Quest Journals
Journal of Architecture and Civil Engineering
Volume 10 ~ Issue 8 (August 2025) pp: 53-58
ISSN(Online): 2321-8193
www.questjournals.org

Research Paper

Risk Analysis and Control Measures in Pipe Welding Activities on Construction Sites

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ABSTRACT:
Pipe welding is a critical activity in construction projects that presents significant safety challenges, with its core tasks initially assessed at a high-risk level (risk score: 12). The overall process involves numerous hazardous supporting activities, notably lifting operations using Heavy Equipment (HE), which also carry a high-risk potential for severe injuries, equipment damage, and fatalities. This study identifies various hazards across these integrated tasks—from welding arc light and fumes to unstable ground conditions and improper manual handling—and evaluates control measures to mitigate these risks to a moderate (score: 6) or low (score: 3) level. Key risk mitigation strategies include ensuring welder and operator competency, conducting daily inspections of welding and lifting gear, utilizing appropriate Personal Protective Equipment (PPE), enforcing clear communication protocols, and maintaining direct supervision by safety personnel. The findings demonstrate that a comprehensive risk management approach, combining technical, administrative, and behavioral controls for all related activities from lifting to welding, is essential for significantly reducing work-related accidents and creating a safer construction environment.

KEYWORDS: *HSE, work risk, heavy equipment, risk control, construction, lifting, welding*

***R**eceived 26 July, 2025; **R**evised 03 Aug., 2025; **A**ccepted 05 Aug., 2025 © The author(s) 2025.*
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I. INTRODUCTION

The oil and gas industry is a highly complex sector that demands substantial capital investment and relies heavily on advanced technologies throughout its processing operations. As a consequence of its operational nature, this industry is exposed to a broad spectrum of risks, many of which are classified as high. These include physical hazards and legal liabilities (operational risks), as well as financial losses arising when the expected hydrocarbon reserves are deemed uneconomical (speculative risks) [1]. Risk management plays a vital role in achieving organizational objectives and enhancing performance. This is evident in areas such as occupational health and safety, asset and personnel security, regulatory compliance, public trust, environmental protection, product quality, project execution, operational efficiency, corporate governance, and overall reputation [2].

Work-related accidents refer to incidents that occur as a result of or during the execution of job activities within a project. These accidents are generally attributed to two primary causes: unsafe acts (actions by personnel that deviate from safety protocols), and unsafe conditions (hazardous or uncontrolled environments) [3].

Welding is defined as a metal joining technique whereby parts of the base and filler metals are melted with or without additional filler materials to form a continuous. Several factors affect welding quality, including welding procedures, which outline the planning and technical specifications required for the fabrication process. These include material preparation, proper sequencing, equipment and consumable selection, and workforce assignment [4].

This study specifically focuses on pipe welding activities within the oil and gas industry and applies a qualitative approach to analyze the significance of associated work risks in construction projects. To enhance the depth and credibility of the findings, the research employed qualitative data collection methods, including in-depth interviews and Focus Group Discussions (FGDs), to determine the severity and relevance of welding-related hazards. The results aim to emphasize the importance of comprehensive risk management in the context

of Health, Safety, and Environmental (HSE) aspects, urging project stakeholders and practitioners to implement proactive and preventive safety measures throughout construction operations.

II. PIPE WELDING

Welding is a critical stage in Flowline construction. Each pipe goes through various stages of welding, x-ray, and testing. The quality of welding work achieved significantly determines the overall quality, safety, and operations.

