevent escalation. Low-risk hazards are deemed acceptable but require regular monitoring to ensure conditions remain controlled.

The recommended control measures for these priority hazards are presented in Table 6.

Table 6. Safety Improvement Recommendations Very High & High Risk

Code	Potential Hazards	Risk	Risk Matrix	Safety Improvement Recommendations
A6	c. Not using a safety body harness	Falls	E	Elimination: Eliminate work performed directly from heights if possible. Substitution: Use scaffolding or MEWP as a ladder replacement. Engineering Controls: Install a lifeline, guardrail, and anchor point in the work area. Administrative Controls: Implement Permit to Work, SOP for working at heights, and work supervision. PPE: Safety glasses, gloves, helmet, safety shoes, and a full safety body harness is mandatory.
B4	b. Errors in the disassembly /installation process	Crushed / Struck by	**H**	Elimination: Reduce manual lifting of parts. Substitution: Use a safer working method. Engineering Controls: Use installation assistive devices. Administrative Controls: Provide training and work supervision. PPE: Helmet, gloves, and safety shoes.
C4	a. Damaged cutting equipment (cutting wheel)	Burns	**H**	Elimination: Do not use damaged tools. Substitution: Use proper cutting equipment. Engineering Controls: Install grounding & machine guards. Administrative Controls: Perform routine equipment inspections. PPE: Face shield, gloves, and safety shoes.
C6	c. APAR unavailable	Burns	**H**	Elimination: Keep flammable materials away from the work area. Substitution: Use working methods that minimize sparks. Engineering Controls: Provide a fire extinguisher (APAR) in the work area. Administrative Controls: Conduct regular fire extinguisher inspections. PPE: Appropriate PPE according to the type of work.
C7	Crimping machine malfunctioning	Pinched	**H**	Elimination: Stop using the damaged machine. Substitution: Use a machine in proper working condition. Engineering Controls: Install an emergency stop. Administrative Controls: Perform machine inspection & maintenance. PPE: Gloves, safety glasses, and safety shoes.

Table 7.Safety Improvement Recommendations Medium & Low Risk

Code	Potential Hazards	Risk	Risk Matrix	Safety Improvement Recommendations
A1	Leakage or failure of the hydraulic system due to equipment damage/non-conformance to specifications	Burns, eye injuries, and skin injection	**M**	Elimination: Discard damaged or non-spec compliant hoses and pipes. Substitution: Use hoses and pipes that meet work standards. Engineering Controls: Label and segregate non-conforming materials. Administrative Controls: Conduct material inspections before use. PPE: Safety gloves and safety shoes.
A2	Unrecommended material lifting load	Back and waist muscle injuries	**M**	Elimination: Reduce manual lifting. Substitution: Use a trolley or lifting assistive device. Engineering Controls: Provide lifting assistive devices. Administrative Controls: Implement proper material lifting SOPs. PPE: Safety gloves and safety shoes.
A3	Non-standard or damaged tools (wrenches)	Hand bone fractures and joint dislocation	**M**	Elimination: Discard or withdraw damaged tools from service. Substitution: Use standard-compliant tools of the correct size. Engineering Controls: Provide proper tool storage. Administrative Controls: Inspect tools before use PPE: Safety gloves and safety glasses.
A4	a. Non standard/damaged tools	Pinched	**M**	Elimination: Stop using damaged tools. Substitution: Use appropriate tools. Engineering Controls: Use clamps or fixtures during installation. Administrative Controls: Inspect equipment before working. PPE: Safety gloves and safety glasses.
A5	b. Not using an appropriate ladder	Falls	**M**	Elimination: Avoid manual lifting. Substitution: Use material lifting equipment. Engineering Controls: Install supports or materia retaining equipment. Administrative Controls: Follow lifting SOPs. PPE: Safety helmet and safety shoes.
A7	Power pack malfunctioning	Fractures and impact injuries	**M**	Elimination: Do not use a damaged power pack. Substitution: Use a properly functioning and well maintained power pack. Engineering Controls: Install a pressure relief valve and a pressure gauge. Administrative Controls: Conduct inspections prior to testing. PPE: Face shield, safety gloves, and safety shoes

