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Occupational Health and Safety Analysis Using the HIRARC Method at Mitsubishi DIPO Bukittinggi

Rival Handika[1], Milana Milana[1*], Nuzul Hidayat[1], M. Yasep Setiawan[1], Reinny Patrisina[2]

Abstract

Occupational safety is a critical concern in automotive workshop environments due to the high-risk nature of tasks such as engine repair, welding, and electrical diagnostics. This study investigates automotive workshop risks at the Mitsubishi DIPO Workshop in Bukittinggi by identifying hazards, assessing risk levels, and formulating workplace accident prevention strategies. The HIRARC (Hazard Identification, Risk Assessment, and Risk Control) method was applied to evaluate 28 potential hazards, two of which were classified as extreme risks. Further analysis of these risks was conducted using the Fishbone Diagram to identify root causes across six contributing factors: human, machine, material, method, environment, and management. Based on these findings, targeted risk control measures were developed following the hierarchy of control, including engineering interventions, administrative policies, and personal protective equipment. This research demonstrates how integrated methods such as HIRARC and Fishbone Diagram can support comprehensive occupational safety planning and risk mitigation in automotive workshops.

Keywords
Occupational Safety, HIRARC, Fishbone Diagram, Automotive Workshop Risk, Workplace Accident Prevention

[1]Automotive Engineering Department, Faculty of Engineering, Universitas Negeri Padang
Prof. Dr. Hamka Street, Air Tawar, Padang, West Sumatra, Indonesia
[2]Industrial Engineering Department, Faculty of Engineering , niversitas Andalas
Limau Manis, Pauh, Padang City, West Sumatra, Indonesia
** milana@ft.unp.ac.id*

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INTRODUCTION

The advancement of automotive technology in the modern era has contributed not only to increased efficiency and productivity but also to a heightened risk of occupational hazards within workshop environments. These technological developments require mechanics to operate a range of advanced machines and tools which, if used improperly or without adequate protection, may result in workplace accidents. Consequently, the implementation of Occupational Health and Safety (OHS) measures is essential in every automotive workshop setting.

Occupational Health and Safety (OHS)

Occupational Health and Safety (OHS) is essential for creating a secure, efficient, and productive workplace. Occupational Health and Safety policies are intended to protect employees and must be uniformly executed in compliance with applicable laws, regulations, and safety standards [1][2]. This encompasses the implementation of preventive technology designed to reduce accidents [3]. The significance of OHS implementation is especially evident in the automobile industry, which presents a considerable risk for occupational hazards.

Effective risk management, encompassing measures identification, risk assessment, and the implementation of suitable control measures, is essential for fostering a robust safety culture in the workplace [4].

The utilization of advanced equipment improves task efficiency but also presents operational dangers without sufficient safety measures. Workplace accidents typically arise from two primary factors: risky activities (such as poor utilization of personal protective equipment (PPE), noncompliance with standard operating procedures (SOP), or insufficient expertise) and unsafe conditions (such radiation exposure, defective tools, or open flames) [5].

Automotive workshops represent some of the most intricate and dynamic work environments. Routine activities, including oil changes, brake inspections, electrical diagnostics, welding, and overhauls, necessitate diverse equipment and entail numerous phases of mechanical contact. Nevertheless, in practice, numerous workers continue to inadequately adhere to OHS regulations, often evidenced by overlooked PPE utilization, omitted equipment checks, and the lack of safety briefings prior to the commencement of work. Similar problems were also noted at the Mitsubishi DIPO Workshop in Bukittinggi. Direct observations and interviews revealed that numerous personnel disregard the utilization of personal protective equipment (PPE) [6]. Moreover, there is an absence of organized documentation or reporting mechanisms for occupational events, as well as a lack of a universally implemented Standard Operating Procedure for workplace safety. These deficiencies markedly elevate the danger of workplace accidents, potentially resulting in severe repercussions for both individual employees and the overall operating efficiency of the workshop. Table 1 illustrates the incident of work-related incidents from February to November 2024.