Table.1 Hazards in Pipe Welding

No.	Job Activities	Hazards
1	Surveying the work area	Biological hazards
		Clearing the area with a machete
2	Traveling to the worksite	Road bends and intersections (blind spots)
		Traffic congestion, narrow roads, slippery surface, rain
		Over speed
		Equipment malfunction
	Entering the worksite	Slippery and potholed roads
		Biological hazards
3	Mobilizing materials and accessories using boom truck	Road bends and intersections (blind spots)
		Traffic congestion
		Narrow and slippery roads due to rain
		Equipment malfunction
		Loose or weak chain bindings
		Climbing on/off the vehicle
		Oncoming vehicle movement
		Distance between vehicles
		Road conditions: narrowing roads, inclines, declines, and turns
		Transporting materials and equipment
4	Lifting using HE (boom truck and excavator)	Unstable ground surface
		Uncompacted soil
		Swing he
		Lifting with HE
		Releasing shackles from equipment
	Manual lifting of materials	Load too heavy
		Incorrect body position
		Fingers and hands pinched
	Hot cutting - cutting torch - cutting roll	Leaking hoses
		Sparks
		Falling gas cylinders and cut materials
	Welding pipe	Welding arc light
		Welding fumes
		Electric current
		Heat source
		Sparks
5	Grinding and brushing	Grinding stone
		Electric current
		Dust/particles from grinding
		Grinder rotation
6	Manual excavation	Improper body posture
		Unsafe hand and foot positioning
7	Excavation and backfilling	Unstable ground surface
8	Using excavator	Swing excavator
		Excavation holes
9	Pipe wrapping work	Unsafe hand positioning
10	Holiday test work	Unsafe hand positioning
11	Installing slip blinds	Finger pinching hazard

No.	Job Activities	Hazards
12	Scaffolding erection and dismantling	Fall from height
		Falling materials
13	Bolting unbolting	Finger pinching hazard
14	Finishing painting	Paint/thinner vapors and spills
15	Housekeeping	Work waste and debris
		Puncture from sharp objects

III. RISK ANALYSIS

According to AS/NZS 4360:2004 [5], this risk analysis considers the combination of two elements: consequence (severity) and probability (likelihood), to define Risk. There is a strong correlation between the level of risk and the severity and likelihood of its occurrence. This analytical method takes into account two key factors: consequence and probability.

This analytical approach focuses on two key components:

1. **Severity of the Consequence**
2. **Likelihood of the Probability**

During the evaluation, risk is defined as a function of how likely an event is to occur and the extent of its possible impact. Essentially, the risk index (R) is derived by multiplying the probability (P) by the consequence (C):

Risk Index (R) = Probability (P) × Consequence (C)

The resulting risk level plays a vital role in supporting risk management decisions. By ranking risks according to their index, organizations can effectively prioritize actions, allocate necessary resources, and determine suitable mitigation or response strategies.

Risk Score	Description	Risk Category
1-3	L	*Low*
4-9	M	Moderate
10-16	H	High
17-25	VH	*Very High*

Source : 3rd Edition of the Australian and New Zealand Standard on Risk Management (2004)

Figure 1. Risk Level

Table 2. Risk Category in Pipe Welding

No.	Job Activities	Hazards	Initial Risk			Residual Risk		
			P	C	R	P	C	R
1	Surveying the work area	Biological hazards	3	2	6	3	1	3
		Clearing the area with a machete						
2	Traveling to the worksite	Road bends and intersections (blind spots) Traffic congestion, narrow roads, slippery surface, rain	3	2	6	3	1	3
		Over speed						
		Equipment malfunction						
		Road bends and intersections (blind spots)						
	Entering the worksite	Slippery and potholed roads	3	2	6	3	1	3
		Biological hazards						
3	Mobilizing materials and accessories using boom truck	Road bends and intersections (blind spots)	3	3	9	3	2	6
		Traffic congestion						
		Narrow and slippery roads due to rain						
		Equipment malfunction						
		Loose or weak chain bindings						
		Climbing on/off the vehicle						
		Oncoming vehicle movement						

