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Hazard Identification, Risk Assessment, Risk Control (HIRARC) for Grinding Operation at the Oil and Gas Company Topside Project

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Abstract

Grinding operations are widely applied in the construction and fabrication works, particularly in oil and gas topside projects. However, they pose significant occupational safety and health risks if not properly controlled. This study aims to identify hazards, assess associated risk levels, and propose appropriate control measures for grinding operations using the Hazard Identification, Risk Assessment, and Risk Control (HIRARC) approach. The study was conducted at an oil and gas company topside project located at Malaysia Marine and Heavy Engineering (MMHE). A mixed-method research design was adopted, involving HIRARC assessment, structured questionnaires, and semi-structured interviews with Health, Safety, and Environment (HSE) personnel and foremen. Quantitative data were analysed using descriptive statistics, while qualitative data were analysed thematically in accordance with the DOSH HIRARC Guideline 2008. The findings identified various physical, mechanical, electrical, and environmental hazards, including grinder kickback, flying metal particles, defective grinding disc, excessive noise, hand-arm vibration, electrical shock, and poor housekeeping. Several hazards were classified as medium to high risk, particularly during equipment preparation and grinding activities. Although existing control measures, such as personal protective equipment, training, and supervision, were implemented, unsafe work practices and human factors were still observed. The findings indicate that systematic HIRARC implementation can support safer grinding operations and reduce the likelihood of work-related injuries in industrial projects

1. Introduction

In an oil and gas construction project, various work activities may contribute to occupational accidents if not properly managed (Kishore et al., 2022). One of the commonly performed tasks in fabrication and topside construction is the grinding operation, which is essential for surface preparation, material finishing, and weld cleaning (Kishore et al., 2022). Grinding activities involve high-speed rotating abrasive discs that generate significant mechanical and physical hazards during operation. Workers may be exposed to flying metal fragments, grinder kickback, disc fracture, and contact with rotating parts, which can result in severe lacerations, eye injuries, and fractures (Al-Thani et al., 2025; Song, 2023). In addition, grinding produces excessive noise, hand-arm vibration, sparks, and metal dust, contributing to potential hearing impairment, vibration-related disorders, fire hazards, and respiratory risks (Li et al., 2023) . Electrical hazards may also arise from damaged cables or improper equipment handling. Without adequate supervision and control measures, these combined hazards can significantly increase the likelihood of occupational accidents in industrial construction environments.

To systematically manage these risks, the Hazard Identification, Risk Assessment, and Risk Control (HIRARC) approach is widely applied in Malaysian workplaces in accordance with the Department of Occupational Safety and Health (DOSH) guidelines (DOSH, 2008). The hirarc method provides a structured process to identify task-specific hazards, evaluate risk levels based on likelihood and severity, and determine appropriate control measures according to the hierarchy of controls (DOSH, 2008). Through systematic implementation, HIRARC supports proactive risk management and continuous improvement in occupational safety and health practices.

1.1 Problem Statement and Objectives

Over the past several years, grinding-related incidents and near-miss cases have been reported in industrial projects, particularly during equipment preparation and active grinding operations. Accidents may occur due to unsafe work practices, such as improper use of grinding tools, failure to use auxiliary handles, defective grinding discs, and inadequate use of personal protective equipment. In addition, limited awareness of grinding hazards and insufficient risk assessment may contribute to unsafe working conditions. Grinding activities involve various hazards, including mechanical hazards from the rotating disc, physical hazards such as noise and vibration, electrical hazards, and environmental hazards related to poor housekeeping. Despite existing safety measures, these hazards continue to pose risks to workers, indicating the need for a systematic assessment of grinding operations using the HIRARC method.

The objectives of this study are:
• To identify hazards associated with grinding operations in an oil and gas company topside project.
• To assess the risk levels of grinding-related hazards using the HIRARC approach.
• To propose appropriate control measures to reduce risks associated with grinding activities

2. Material and Methodology

Early planning for this study involved obtaining site permission and conducting preliminary site observations at the oil and gas company topside project located at Malaysia Marine and Heavy Engineering (MMHE), Pasir Gudang, Johor. The study adopted a mixed-method approach to systematically identify hazards, assess risks, and evaluate safety practices related to grinding operations.

2.1 Materials

The materials used in this study consisted of grinding equipment commonly utilised at the project site, including angle grinders and pencil grinders. Research instruments included a Hazard Identification, Risk Assessment, and Risk Control (HIRARC) form based on the DOSH HIRARC Guideline 2008, a structured questionnaire distributed to grinding workers, and semi-structured interview questions used for discussions with Health, Safety, and Environment (HSE) personnel and foremen. Supporting materials such as past incident records, near-miss reports, and site observation notes related to grinding activities were also reviewed to support hazard identification and risk assessment.

2.2 Methods

This study employed a mixed-method research design involving HIRARC assessment, questionnaire surveys, and semi-structured interviews. The research process began with instrument development, followed by pilot testing to ensure clarity and suitability of the questionnaire and interview questions. Data collection was then carried out through questionnaire distribution to 11 workers involved in grinding operations and interviews with members of the HSE team and foremen.

