Application of the HIRADC Method for Hazard Risk Mitigation in Steel Pipe Manufacturing Processes

Wulung Aditya[1], Rachmat Yustiawan Hadi[2], Cayo Pungki Andrianto[3], M. Ferdaus Noor Aulady[4]
[1,2,3,4,5] Master of Industrial Engineering, Institut Teknologi Adhi Tama Surabaya, Indonesia
[1]wulungaditya.teknikindustri@gmail.com
[2]rachmatyustiawan@gmail.com
[3]cayopungki85@gmail.com

Abstract. *This study applies the Hazard Identification, Risk Assessment, and Determining Control (HIRADC) method to evaluate occupational health and safety (OHS) risks in a steel pipe manufacturing company in East Java, focusing on machine installation and construction work performed by third-party contractors. These activities pose elevated risks due to limited supervision and inconsistent OHS standards among contractors. A qualitative-descriptive approach was used, incorporating direct observations and semi-structured interviews with 13 participants—10 contractor workers and 3 internal safety officers. The HIRADC process identified 43 hazards, initially categorized into 16 low-, 20 medium-, and 7 high-risk levels. After implementing control measures based on the hierarchy of controls (elimination, substitution, engineering controls, administrative controls, and use of PPE), risks were significantly reduced to 35 low- and 8 medium-risk hazards. Notably, all hazards in machine installation work were reduced to low risk, while in construction work, all high-risk hazards were eliminated, resulting in 8 medium- and 24 low-risk hazards. The findings confirm the effectiveness of structured risk control strategies and highlight the value of HIRADC in contractor-managed operations. This study reinforces the importance of strengthening administrative and engineering controls and maintaining ongoing risk assessments. It also emphasizes the need for continuous training and management commitment to ensure the sustainability of OHS systems in dynamic industrial environments.*

Keywords: *HIRADC, Occupational Risk, Steel Pipe Industry, Contractor, Control Hierarchy.*

1. Introduction

Occupational Health and Safety (OHS) is a critical aspect of industrial operations, not only related to the protection of workers but also reflecting a company's social responsibility in creating a safe, healthy, and productive working environment. The implementation of an effective OHS management system has been proven to reduce workplace accidents, lower accident-related costs, and enhance both operational efficiency and corporate reputation (Ridley & Channing, 2008).

In practice, tasks involving third parties or external contractors tend to carry more complex risks. This is due to several contributing factors, including variations in OHS standards applied by contractors, limited direct supervision by the parent company, and the temporary yet high-risk nature of such work (Goetsch, 2011). In the steel pipe manufacturing industry, such as at PT. XYZ, activities like production machine installation, civil works (e.g., excavation, foundation, and concreting), and steel structure construction are routine tasks often delegated to third-party contractors.

To effectively manage these risks, a systematic and comprehensive approach is required. One such approach is the HIRADC method (Hazard Identification, Risk Assessment, and Determining Control), which forms an integral part of the OHS management system aligned with the international standard ISO 45001:2018. This standard mandates organizations to regularly identify hazards and assess risks to prevent workplace accidents and continuously improve OHS performance (ISO, 2018).

Furthermore, national regulations such as the Regulation of the Minister of Manpower of the Republic of Indonesia No. 5 of 2018 concerning Occupational Health and Safety in the Work Environment explicitly require all employers to conduct hazard identification and risk assessment as a basis for hazard control (Ministry of Manpower RI, 2018). This regulation aligns with the principles of HIRADC and provides the legal foundation for OHS implementation across all industrial sectors in Indonesia.

However, in real-world applications, the implementation of HIRADC by third-party contractors is often performed only as a formality, lacking in-depth analysis. As a result, risks such as falling from heights, being struck by heavy equipment, and exposure to hazardous chemicals persist—threatening both worker safety and project continuity (Manu et al., 2013).

This study aims to conduct an OHS risk analysis using the HIRADC method, specifically focusing on machine installation and construction work performed by contractors in the steel pipe industry at PT. XYZ. What distinguishes this study from previous applications of HIRADC is its practical, in-depth evaluation of how effectively the method is implemented in a real industrial setting involving third-party contractors—an area that has received limited empirical attention. By focusing on the operational context in Indonesia's steel manufacturing sector, this study provides new insights into the applicability and effectiveness of HIRADC in environments where regulatory compliance is expected but not always substantively achieved.