No.	Job Activities	Hazards	Initial Risk			Residual Risk		
			P	C	R	P	C	R
		Distance between vehicles						
		Road conditions: narrowing roads, inclines, declines, and turns						
		Transporting materials and equipment						
4	Lifting using HE (boom truck and excavator)	Unstable ground surface	4	3	12	3	2	6
		Uncompacted soil						
		Swing he						
		Lifting with HE						
		Releasing shackles from equipment						
	Manual lifting of materials	Load too heavy	2	3	6	2	3	6
		Incorrect body position						
		Fingers and hands pinched						
	Hot cutting - cutting torch - cutting roll	Leaking hoses	3	4	12	1	3	3
		Sparks						
		Falling gas cylinders and cut materials						
	Welding pipe	Welding arc light	3	4	12	3	2	6
		Welding fumes						
		Electric current						
		Heat source						
		Sparks						
5	Grinding and brushing	Grinding stone	3	3	9	3	2	6
		Electric current						
		Dust/particles from grinding						
		Grinder rotation						
6	Manual excavation	Improper body posture	2	2	4	2	1	2
		Unsafe hand and foot positioning						
7	Excavation and backfilling	Unstable ground surface	3	3	9	2	2	4
8	Using excavator	Swing excavator	3	3	9	2	2	4
		Excavation holes						
9	Pipe wrapping work	Unsafe hand positioning	3	2	6	2	1	2
10	Holiday test work	Unsafe hand positioning	3	2	6	2	1	2
11	Installing slip blinds	Finger pinching hazard	3	3	9	2	3	6
12	Scaffolding erection and dismantling	Fall from height	3	1	3	2	1	2
		Falling materials						
13	Bolting unbolting	Finger pinching hazard	3	3	9	3	1	3
14	Finishing painting	Paint/thinner vapors and spills	3	2	6	3	1	3
15	Housekeeping	Work waste and debris	2	2	4	2	1	2
		Puncture from sharp objects						

Source: Risk Category Project (2025)

The lifting procedure using Heavy Equipment (HE), such as boom trucks and excavators, carries a risk level of 12 (High) across all identified hazards. These include unstable ground surfaces that could cause the HE to sink, uncompressed soil leading to equipment subsidence, and HE swing movements that may strike workers, causing injuries, fractures, unconsciousness, or damage to surrounding equipment. Control measures include ensuring that HE operators are competent, identifying the ground surface before positioning the HE, and placing the HE on stable ground with strong support that prevents sinking. Make sure no workers are present within the HE swing area, install warning signs and barricades in the HE operation area, and supervise HE activities to reduce the risk level to 6 (Moderate).

Lifting with HE can lead to the equipment toppling, potentially causing worker injuries, fractures, or fatalities. Control measures include ensuring all involved workers are competent and understand the work procedures and potential pinch points, being cautious with hand and finger positions, using appropriate

equipment, and always wearing high-impact gloves. Before starting, conduct a daily checklist of HE and lifting gear, ensure the gear has been inspected and is certified. Match the weight of the pipe or load being lowered or lifted with the maximum capacity of the HE and lifting gear. Ensure HE is positioned safely around pipes or trenches, with a minimum excavator distance of 0.5 meters from the edge. The operator must follow the lifting plan and be aware of HE movement and the load. Only one rigger is allowed to give signals, and communication between the rigger and operator must be clear. Supervision by a supervisor and Safetyman is mandatory. Ensure no workers walk through the HE working radius, and place signs and barricades around the HE and excavator to reduce the risk level to 6 (Moderate).

Installing lifting gear may lead to detached equipment, snapped webbing slings, and falling loads that could injure workers or damage equipment. After controls are implemented including performing daily checklists on HE and lifting gear, ensuring the load weight matches the capacity of the HE and gear, confirming lifting gear has been inspected and certified, keeping workers out of the HE operation radius, and placing signs and barricades in the excavator's working area the risk level is reduced to 6 (Moderate).

Risk mitigation can be achieved through periodic equipment inspections, using PPE, administrative controls such as warning signs and HSE tools, limiting the number of workers and working hours, providing HSE education, inspecting work and equipment, and utilizing additional tools like windsocks, handheld transceivers (HT), and drones to aid in safe operations. Further mitigation includes improving cooperation and communication between employees and HR teams in implementing HSE aspects [6]. Supervision and repair of damaged public utilities should also be conducted. Efficient work scheduling, such as transporting soil and materials outside of peak hours, helps traffic flow. Other risks can be mitigated through careful planning for adverse weather. Building new roads or repairing existing ones is also recommended [7].