Table 1. Recorded Work Accidents of Mechanics at Mitsubishi DIPO Bukittinggi

Number	Moon	Number of Cases
1	February	-
2	March	2
3	April	1
4	May	1
5	June	-
6	July	1
7	August	2
8	September	1
9	October	-
10	November	1

As presented in Table 1, several occupational accidents occurred at Mitsubishi DIPO Bukittinggi between February and November 2024, several of which resulted in worker injuries that disrupted the completion of routine workshop operations. These incidents highlight the pressing need for structured Occupational Health and Safety (OHS) management. Given this context, the present study aims to identify potential hazards associated with various work activities at the Mitsubishi DIPO Workshop in Bukittinggi and to assess the corresponding levels of risk. The ultimate objective is to develop and propose appropriate preventive and control measures that can effectively reduce the probability and impact of workplace accidents. To achieve this, the study adopts the Hazard Identification, Risk Assessment, and Risk Control (HIRARC) method as its primary analytical framework.

HIRARC Methodology in Occupational Risk Management

The Hazard Identification, Risk Assessment, and Risk Control (HIRARC) technique provides a systematic framework for controlling occupational safety risks through the identification of hazards, evaluation of risk levels, and selection of suitable control methods. The strategy is essential for delivering a systematic comprehension of workplace hazards and acts as a basis for decision-making in occupational health and safety management [7][8]. The procedure commences with hazard identification, entailing meticulous monitoring of job actions and environmental elements that may lead to health or safety events. This step seeks to identify all potentially detrimental occurrences and evaluate their probable impacts on severity and frequency [9][10]. Organizations can acquire comprehensive insights into the particular risks linked to each task or area inside the workplace through this procedure.

Upon identifying risks, a risk assessment is performed to evaluate the extent of threat they pose. This entails computing a risk score, derived by multiplying the probability of occurrence by the potential impact of each hazard [11]. The resultant score, classified using a risk matrix, aids in assessing the immediacy and magnitude of the necessary response [12]. Once the risk level is determined, suitable risk control strategies must be chosen. The controls adhere to the hierarchy of control principles: hazard removal, substitution with a safer alternative, adoption of engineering controls, formation of administrative procedures, and provision of personal protective equipment (PPE) [13]. Each control solution must be selected based on its efficacy and sustainability in risk mitigation. These measures collectively guarantee the proactive and systematic management of occupational hazards, especially in high-risk settings like automotive workshops.

The Fishbone Diagram complements the HIRARC method by providing a systematic approach to identify the root causes of potential hazards in greater depth. This diagram helps categorize contributing factors into groups such as human, machine, method, material, environment, and management. Consequently, hazard analysis becomes more comprehensive and focused, enabling more effective and targeted risk control planning [14].

METHOD

This study employed a mixed-methods approach, integrating both quantitative and qualitative research methods to produce more comprehensive, valid, reliable, and objective results [15]. The research was conducted over the period of January 30 to February 5, 2025, at the Mitsubishi DIPO Workshop in Bukittinggi. The participants consisted of all 13 mechanics currently employed at the workshop.

The research procedure included several key stages: field observation, literature review, data collection, hazard identification, risk assessment, and risk control analysis using the Fishbone Diagram. To quantify the risks, the study applied the Australia/New Zealand Standard (AS/NZS) risk matrix, which evaluates risks by combining the probability of occurrence (likelihood) with the severity of consequences. The risk score is calculated using the following formula [16]:

$$\text{Risk Score} = \text{Likelihood x Consequence}$$

This systematic method allows for the classification of risks into priority levels—such as low, medium, high, and extreme, which then serve as the basis for recommending appropriate control measures in accordance with the HIRARC framework. The scales used for risk evaluation in this study are based on the Australia/New Zealand Standard (AS/NZS) risk matrix, which combines the likelihood of occurrence with the severity of consequences to determine risk levels. The classification criteria are presented in Table 2 and Table 3, while the risk matrix used for assessment is illustrated in Figure 1.