Code	Potential Hazards	Risk	Risk Matrix	Safety Improvement Recommendations
A8	a. Messy work area	Tripping	**L**	Elimination: Clear the work area of unnecessary items. Substitution: Use appropriate storage designated areas. Engineering Controls: Provide racks and clearly defined walking paths. Administrative Controls: Implement 5S/5R program. PPE: Anti-slip safety shoes.
A9	b. Oil-contaminated waste	Slipping	**M**	Elimination: Clean up oil spills immediately. \n Substitution: Use oil-absorbent materials. Engineering Controls: Provide spill kits and wast containers. Administrative Controls: Implement waste handling SOPs. PPE: Safety gloves and safety shoes.
B1	Unrecommended material lifting load	Back and waist muscle injuries	**M**	Elimination: Reduce manual lifting. Substitution: Use material lifting devices. Engineering Controls: Provide ergonomic work tables or desks. Administrative Controls: Implement ergonomic work SOPs. PPE: Safety gloves and safety shoes.
B2	Non-standard or damaged tools (wrenches)	Hand bone fractures and joint dislocation	**M**	Elimination: Discard damaged tools. \n Substitution: Use standard-compliant tools. Engineering Controls: Provide tool storage areas. Administrative Controls: Conduct routine tool inspections. PPE: Safety gloves and safety glasses.
B3	a. Non - standard/damaged tools	Pinched	**M**	Elimination: Stop using damaged tools. Substitution: Use appropriate tools for the specific task. Engineering Controls: Use a jack stand or fixture Administrative Controls: Implement work SOPs. PPE: Helmet, safety gloves, and safety shoes.
B5	a. Messy work area	Tripping	**L**	Elimination: Clear the work area of unnecessary items. Substitution: Use appropriate designated storage. Engineering Controls: Use a jack stand or fixture Administrative Controls: Implement work SOPs. PPE: Helmet, safety gloves, safety shoes.
B6	b. Oil/lubricant-contaminated waste	Slipping	**M**	Elimination: Clean up oil spills immediately Substitution: Use oil-absorbent pads Engineering Controls: Provide spill kits. Administrative Controls: Implement waste handling SOPs PPE: Safety gloves and safety shoes.

Code	Potential Hazards	Risk	Risk Matrix	Safety Improvement Recommendations
C1	Non-standard or damaged tools	Hand bone fractures and joint dislocation	**M**	Elimination: Discard or withdraw damaged tools from service. Substitution: Use standard-compliant tools. Engineering Controls: provide proper tool storage. Administrative Controls: Conduct tool inspections PPE: Safety gloves and safety glasses.
C2	a. Unrecommended material lifting load	Back and waist muscle injuries	**M**	Elimination: Reduce manual lifting. Substitution: Use a trolley. Engineering Controls: Provide ergonomic work tables or desks. Administrative Controls: Follow lifting SOPs. PPE: Safety gloves and safety shoes.
C3	b. Material falling / Struck by material	Crushed / Struck by	**M**	Elimination: Avoid unsafe material stacking. Substitution: Use material storage racks. Engineering Controls: Install material-retaining equipment. Administrative Controls: Arrange the material stacking pattern PPE: Helmet and safety shoes.
C5	b. Not using PPE	Burns	**M**	Elimination: Minimize cutting contact. Substitution: Use a safer working method. Engineering Controls: Install spark guards. Administrative Controls: Enforce mandatory PPE usage. PPE: Face shield, safety gloves, and safety shoes.
C8	Not using PPE properly	Eye injuries	**M**	Elimination: Reduce direct fluid exposure. Substitution: Use a safer flushing method. Engineering Controls: Install spark/splash guards. Administrative Controls: Implement flushing SOP PPE: Goggles, safety gloves, and safety shoes.
C9	Not using PPE properly	Eye injuries	**M**	Elimination: Avoid direct paint exposure. Substitution: Use a safer painting method. Engineering Controls: Provide proper ventilation. Administrative Controls: Implement painting SOP PPE: Respirator, apron, and safety gloves.
C10	a. Messy/dirty work area	Tripping	**L**	Elimination: Clean up the work area. Substitution: Use appropriate designated storage. Engineering Controls: Provide racks and clearly defined walking paths. Administrative Controls: Follow 5S/5R program. PPE: Safety shoes.
C11	b. Oil/lubricant-contaminated waste	Slipping	**M**	Elimination: Clean up oil spills immediately. Substitution: Use oil-absorbent pads. Engineering Controls: Provide spill kits Administrative Controls: Implement waste handling SOPs. PPE: Safety gloves and safety shoes.