Releasing shackles from equipment can cause pinch injuries, bruises, or fractures, with a risk level of 12 (High). Control measures include ensuring only competent workers perform the task, maintaining good communication between rigger and operator, identifying pinch points, positioning hands and fingers safely, using suitable tools, following work procedures, and always wearing high-impact gloves to reduce the risk to 6 (Moderate).

Work accidents can be prevented by wearing proper footwear such as boots, using protective equipment including wide-brimmed hats for face protection, thick plastic gloves, cloth or disposable masks, and boots to reduce injury risk [8].

Manually lifting materials presents risks such as strains from heavy loads, falling objects, back injuries from poor posture, and finger or hand pinching, all with a risk level of 6 (Moderate). Controls include avoiding forced lifting by seeking assistance, using proper body posture, wearing job-appropriate PPE, keeping loads under one-third of body weight, ensuring safe and obstacle-free movement, and protecting against sharp edges. These measures reduce the risk level to 3 (Low).

Hot cutting poses risks such as hose leaks causing gas leakage or fires, sparks that may damage eyesight, burn skin, or start fires, and falling cylinders or material pieces that may strike and injure workers. Controls include checking hose suitability and leaks, providing water spray for leak detection, ensuring flashbacks are installed on oxygen and acetylene regulators, removing flammable materials from the area, having fire extinguishers available, using proper PPE, performing gas tests with detectors before hot work, keeping hoses and flammables away from sparks, ensuring the work area isn't dry, and placing cylinders on racks properly. These controls reduce the risk to 3 (Low).

Welding pipes carries a high risk level of 12 (High). Welding light can damage eyes, causing irritation or long-term harm, and welding fumes can lead to respiratory issues or lung damage. Controls include avoiding direct exposure to the arc, wearing welding goggles and cap, and using a fume mask. These measures reduce the risk level to 6 (Moderate).

Electrical hazards can cause shocks and fires, resulting in burns, blisters, unconsciousness, or death. Controls include a pre-work checklist to ensure control steps are implemented, weekly inspections of hot work safety, monthly site inspections for compliance, TKO and CTO communications, checking cables for damage, securing proper cable connections, ensuring grounding and ELCBs are functional, and ensuring maintenance is performed by qualified personnel. These reduce the risk level to 6 (Moderate).

Heat sources may cause burns, blisters, fainting, or fatalities. Control measures include welders using aprons, trousers, and leather gloves, monitoring heat sources during welding, and ensuring gas testing is conducted before hot work. These steps lower the risk to 6 (Moderate).

Sparks may cause fires or explosions. Controls include ensuring flammable items are removed from the work area, using job-appropriate PPE (e.g., fume masks, aprons, trousers), providing fire extinguishers, distancing flammable items from sparks, and conducting gas tests in the hot work area before starting. These actions reduce the risk level to 6 (Moderate).

To prevent irritation from sparks or direct exposure to eyes and skin, and to avoid respiratory issues from gas or vapor inhalation, controls include using PPE such as safety goggles and masks, following instructions in the Material Safety Data Sheet (MSDS), and prohibiting eating or drinking in the work area.

These procedures align with Law No. 1 of 1970 Article 13 on occupational safety, Ministerial Decree No. 333/MEN/1989 on occupational disease reporting, Ministerial Decree No. 187/MEN/1999 on hazardous chemical control, and Government Regulation No. 18 of 1999 (amended by PP No. 101 of 2014) on B3 waste management. Additional measures include following Waste Management Work Instructions (IK), PPE training, safe chemical handling, and fire risk control through the provision of fire extinguishers (APAR), in line with Law No. 1 of 1970, Ministerial Regulation No. 04/MEN/1980 on APAR installation and maintenance, Ministerial Decree No. 186/MEN/1999 on fire response units, and Ministerial Regulation No. PER-02/MEN/1983 on work permit systems. This regulation covers high-risk work activities like welding, emergency preparedness, and the importance of periodic emergency response training [9].