Table 2. Scale of Impact (Consequence) [16]

Level	Category	Description
1	Insignificant	No injury; minor financial loss
2	Minor	First aid required; handled on-site; moderate financial loss
3	Moderate	Requires medical treatment; on-site incident with external assistance; large financial loss
4	Major	Severe injury; loss of production capacity; off-site treatment without lasting effects
5	Catastrophic	Fatality; widespread poisoning; significant operational disruption; extensive financial loss

Table 3. Likelihood Scale (Likelihood) [16]

Level	Category	Description
1	Almost Certain	Expected to occur in most circumstances
2	Likely	Will probably occur under most conditions
3	Possible	Could occur at some point
4	Unlikely	Rare, but not impossible
5	Rare	May occur only under exceptional or very specific conditions

Likelihood	Consequence				
	1	2	3	4	5
5	H	H	E	E	E
4	M	H	H	E	E
3	L	M	H	E	E
2	L	L	M	H	E
1	L	L	M	H	H

Figure 1. Risk Matrix [16]

Furthermore, after calculating the risk score and level, this study used the Fishbone Diagram approach to identify risks' primary causes. The Fishbone Diagram (Ishikawa Diagram) was used to identify and categorize each high-priority risk's causes. This visual tool helps researchers classify probable contributing components into theme areas such human factors, equipment, methods, materials, environment, and management systems to create effective and targeted control measures [17].

RESULT AND DISCUSSION

Result

This study collected data through direct observations and interviews with 13 mechanics at the Mitsubishi DIPO Workshop in Bukittinggi. The information gathered includes a comprehensive record of work activities, potential hazards, and associated risks specific to the workshop's service operations. A subsequent risk assessment was collaboratively conducted with the workshop supervisor and participating mechanical staff to validate the identified hazards and classify risk levels.

The evaluation of risk was carried out using the HIRARC (Hazard Identification, Risk Assessment, and Risk Control) method. This approach applies to two primary indicators: likelihood (the probability of an incident occurring) and consequence (the severity of its potential outcome). For example, one identified hazard involved a mechanic's hand being exposed to hot engine oil, which could result in burns. According to the risk matrix criteria (see Tables 2 and 3), the likelihood of this occurring was rated as 5, indicating a high probability due to the frequency of this task. The consequence was rated as 3, corresponding to a moderate level of injury, such as minor to moderate burns. Using the HIRARC formula (Likelihood × Consequence), the risk score is calculated as 5 × 3 = 15, classifying the hazard as an extreme risk, as depicted in Figure 1.

A comprehensive summary of all identified hazards, associated risks, and risk classifications is provided in Table 4, which serves as the foundation for subsequent analysis and control planning. For clarity, the risk level categories used in the table are defined as follows:

L = Low Risk, **M** = Moderate Risk, **H** = High Risk, and **E** = Extreme Risk.

Table 4. Hazard Identification, Risk Assessment and Risk Level Determination

No	Activities	Hazard Identification	Risk	Likelihood	Consequence	Risk Score	Risk Level
1.	Oil Change	Hands exposed to hot oil	Burns on the skin of the hands	5	3	15	E
		Eyes splashed with oil	Eye irritation, vision damage	2	3	6	M
		Face hit by the underside of the engine (Pajero car)	Facial injuries, facial fractures or other injuries	2	3	6	M
		Body hit by car	Severe injuries to the body, fractures, even death	1	5	5	H
		Slipped by oil	Accidents due to falls, cuts or fractures	3	3	9	H
		Leg hit by car tire	Leg injury, fracture, or serious injury	2	3	6	M
2	Brake Check	Hand clamped caliper	Injuries to the hands, broken bones or severe bruises	3	3	9	H
		Hand clamped on drum brake work	Hand injury, fracture, or wound to the finger	3	3	9	H
		Skin exposed to brake fluid	Skin irritation	2	2	4	L
3	Battery and Electrical Checks	Hands hit by water	Skin irritation, chemical burns, skin damage	2	3	6	M
		Electrocution/short circuit	Electrical injuries, burns, internal organ damage	2	5	10	E