Through hazard identification, risk assessment, and the determination of appropriate control measures, the findings of this study are expected to serve as a foundation for strengthening supervision and risk management systems, particularly for activities involving external parties.

[1] Corresponding author: indonesia@mail.com

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2. Methods

This study adopts a qualitative-descriptive approach that incorporates both narrative and numerical elements to analyze occupational health and safety (OHS) risks, with a particular focus on activities involving external contractors in the Engineering Department of a steel pipe manufacturing company located in East Java. The selected activities—machine installation and civil construction—are known for their high-risk nature and are commonly delegated to third-party contractors, making them a relevant focus for hazard and risk analysis.

To assess OHS risks, the study employs the HIRADC framework (Hazard Identification, Risk Assessment, and Determining Control), which is aligned with ISO 45001:2018. The HIRADC process includes: (1) identifying potential hazards related to the observed work activities, (2) assessing the risks by evaluating the likelihood (frequency or probability of occurrence) and severity (impact of consequences) using a standardized risk matrix, and (3) determining appropriate control measures based on the level of risk. While risk scores are derived numerically, they serve as structured inputs to support qualitative interpretation and decision-making, not for statistical inference.

Data collection was carried out through direct field observations and semi-structured interviews. The sample was selected using purposive sampling, targeting individuals directly involved in or responsible for managing high-risk activities. A total of 13 respondents participated in the interviews, including 10 contractor workers and 3 internal safety officers. Interviews focused on work procedures, awareness of potential hazards, and the implementation of safety controls in practice. Each interview lasted between 30 to 60 minutes and was guided by a predefined protocol to maintain consistency across sessions.

Observations were conducted over a two-week period, during which the researcher monitored ongoing machine installation and construction activities on-site, taking structured notes and documenting observed hazards and compliance with safety procedures. Validation of data was ensured through triangulation, which involved comparing findings from interviews with direct observations and reviewing supporting documents, such as safety inspection checklists and incident logs.

This methodology enables a context-rich analysis of how the HIRADC method is applied in real industrial settings and how well it supports safety performance among third-party contractors. By combining field evidence with structured risk assessments, this study offers both practical insights and critical evaluations of HIRADC implementation in an operational environment that is often underrepresented in empirical OHS research.

The overall risk level for each hazard was calculated using the following formula:

$$\textit{Risk}\ (R) = \textit{Likelihood}\ (L) \times \textit{Severity}\ (S) \qquad (1)$$

Table 1
Risk Assessment Methods Based on Likelihood (Source: ISO 31010, 2019)

Level	Likelihood Description	Probability (%)	Frequency
1	Rare	< 5%	May occur only in exceptional cases.
2	Unlikely	5% – 20%	Could happen at some time.
3	Possible	21% – 50%	May occur under certain conditions.
4	Likely	51% – 80%	Will probably occur in most situations.
5	Almost Certain	> 80%	Expected to occur frequently or frequently.

Table 2
Risk Evaluation Method Based on Severity (Source: Sukwika & Pranata, 2022)

Level	Category	Description
1	Insignificant	Without injury and/ or very small loss the meter.
2	Minor	Needs treatment/ first aid and/ or level loss material currently.
3	Moderate	Need maintenance medical (so that need Rest temporary time) which has an impact on the disappearance day work and/ or cause loss sufficient material big
4	Major	Resulting in loss of body function (disability) and / or the production process stops and/ or result in loss great material.
5	Catastrophe	Causing death and/ or resulting loss very material big.

The risk level obtained after analysis based on Likelihood and Severity can be further categorized using a risk matrix, as shown below:

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Risk Analysis			*Likelihood Level*				
			1	**2**	**3**	**4**	**5**
			Rare	*Unlikely*	*Possible*	*Likely*	*Almost Certain*
Severity Level	**1**	*Insignificant*	1	2	3	4	5
	2	*Minor*	2	4	6	8	10
	3	*Moderate*	3	6	9	12	15
	4	*Major*	4	8	12	16	20
	5	*Catastrophe*	5	10	15	20	25

Fig. 1 Risk Matrix Based on Likelihood and Severity (Source: Sukwika & Pranata, 2022)

The risk level resulting from the risk score calculation can be interpreted as follows:

Table 3
Risk Score, Category, Indicator Color and Action (Source: Sukwika & Pranata, 2022)

Risk Score	Category	Indicator Color	Action
> 16	Very High/ Extreme	Dark Red	Need action control potential danger with as soon as possible maybe (prioritized emergency do control potential danger).
10-16	High	Red	Need action control potential danger with immediately (prioritized for do control potential danger).
5-9	Medium	Yellow	Need planning control danger .
0-4	Low	Green	Can under consideration as potential danger which can accepted and no need an action special.