IV. CONCLUSION

This study concludes that lifting operations and related tasks involving HE on construction sites pose high-risk potentials, including injuries, fractures, and fatal accidents. However, these risks can be effectively reduced through the implementation of proper control measures. These include verifying worker and operator competence, performing daily equipment inspections, aligning loads with equipment capacity, and ensuring stable equipment positioning. The consistent use of PPE such as high-impact gloves, welding masks, and protective clothing, combined with strict adherence to safe work procedures and clear communication between riggers and operators, plays a critical role in risk mitigation. Supervision by competent personnel and compliance with safety regulations such as Law No. 1 of 1970 further strengthen the effectiveness of these controls. Additionally, risks associated with hot work, electrical hazards, and manual handling can be minimized through planning, environmental adjustments, and hazard anticipation. By applying an integrated risk management approach, the severity and likelihood of workplace accidents in lifting and other high-risk activities can be significantly lowered, ensuring a safer construction environment.

REFERENCES

[1] R. Sahabuddin, A. Adriyansyah, H. M. Arif, N. S. Suparman, and D. Reskianto, "Pengaruh Kesehatan Dan Keselamatan KerjaTerhadap Kinerja Karyawan," *Jurnal Mirai Management*, vol. 8, pp. 349–357, 2023.

[2] E. Karmeli, S. Suprianto, A. Muis, and B. D. Pamungkas, "Pengaruh Implementasi Keselamatan Dan Kesehatan Kerja (K3) Terhadap Kinerja Karyawan," *Samalewa: Jurnal Riset & Kajian Manajemen*, vol. 1, no. 1, pp. 11–23, Jun. 2021, doi: 10.58406/samalewa.v1i1.368.

[3] M. R. Iskandar and F. Purwoko, "Perilaku Kolom Beton Ringan Akibat Beban Aksial dan Momen," 2021.

[4] C. Qori Alfiyah, A. Yekti Pulih Asih, W. Afridah, and A. Hakim Zakkiy Fasya, "Analisis Risiko Kecelakaan Kerja Dengan Metode Failure Mode And Effect Analysis Pada Pekerja Proyek Kontruksi: Literature Review," *Jurnal Ilmu Psikologi dan Kesehatan (SIKONTAN)*, vol. 1, no. 4, pp. 283–290, Mar. 2023, doi: 10.47353/sikontan.v1i4.715.

[5] B. Hart, "Australian/New Zealand Standard RISK MANAGEMENT," 2006. [Online]. Available: www.saiglobal.com/shop

[6] S. F. Balqist, S. S. Riskijah, and D. Zettyara, "Evaluasi Kinerja Proyek Pembangunan Gedung Apartemen X di Jakarta Selatan," 2025. [Online]. Available: http://jurnal.polinema.ac.id/

[7] Fitriyani, A. Gusti, and F. Hermawati, "Analisis Risiko Keselamatan dan Kesehatan Kerja pada Pekerja Industri Batu Bata di Kabupaten Padang Pariaman," 2023.

[8] R. Orr, D. Maupin, R. Palmer, E. F. D. Canetti, V. Simas, and B. Schram, "The Impact of Footwear on Occupational Task Performance and Musculoskeletal Injury Risk: A Scoping Review to Inform Tactical Footwear," *Int J Environ Res Public Health*, vol. 19, no. 17, p. 10703, Aug. 2022, doi: 10.3390/ijerph191710703.

[9] M. Nur, V. Valentino, R. K. Sari, and A. A. Karim, "Analisa Potensi Bahaya Kecelakaan Kerja Terhadap Pekerja Menggunakan Metode Hazard Identification, Risk Assement And Risk Control (HIRARC) Pada Perusahaan Aspal Beton," *Jurnal Teknologi dan Manajemen Industri Terapan (JTMIT)*, vol. 2, no. 3, pp. 150–158, 2023.