No	Activities	Hazard Identification	Risk	Likelihood	Consequence	Risk Score	Risk Level
4	Radiator Checks	Hands exposed to hot radiator water	Skin irritation, minor burns or skin damage	3	2	6	M
		Hot radiator water on the face	Burns on the face, injuries to the skin of the face	1	3	3	M
5	Vehicle repair parts (Grinding)	Hand is hit by a splash that bounces while grinding	Cuts, bruises, skin irritation due to bounced objects	2	2	4	L
		Face hit by a splash of a bounced object	Eye injuries, facial wounds, risk of infection	1	3	3	M
		Hand scratched by grinder	Tears, bleeding, nerves or tendon damage	1	4	4	H
6	Vehicle repair parts (Drilling)	Hands hit by splashes of drilled objects	Injuries to hands, cuts, or bruises from splashes	1	2	2	L
7	Vehicle repair parts (Welding)	Hands hit by fireworks	Burns, skin irritation, risk of infection	2	2	4	L
		Face hit by fireworks	Burns, skin irritation, risk of infection	1	2	2	L
8	Overhaul	Limbs hit by machines or objects	Injuries to the body, fractures, severe wounds	2	3	6	M
		Hand sprained when opening when unbolting the machine	Hand injury, sprain, or joint injury	2	2	4	L
		Hand scratched sharp machine parts	Cuts or tears in the hands, infection	3	2	6	M
		Hands are pinched at the time of piston installation	Hand injury, fracture, or serious wound	1	3	3	M
9	House Keeping and Car Wash	Slipping while cleaning floors	Injuries due to falls, cuts or fractures	3	3	9	H
		Hands exposed to high-pressure water	Injury to the hand, or laceration	2	2	4	L

No	Activities	Hazard Identification	Risk	Likelihood	Consequence	Risk Score	Risk Level
10	Other Jobs	Hand clamped fan belt	Injuries to the hands, fractures, or severe wounds	2	4	8	H
		Eyes exposed to splashes of anti-rust liquid	Eye irritation, vision damage, infection	2	3	6	M
		Hand hit by broken glass shards	Hand wounds, bleeding, or infection	1	3	3	M

The results of the risk assessment across ten types of work activities revealed a total of 28 identified hazards, categorized as follows: 7 low-risk, 12 moderate-risk, 7 high-risk, and 2 extreme-risk hazards. Work activities classified as extreme risk require immediate control measures to reduce or eliminate potential hazards and prevent workplace accidents. As such, further analysis was conducted using the Fishbone Diagram to identify the root causes of these high-severity risks, thereby enabling the formulation of appropriate and effective control strategies. The hazards with the highest risk scores in the extreme category were: (1) hand exposure to hot oil, and (2) electric shock or short circuit. The causal factors contributing to these risks are analyzed and presented in Figure 2 and Figure 3, respectively.