Discussions

The integration of JSA and HIRARC provided a systematic framework for identifying hazards, evaluating occupational risks, and establishing appropriate control priorities in mechanical work activities at PT Arasindo Bina Bersama. By breaking each activity into sequential job steps, JSA enabled hazards to be identified at every stage before being evaluated using the HIRARC risk matrix. The risk assessment identified 26 workplace hazards, with Medium Risk as the dominant category (18 hazards), followed by one Very High Risk, four High Risk, and the remaining Low Risk hazards. The presence of High Risk and Very High Risk hazards indicates that existing control measures have not fully eliminated critical workplace risks. The highest-priority hazards included working at height without a safety harness, improper axle installation procedures, damaged cutting equipment, the absence of fire extinguishers, and malfunctioning crimping machines.

These findings indicate that current safety practices are still largely dependent on administrative controls and personal protective equipment, while engineering controls remain insufficient for several critical activities. Consequently, strengthening engineering controls alongside administrative improvements is essential to reduce both the likelihood and severity of occupational accidents. The results also demonstrate that applying the Hierarchy of Controls provides an effective basis for prioritizing risk control measures. Hazards categorized as Very High Risk and High Risk require immediate corrective actions, Medium Risk hazards require further risk reduction, and Low Risk hazards should be managed through continuous monitoring.

The findings are consistent with previous studies showing that the integration of JSA and HIRARC enhances hazard identification by systematically evaluating each work step and provides a reliable basis for occupational risk assessment and the selection of appropriate control measures [11], [16], [17], [22]. In this study, the integrated approach not only facilitated systematic hazard identification and risk evaluation but also established clear control priorities that supported the development of safety improvement recommendations based on the Hierarchy of Controls. Overall, the proposed framework demonstrates that integrating work analysis, hazard identification, risk assessment, risk prioritization, and control selection can support more effective occupational safety decision-making in mechanical maintenance activities, particularly in industries involving hydraulic systems and heavy equipment.

CONCLUSION

This study identified occupational hazards and evaluated risk levels in three mechanical work activities at PT Arasindo Bina Bersama using the integration of JSA and HIRARC. The assessment results showed that Medium Risk hazards constituted the largest proportion, while Very High Risk and High Risk hazards were identified as the highest priorities requiring immediate corrective actions. Based on these findings, risk control priorities were established, and safety improvement recommendations were developed using the Hierarchy of Controls to support more effective occupational risk management.

The proposed approach demonstrates that integrating JSA, HIRARC, risk control prioritization, and the Hierarchy of Controls provides a systematic framework for supporting occupational safety decision-making in mechanical maintenance activities. This framework contributes to the development of Industrial Engineering by providing a practical approach for hazard management, risk control prioritization, and continuous

safety improvement in industrial workplaces. Future research is recommended to evaluate the proposed control measures after implementation and to validate the framework in different industrial sectors.

ACKNOWLEDGMENT

The authors would like to express their sincere gratitude to PT Arasindo Bina Bersama, for granting permission to conduct this research and facilitating the data collection process. The authors also thank the lecturers and the Industrial Engineering Department from Sekolah Tinggi Teknologi Wastukancana Purwakarta for their guidance and support throughout this research.

REFERENCES

[1] T. Kusumastuti, C. P. Eliza, A. N. Hanifah, and Z. M. Choirala, "Identifikasi bahaya dan metode identifikasi bahaya pada proses industri dan manajemen risiko," *Environment Education and Conservation*, vol. 1, no. 1, 2024, doi: 10.61511/educo.v1i1.2024.527.