3. Results and Analysis

3.1. Risk Evaluation Before Improvement

Risk evaluation is conducted by determining the risk level through the multiplication of the *Likelihood* and *Severity* levels for each potential hazard. The following is the risk evaluation of the existing condition, prior to any improvements in Machine Installation Work.

Table 4
Risk Evaluation of Hazards in Machine Installation Work (Before Improvement)

No.	Job	Hazard Source	Potential Hazard	Severity Impact	Before Improvement			
					Likelihood	Severity	Risk Score	Risk Category
1	Machine Handling	- Engine fall	- Engine fall	- Bruises, cracks, fractures	2	4	8	Medium
		- Clamping machine	- Clamped machine	- Bruises, cracks, fractures	2	4	8	Medium
		- Hit by the engine	- Hit by the engine	- Bruises, cracks, fractures	2	4	8	Medium
		- Scratched	- Scratch wounds	- Scratch wounds	2	1	2	Low
2	Machine Setting	- Clamping machine	- Clamped machine	- Bruises, cracks, fractures	2	4	8	Medium
		- Hit by the engine	- Hit by the engine	- Bruises, cracks, fractures	2	4	8	Medium
		- Hit by a hammer	- Hit by a hammer	- Bruises, blow injuries	2	1	2	Low
		- Pierced by nails	- Pierced by nails	- Bruises, puncture wounds	2	1	2	Low
		- Scratched	- Scratch wounds	- Scratch wounds	2	1	2	Low
3	Machine Trial	- Clamping machine	- Clamped machine	- Bruises, cracks, fractures	2	4	8	Medium
		- Hit by the engine	- Hit by the engine	- Bruises, cracks, fractures	2	4	8	Medium

Based on the table above, the Risk Evaluation of Hazards in Machine Installation Work (Before Improvement) shows the following risk categories: Extreme = 0, High = 0, Medium = 7, and Low = 4.

Using the same calculation method, the Risk Evaluation of Hazards in Construction Work (Before Improvement) shows the following risk categories: Extreme = 0, High = 7, Medium = 13, and Low = 12.

3.2. Risk Evaluation and Control Measures (After Improvement)

Risk control identification is carried out based on the hierarchy of controls, which includes: elimination, involving the removal of hazardous conditions; substitution, referring to the replacement of hazardous actions or conditions; engineering controls, which incorporate the use of technology and closely monitored work methods to minimize risks; administrative controls,

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consisting of structured procedures or methods; and the use of Personal Protective Equipment (PPE) to ensure worker protection from occupational hazards and risks. The risk control measures for work activities in the Engineering Department are as follows:

Table 5
Risk Evaluation of Hazards in Machine Installation Work (After Improvement)

No.	Job	Hazard Source	Control	After Improvement			
				Likelihood	*Severity*	*Risk Score*	*Risk Category*
1	Machine Handling	- Engine fall	- Standard inspection of used equipment	1	2	**2**	**Low**
		- Clamping machine	- Safety sign	2	2	**4**	**Low**
		- Hit by the engine	- Standard inspection of used equipment	2	2	**4**	**Low**
		- Scratched	- Wearing gloves	2	1	**2**	**Low**
2	Machine Setting	- Clamping machine	- Safety sign	2	1	**2**	**Low**
		- Hit by the engine	- Check the condition of the equipment to be used	2	1	**2**	**Low**
		- Hit by a hammer	- Wearing gloves	2	1	**2**	**Low**
		- Pierced by nails	- Wearing gloves	2	1	**2**	**Low**
		- Scratched	- Wearing gloves	2	1	**2**	**Low**
3	Machine Trial	- Clamping machine	- Safety sign	2	1	**2**	**Low**
		- Hit by the engine	- Standard inspection of used equipment	2	1	**2**	**Low**

Based on the table above, the Risk Evaluation of Hazards in Machine Installation Work (After Improvement) shows the following risk categories: Extreme = 0, High = 0, Medium = 0, and Low = 11.