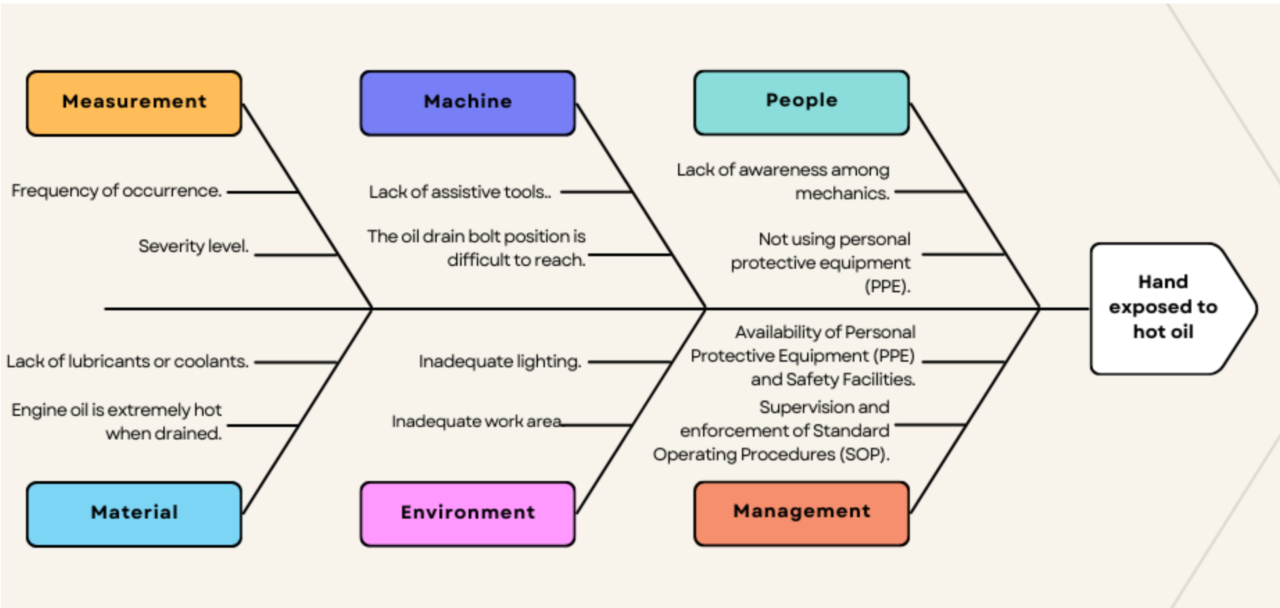

Figure 2. Fishbone Diagram for the Risk of Hands Exposed to Hot Oil

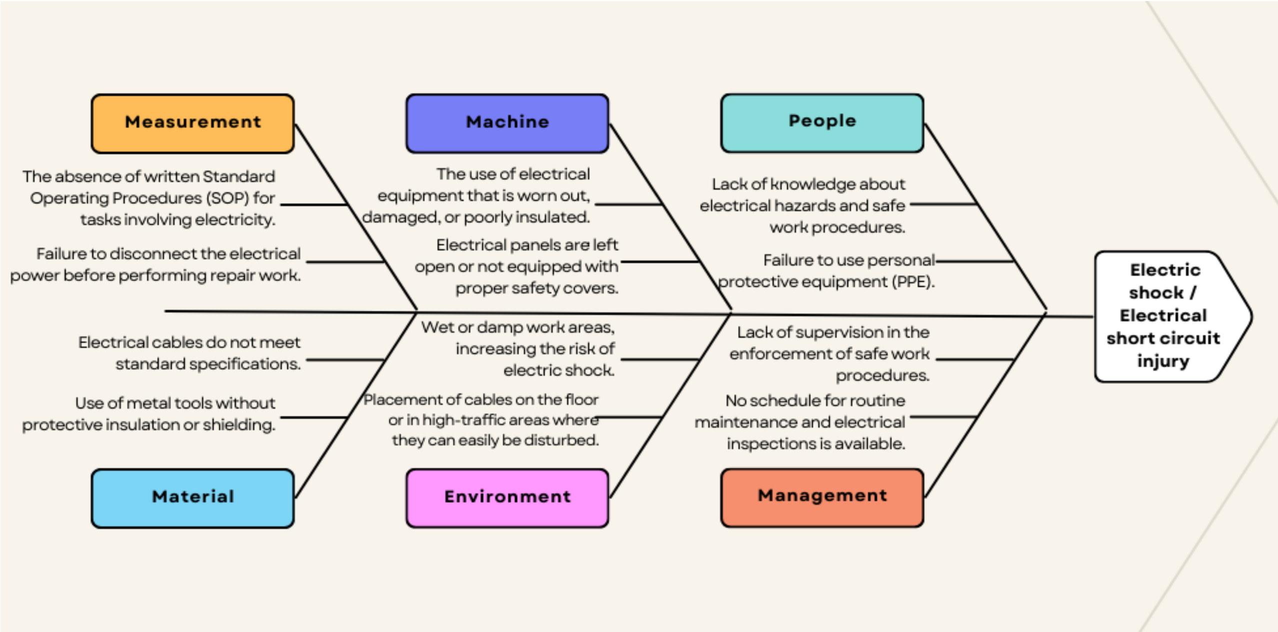

Figure 3. Fishbone Diagram for Risk of Electrocution/Short Circuit

The Fishbone Diagram categorizes potential causes into six major domains: People, Machine, Material, Measurement/Method, Environment, and Management. These categories form the framework for root cause analysis and will be further elaborated in the Discussion section.

Discussion

This study's results show the presence of multiple possible risks in car maintenance and repair processes at the workshop. The initial phase entailed performing observations and interviews with the lead mechanic to ascertain potential dangers that could jeopardize mechanics during maintenance and repair activities. Secondly, it was determined that workshop activities encompass 28 potential hazards, categorized into ten work classifications: five in oil change operations, four in brake inspections, two in battery and electrical assessments, two in radiator evaluations, three in grinding tasks, one in drilling, two in welding, four in overhaul procedures, two in housekeeping and car washing, and three classified as miscellaneous tasks. Third, interviews were performed with all 13 mechanics to evaluate the probability and impact of each detected danger. The risk score was calculated by multiplying the likelihood and consequence values. The scores were subsequently utilized to categorize risk categories, as illustrated in Table 4. The findings are encapsulated as follows:

1. **Extreme Risk**: Hazards such as "hand exposed to hot oil" (score 15) and "electric shock/short circuit" (score 10) were found to have both high likelihood and high severity.