[2] Y. Fuadi, M. Mulyadi, I. Siboro, and M. Ramdan, "Identifikasi Bahaya dan Pengendalian Risiko pada Pekerjaan Pengupasan Batu Bara Di PT Pama Persada Nusantara Kota Sangatta," *IDENTIFIKASI*, vol. 11, no. 2, 2025, doi: 10.36277/identifikasi.v11i2.586.

[3] A. Maghfira, A. H. Pratama, and C. Paotonan, "Analisis Risiko Kecelakaan Kerja pada Pekerjaan Instalasi Bangunan Lepas Pantai dengan Menggunakan Metode Job Safety Analysis," *Riset Sains dan Teknologi Kelautan*, 2023, doi: 10.62012/sensistek.v6i2.31600.

[4] E. A. Nisa, "Analisis Risiko Kecelakaan Proses Pembuatan Pipa di PT. XYZ dengan Metode JSA," *Journal of Industrial Engineering and Technology*, vol. 1, no. 2, 2025, doi: 10.36277/jietech.v1i2.22.

[5] R. Y. Parapat, E. Sandjaya, S. A. Nurfadhilah, M. M. Fetok, N. Hikmah, and Salafffudin, "Evaluasi Keselamatan Kerja (K3) Di PT. Timah Industri Dengan Menggunakan Metode HIRARC," *Evaluasi Keselamatan Kerja (K3) Di PT. Timah Industri Dengan Menggunakan Metode HIRARC*, vol. 2, 2024.

[6] W. Amalia, W. F. Mufti, and S. Alfiza, "Identifikasi Bahaya dan Pengendalian Risiko Kecelakaan Kerja Menggunakan Metode HIRARC (Hazard Identification, Risk Assesment, Risk Control) Pada Industri Pengolahan Hasil Perikanan," *Jurnal Teknik Industri Terintegrasi*, vol. 8, no. 3, 2025, doi: 10.31004/jutin.v8i3.46608.

[7] Vella Sephia Arianto and Syadzadhiya Qothrunada Z, "Analisis Manajemen Risiko terhadap Keselamatan dan Kesehatan Kerja (K3) dengan Metode HIRARC di Pelabuhan Tanjung Perak," *Globe: Publikasi Ilmu Teknik, Teknologi Kebumian, Ilmu Perkapalan*, vol. 3, no. 2, 2025, doi: 10.61132/globe.v3i2.833.

[8] A. Shabrina, T. Nurhayati, D. N. Islami, and A. M. Suyono, "Identifikasi Bahaya dengan Metode Job Safety Analysis Di PT. XYZ," *Jurnal LOGIC (Logistics & Supply Chain Center)*, vol. 1, no. 2, 2023, doi: 10.33197/logic.v1i2.989.

[9] Dewanto Azmi Pradana, G. Prasetyo, M. A. Putra, I. Gunawan, and Y. Prastyo, "Identifikasi Risiko Kecelakaan Kerja pada Area Mesin Produksi PT. XYZ dengan Metode Job Safety Analysis (JSA) dan Metode FINE," *Journal of Management and Innovation Entrepreneurship (JMIE)*, vol. 2, no. 4, 2025, doi: 10.70248/jmie.v2i4.2344.

[10] M. A. F. Hibatullah, E. D. Priyana, and A. W. Rizqi, "Analisis Potensi Bahaya Menerapkan metode JSA dan HIRARC Pada Departemen Civil dan Electrical PT. ABC," *INTECOMS: Journal of Information Technology and Computer Science*, vol. 7, no. 3, 2024, doi: 10.31539/intecoms.v7i3.10570.

[11] R. T. Rianto and E. Ismiyah, "Analisis Keselamatan Dan Kesehatan Kerja (K3)Pada Proses Pengolahan Padi Dengan Menggunakan Metode Job Safety Analysis (JSA) dan Hazard Identification, Risk Assessment, And Risk Control (HIRARC)," *INTECOMS: Journal of Information Technology and Computer Science*, vol. 8, no. 3, 2025, doi: 10.31539/intecoms.v8i3.15538.

[12] A. K. Widana, "Identifikasi Bahaya dan Penilaian Risiko Keselamatan dan Kesehatan Kerja Menggunakan Metode Hirarc pada Gardu Induk Ampenan," *Jurnal Informatika dan Teknik Elektro Terapan*, vol. 12, no. 3S1, 2024, doi: 10.23960/jitet.v12i3s1.5272.