Hazard identification was conducted through site observation, review of incident records, and consultation with site personnel. Risk assessment was performed using the HIRARC risk matrix by evaluating the likelihood and severity of each identified hazard. Existing control measures were reviewed, and additional control measures were proposed based on the hierarchy of controls. The overall research process followed a structured flow beginning from site permission, instrument development, pilot testing, data collection, HIRARC completion, and data analysis. The overall research flow for this study is illustrated in Figure 1.

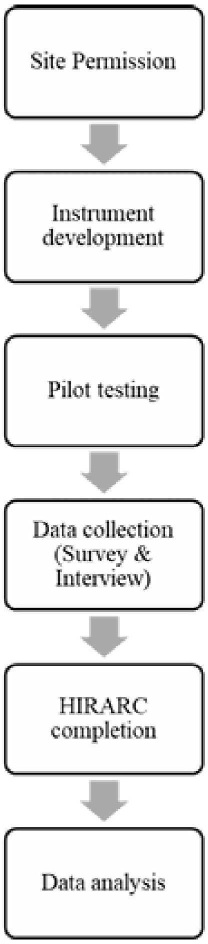

Figure 1 *Data collection flowchart*

2.3 Data Analysis

Quantitative data obtained from the questionnaire survey were analyzed using the Statistical Package for Social Sciences (SPSS). Descriptive statistical analysis was applied to determine frequencies, percentages, and mean values related to grinding hazards, risk awareness, and safety practices. Qualitative data from semi-structured interviews were analysed through manual thematic categorisation to identify recurring safety issues, unsafe practices, and challenges in implementing control measures. Findings from both quantitative and qualitative analyses were integrated with the HIRARC assessment to support the evaluation of grinding-related risks and the proposal of suitable control measures.

3. Results and Discussion

Table 1: Ranking of grinding hazards based on mean scores

Rank	Hazard	Mean
1	Sparks/ Airborne Dust and Noise exposure	4.55
2	Emission of metal fragments or particles	4.45
3	Eye irritation or discomfort	4.00
4	Grinding wheel disc Fracture	3.82
5	Vibration and Fire ignition	3.55

The first objective of this study was to identify the main hazards associated with grinding activities at the oil and gas company's topside project. The results from the questionnaire survey and site observation indicate that workers are exposed to multiple hazards during grinding operations. As shown in Table 1, sparks and airborne dust, noise exposure, and emission of metal fragments recorded the highest mean scores (mean = 4.45–4.55), indicating that these hazards are frequently encountered. Eye irritation or discomfort also recorded a high mean score (mean = 4.00), suggesting regular exposure to dust and sparks during grinding.

Moderate mean scores were observed for grinding wheel disc fracture and vibration or fire ignition (mean = 3.55–3.82), indicating that while these hazards are less frequent, they remain significant due to their potential severity. These findings are consistent with site observations and interview responses, where workers highlighted noise, sparks, vibration, and flying particles as common risks. Overall, the results confirm that physical hazards are the dominant hazards during grinding operations, thus achieving the first objective.

Next, the second objective was to assess the level of risk associated with grinding hazards using a semi-quantitative risk assessment approach. Based on the HIRARC risk matrix, grinding-related hazards such as exposure to sparks, flying metal fragments, excessive noise, and improper handling of grinding equipment were generally classified as medium to low risk. This classification reflects that although these hazards occur frequently during grinding activities, existing control measures reduce the severity of potential injuries. The risk assessment results indicate that hazards with higher mean scores tend to correspond to medium risk levels, particularly during active grinding work and equipment preparation stages. For instance, sparks and airborne particles were commonly encountered but were assessed as medium risk due to the availability of personal protective equipment and established work procedures that limit injury severity.

Table 2: HIRARC Results Form

1. Hazard Identification				2. Risk Analysis				3. Risk Control	
No	Work Activity	Hazard	Which can cause/ effect	Existing Risk Control (if any)	Likeli-hood	Seve rity	Risk	Recommended Control Measures	PIC (Due date/ status)
1.	Equipment and tool preparation	Incompetent operator (lack of training)	- Pick wrong wheel size of disc (speed rating) - Fail to inspect grinder and disc before use - Install grinding disc incorrectly - Remove or not use the wheel guard	- Grinding awareness training - Tools box talk briefing	3	4	12 (Medium)	Administrative control: - Supervision by grinder supervisor - Competency assessment - Refresher training	HSE/ Foreman grinder
		Improper PPE selection	Hand, eye, body injury	- PPE Issuance (Semi leather glove, high impact face shield, N95 mask, ear plug, ear muff)	2	4	8 (Medium)	Administrative control: - PPE briefing - Supervision - PPE Enforcement before enter site area	HSE/ Foreman grinder
2.	Site Observation	Poor housekeeping	Slip, trip, loss of balance	- Toolbox briefing - Mass housekeeping every Friday	3	3	9 (Medium)	Administrative control: - Pre-Job housekeeping check	Foreman grinder/ Operator