2. **High Risk**: Hazards such as "slipped by oil" (score 9), "hand pinched by calipers" (score 9), "hand pinched on drum brake work" (score 9), "slipped while cleaning floor" (score 9), "hand hit by fan belt debris" (score 8), "body hit by car" (score 5), and "hand scratched by grinders" (score 4) were identified as having significant impact, although slightly lower probability than extreme risks.
3. **Moderate Risk**: Hazards such as "eye splashed with oil", "face hit by the bottom of the engine", "foot hit by car tire", "hand hit by battery water", "hot radiator water on face", "limb hit by engine or object", "hand scratched by sharp engine parts", "eye hit by splash of anti-rust liquid", "hand pinched during piston installation", and "hand hit by broken glass shards" fall under this category. These risks still require proactive control to prevent more severe injuries.

4. **Low Risk**: Hazards such as "skin exposed to brake fluid", "hand exposed to sparks while grinding", "hand exposed to sparks during welding", "hand sprained when opening engine bolts", "hand exposed to high-pressure water", "hand exposed to sparks while drilling", and "face exposed to sparks" are considered low risk, yet still demand basic safety precautions to prevent minor incidents or operational disruptions.

Fifth, risk control measures were developed in coordination with the chief mechanic, taking into account technical feasibility and actual field conditions. These controls were implemented following the hierarchy of control—starting from elimination (e.g., use of oil suction aids), engineering controls (e.g., tool guards), administrative measures (e.g., training, SOP implementation), and the use of PPE (e.g., heat-resistant gloves, face shields, anti-slip shoes).