[13] M. A. Firmansyah and E. Ismiyah, "Analisis Keselamatan dan Kesehatan Kerja Menggunakan Metode Hirarc dan Heart (Studi Kasus : PT. Paku Jaya)," *Jurnal Teknik Industri Terintegrasi*, vol. 7, no. 3, 2024, doi: 10.31004/jutin.v7i3.30807.

[14] H. Fadili, Mohammad Fadli Perdana, Suryadi, and Dicky Suryapranatha, "Identifikasi Potensi Bahaya Keselamatan Dan Kesehatan Kerja Dengan Menggunakan Metode HIRARC," *Jurnal Teknologi dan Manajemen Industri Terapan*, vol. 4, no. 3, 2025, doi: 10.55826/jtmit.v4i3.1003.

[15] M. I. Hamdani and D. Andesta, "Analisis Potensi Bahaya Menggunakan Metode JSA dan HIRARC untuk Mengurangi Angka Kecelakaan Kerja pada Area Workshop Fabrikasi PT. ABC," *G-Tech: Jurnal Teknologi Terapan*, vol. 8, no. 2, 2024, doi: 10.33379/gtech.v8i2.4076.

[16] S. Anjani and E. Ismiyah, "Analisis Keselamatan Dan Kesehatan Kerja (K3) Menggunakan Metode Job Safety Analysis (JSA) Dan Hazard Identification, Risk Assessment &Amp; Risk Control (HIRARC) Di Bengkel Fabrikasi PT ABC," *INTECOMS: Journal of Information Technology and Computer Science*, vol. 8, no. 5, 2025, doi: 10.31539/022fz487.

[17] M. R. Wiryawan and N. A. Mahbubah, "Evaluasi Risiko Keselamatan Dan Kesehatan Kerja Pada Proyek Instalasi Pipanisasi Di PT EFE Berbasis Metode JSA DAN HIRARC," *SIGMA TEKNIKA*, vol. 7, no. 1, 2024, doi: 10.33373/sigmateknika.v7i1.6359.

[18] K. Yosefany Sinaga, "Pengendalian Risiko Pada Pemeliharaan Jaringan Dengan Menggunakan Pendekatan HIRARC dan JSA pada PT PLN (PERSERO) UP3 SEMARANG," *Industrial Engineering Online Journal*, vol. 14, 2025.

[19] M. A. Yutaro and D. Roosmini, "Manajemen Risiko Keselamatan di Area Wellpad dan Area Power Plant Pembangkit Tenaga Panas Bumi (PLTP X) Menggunakan Metode HIRARC," *Jurnal Keselamatan Kesehatan Kerja dan Lingkungan*, vol. 5, no. 1, 2024, doi: 10.25077/jk3l.5.1.83-92.2024.

[20] M. F. Wahyudi, N. Oktyajati, S. Mayasari, and S. Purwati, "Analisis Risiko Keselamatan Kerja (K3) Dengan Menggunakan Metode Hirarc (Hazard Identification Risk Assessment and Risk Control) Studi Kasus : Pt Dwi Tunggal Jaya Asia," *Journal of Research and Technology Studies*, vol. 02, no. 2, 2023.

[21] D. H. Lalenoh, A. K. T. Dundu, and Lucia. I. R. Lefrandt, "Identifikasi Bahaya dan Penilaian Risiko Keselamatan dan Kesehatan Kerja (K3) Pada Proyek Runway dan Taxiway Bandara Lolak Bolaang Mongondow Menggunakan Metode Hirarc," *Syntax Literate ; Jurnal Ilmiah Indonesia*, vol. 7, no. 9, 2023, doi: 10.36418/syntax-literate.v7i9.13723.

[22] Moh.Aditya Putra and Moh. Jufriyanto, “Analisis Potensi Bahaya kerja dengan Metode JSA Dan HiRARC Di Area Produksi ,” *Jurnal Teknologi dan Manajemen Industri Terapan*, vol. 5, no. 1, 2026, doi: 10.55826/jtmit.v5i1.1425.

(This page is intentionally left blank)