		Presence of flammable materials	Fire explosion	- Firewatcher - Fire extinguisher 1kg - Fire blanket	1	4	4 (Low)	Administrative: Walkabout around site area	HSE
3.	Disc Installation	Defective/ expired disc	Disc rupture, severe injury	Visual inspection	2	4	8 (Medium)	Administrative: Disc Expired tagging & colour	HSE
		Wrong disc size/ RPM (Rotation Per Minute)	Kickback, disc breakage	Supervisor verification	2	4	8 (Medium)	Administrative: Disc selection chart	HSE
		Guard removed/ not installed	Flying debris, hand injury	Wheel Guard available	2	4	8 (Medium	Engineering: Mandatory fixed wheel guard	HSE
		Improvised tool used (not pin spanner)	Hand injury	Toolbox reminder	2	4	6 (Medium)	Administrative: inspection to prohibit improvised tools	HSE
4.	Plug-in grinding socket to electrical sources	damaged cable	Electric shock	Visual inspection	2	4	8 (Medium)	Substitution: Change with more thick electrical cable	HSE
		Wet environment	Electrocution	Area kept dry	1	4	4 (Low)	Administrative: Stop work during wet condition	HSE/ Foreman Grinder
5.	Grinding operation	Grinder kickback	Severe hand/ arm injury	- Grinding awareness - Anti-kickback - Dead-man switch	3	4	12 (Medium)	Administrative: Proper Grinding training	Management
		Loss of grip (thick glove/ wrong glove)	Finger amputation	Gloves provided	3	4	12 (Medium)	Adminisrative: Toolbox talk briefing regarding PPE matrix to workers.	HSE
		Flying sparks/ particles	Eye, face, injury	Face shield and goggles	3	3	9 (Medium)	Engineering: shielding	Foreman grinder/ operator
		Overhead grinding	Thigh/ body injury	- 2 minutes grinding overhead rules - Supervisor monitoring	2	4	8 (Medium)	Administrative: Training on workers uses a 7 inch grinding machine within 2 minutes if overhead needs overhead grinding.	Management
		Excessive noise	Temporary hearing loss	Ear plug/ ear muff	3	2	6 (Medium)	Administrative: Exposure time control	HSE
		Vibration	fatigue	- Semi leather glove - Awareness	2	2	4 (Low)	Engineering: Vibration dampened grinder	Management
6.	Unplugging grinding socket	Plug pulled by cable	Cable damage, shock	Awareness	2	3	6 (Medium)	Administrative: Proper unplugging practice	Operator
7.	Housekeeping after work completion	Leftover sharp metal	Cut injury	Cleaning practise - Mass housekeeping	2	3	6 (Medium)	Administrative: End-of-job inspection	Foreman grinder/ HSE
		Grinder left plugged in	Accidental start	Switch-off reminder	1	4	4 (Low)	Administrative: Lock-out after use	Foreman grinder/ HSE

The third objective focused on evaluating existing control measures and proposing improvements to reduce grinding-related risks. Findings from the questionnaire, interviews, and site observations show that several control measures are already in place, including the use of personal protective equipment (PPE), permit-to-work (PTW) systems for hot work, equipment inspections, and competency verification through training and certification.

However, gaps were also identified, such as inconsistent PPE usage, prolonged exposure to noise and vibration, and limited administrative controls for work rotation. Based on the hierarchy of controls, additional measures were proposed, including stricter enforcement of PPE compliance, regular refresher training, improved supervision, proper selection and inspection of grinding discs, and enhanced housekeeping practices.

4. Conclusion

This study applied the Hazard Identification, Risk Assessment, and Risk Control (HIRARC) approach to evaluate grinding operations at an oil and gas topside project. The findings show that grinding activities expose workers to multiple hazards, particularly during equipment preparation and active grinding, with several risks classified as medium to high despite existing controls. Survey and interview results indicated that while workers generally understand grinding hazards and the importance of personal protective equipment, unsafe practices and inconsistent compliance remain, often influenced by human factors such as inadequate supervision and complacency. These results highlight that awareness alone is insufficient without continuous monitoring and enforcement of safety measures. Overall, the study demonstrates that the systematic use of HIRARC is crucial in prioritizing risks and strengthening control measures, supporting safer grinding operations in high-risk industrial environments.

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Conflict of Interest

The authors declared that there is no conflict of interest regarding the publication of the paper.

Author Contribution

The authors confirm contribution to the paper as follows: ***study conception and design:*** *Putriana Helmi, Mohd Akhir Ahmad, Muhamad Zulhilmi Md Foa'at;* ***data collection:*** *Putriana Helmi, Muhamad Zulhilmi Md Foa'at;* ***analysis and interpretation of results:*** *Putriana Helmi, Mohd Akhir Ahmad;* ***draft manuscript preparation:*** *Putriana Helmi. All authors reviewed the results and approved the final version of the manuscript.*

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