Sixth, a Fishbone Diagram analysis was used to explore the root causes of the highest-risk activities—namely, hand exposure to hot oil and electrical shock—both of which were classified as extreme risks. As shown in Figure 2 and Figure 3, the potential causes were grouped into six categories: People, Machine, Material, Measurement/Method, Environment, and Management. Under the People category, the dominant contributing factor was a lack of worker awareness regarding the dangers of hot oil and electrical systems. In the Machine domain, damaged or exposed electrical equipment and the absence of proper panel protection increased the likelihood of electric shock or fire. In the Material category, non-standard or damaged electrical cords, including frayed or non-insulated tools, contributed to electrical hazard susceptibility. Methodologically, weak adherence to SOPs—particularly during oil changes and electrical procedures—was found to promote unsafe practices. From an Environmental perspective, damp or wet surfaces significantly increased the likelihood of electric shock, particularly in the presence of exposed equipment. Lastly, from a Management standpoint, the absence of routine supervision, inspection, and structured safety protocols exacerbated the overall risk level in the workplace.

These six factors are interconnected and must be addressed holistically to establish a safe and healthy working environment. As such, the following risk control strategies are recommended:

1. Provide periodic occupational safety training on thermal and electrical hazards.
2. Mandate the use of PPE such as heat-resistant gloves, insulated gloves, and safety shoes.
3. Develop and enforce strict SOPs for oil change and electrical tasks.
4. Conduct regular inspections and maintenance of electrical systems, machinery, and work tools.
5. Provide work aids such as oil funnels, safe storage containers, and automatic circuit breakers.
6. Improve the layout of workspaces to ensure cleanliness, dryness, brightness, and freedom from physical obstructions.
7. Strengthen OHS oversight, including incident documentation, regular audits, and supervisory accountability.

The root cause analysis with the Fishbone Diagram highlights essential factors—people, machines, materials, procedures, environment, and management—that correspond with findings by [18], which recognize these variables as key contributors to workplace mishaps. Furthermore, the risk control recommendations in this study align with Government Regulation of the Republic of Indonesia No. 50 of 2012 regarding the Occupational Health and Safety Management System (SMK3), which requires ongoing safety training, implementation of standard operating procedures (SOPs), utilization of personal protective equipment (PPE), and regular inspections to maintain a safe work environment. The comprehensive use of these measures is anticipated to markedly diminish the likelihood of accidents in car workshops.

CONCLUSION AND RECOMMENDATION

Conclusion

This study, utilizing the HIRARC approach, found 28 possible hazards at the Mitsubishi DIPO Workshop in Bukittinggi that threaten workers' physical safety during tasks including welding, drilling, and grinding. The risk assessment, which involved analyzing the probability of occurrence and the severity of effects, identified seven low-risk, twelve moderate-risk, seven high-risk, and two extreme-risk dangers. In conjunction with the HIRARC study, the Fishbone Diagram was employed to methodically ascertain the root causes of these risks, classified into six principal categories: human, machine, material, method, environment, and management. This comprehensive method enabled more precise hazard detection and the formulation of efficient control measures. Subsequent risk mitigation procedures were executed following the hierarchy of controls, with the objective of reducing or eradicating dangers whenever feasible. Moderate and low risks required mitigation by training, workspace design, SOP enforcement, and the regular use of suitable personal protective equipment (PPE), but high hazards—such as electrical shock and collisions with moving vehicles—demand stringent intervention. This encompasses the utilization of comprehensive personal protective equipment, routine examination and maintenance of apparatus, optimized workplace configuration, and augmented managerial oversight. These integrated risk management initiatives are anticipated to markedly enhance occupational safety in the automotive workshop environment.

Recommendation

This study recommends that workshop managers and business stakeholders enhance their occupational safety practices by adopting a systematic, standardized, and routinely assessed safety management system. This encompasses regular risk assessments, control evaluations, and systematic documentation. Simultaneously, initiatives must be undertaken to improve employee knowledge and adherence through ongoing safety training and the development of a robust safety culture across all organizational tiers. Future studies are advised to investigate the incorporation of digital technology, including real-time hazard monitoring systems and mobile safety reporting tools, to enhance risk reduction efforts. Subsequent study may evaluate the economic ramifications of workplace accidents and devise new, sustainable solutions to enhance occupational health and safety in small and medium-sized firms, especially within high-risk sectors like vehicle repair.

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