Using the same calculation method, the Risk Evaluation of Hazards in Construction Work (After Improvement) shows the following risk categories: Extreme = 0, High = 0, Medium = 8, and Low = 24.

The following is a visual comparison chart showing the number of risks before and after the intervention for machine installation and construction work:

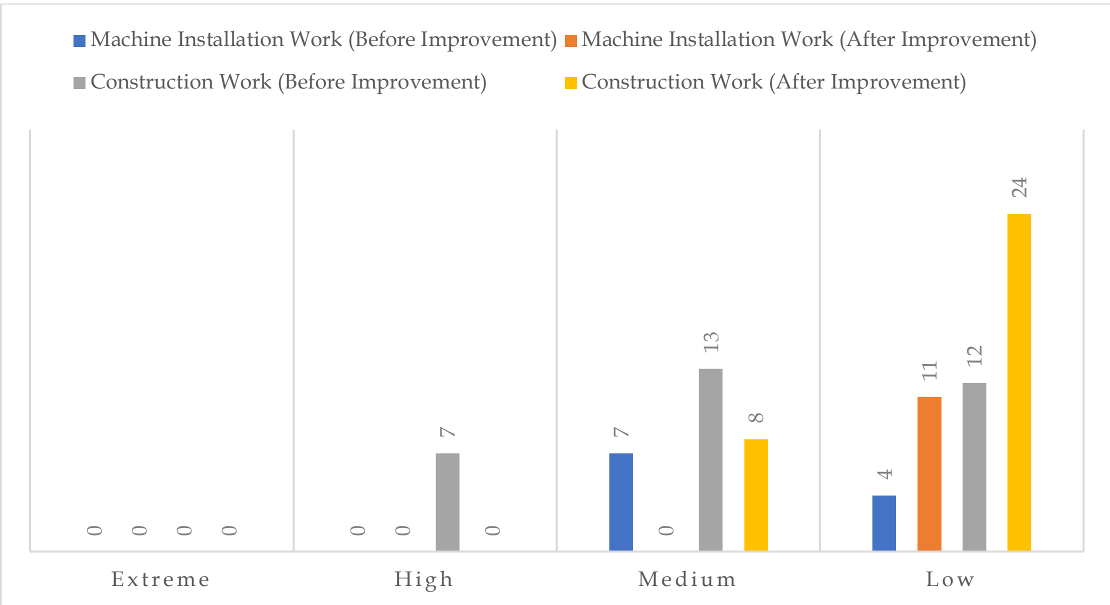

Fig. 2 Risk Comparison Before and After Improvement Chart

This chart illustrates:
A significant reduction in Medium and High risk categories following the implementation of control measures. All hazards in machine installation work were successfully reduced to the Low risk category. In construction work, High risks were completely eliminated, with a notable increase in Low risk hazards.

Limitations and Critical Reflections:

This single-case study at PT. XYZ limits the generalizability of the findings. The effectiveness of control measures depends on worker compliance and contractor cooperation, which were not quantitatively measured. Long-term sustainability is uncertain without ongoing training, monitoring, and management support. Organizational barriers to maintaining and scaling risk controls were also not explored.

4. Conclusion

Based on the HIRADC analysis conducted in the Engineering Department of a steel pipe manufacturing facility in East Java—covering activities such as machine installation and construction work—a total of 43 potential hazards were identified and initially classified into 16 low-risk, 20 medium-risk, and 7 high-risk categories. Following the implementation of risk control measures based on the hierarchy of controls (elimination, substitution, engineering controls, administrative controls, and the use of PPE), a significant reduction in risk levels was observed. Post-intervention, 35 hazards were classified as low risk and 8 as medium risk. Notably, all hazards in machine installation work were reduced to the low-risk category, while in construction work, all high-risk hazards were eliminated, resulting in 8 medium-risk and 24 low-risk hazards. These findings demonstrate the effectiveness of the applied risk control interventions.

It is recommended that the company maintains and continuously improves its application of the hierarchy of controls, with particular emphasis on enhancing administrative and engineering controls. Regular risk evaluations should be conducted as part of a sustainable occupational health and safety management system to ensure responsiveness to changes in work processes and emerging hazards.

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