PROGRESS IN ENGINEERING APPLICATION AND TECHNOLOGY
e-ISSN: 2773-5303

PEAT

Vol. 7 No. 1 (2026) 862-869
https://publisher.uthm.edu.my/periodicals/index.php/peat

Hazard Identification, Risk Assessment and Risk Control of Waterbase Tank Cleaning Operations

Harris Hakimy Yusriman[1], Syahrun Neizam Mohd Dzulkifli[1]*

[1] *Department of Chemical Engineering Technology, Faculty of Engineering Technology, Universiti Tun Hussein Onn Malaysia, 84600 Pagoh, Johor, MALAYSIA*

*Corresponding Author: syahrun@uthm.edu.my
DOI: https://doi.org/10.30880/peat.2026.07.01.097

Article Info

Received: 12 January 2026
Accepted: 20 February 2026
Available online: 25 May 2026

Keywords

Waterbase, Tank Cleaning, HIRARC, Risk Control, Risk Assessment, Adhesive Manufacturing

Abstract

In many manufacturing companies, workplace accidents, occupational diseases, and injuries remain major concerns that can affect employee wellbeing, productivity, and overall operational efficiency. These issues are often associated with weaknesses in hazard identification and risk assessment practices, especially when work involves non-routine or high-risk operations such as tank cleaning. Tank cleaning is particularly challenging because it may involve confined space entry, exposure to chemical residues, poor ventilation, slippery surfaces, and the potential for equipment-related hazards if isolation procedures are not properly applied. Therefore, the purpose of this research is to evaluate the hazards and potential dangers during tank cleaning operations in an adhesive manufacturing company using a qualitative approach. This study applies Hazard Identification, Risk Assessment and Risk Control (HIRARC) as the main framework, supported by systematic field observations and a comprehensive review of relevant literature to strengthen the assessment. By combining these methods, the study aims to identify key hazards, determine the level of risk associated with each activity, and recommend suitable control measures based on the hierarchy of controls. The outcomes of this research will support risk reduction efforts and promote safer and healthier working conditions for tank cleaning operations.

1. Introduction

The adhesive manufacturing industry transitioned toward waterbase production systems to reduce environmental impact and VOC emissions. This shift improved worker safety compared to solvent-based alternatives. However, large mixing and storage tanks required frequent cleaning to maintain product consistency and prevent batch contamination. These routine cleaning operations remained essential for ensuring high-quality adhesive formulations.

Despite the absence of flammable solvents, waterbase tank cleaning presented significant occupational hazards. Workers faced risks from chemical residue exposure, ergonomic stressors, and mechanical dangers (1). Confined space entry emerged as a primary concern during these activities. The inherent complexity of chemical feedstocks necessitated stringent safety protocols to protect personnel from physical and health-related injuries (2)(3).

This study established a comprehensive framework for managing risks associated with waterbase tank cleaning. The methodology focused on systematic hazard identification and risk evaluation within an industrial adhesive

plant (3). Researchers identified specific dangers such as slippery surfaces, chemical mists, and physical strain. A structured approach was required to maintain operational efficiency and ensure compliance with safety regulations (4).

2. Methodology

2.1 Research Framework

This study adopts a qualitative research design to explore and understand occupational hazards within the selected case study. Qualitative methods were chosen to allow in-depth examination of real working conditions, practices, and safety-related issues as they occur in the workplace. Data were collected through structured field observations, document analysis, and surveys, enabling comprehensive identification and interpretation of hazards associated with the targeted work activities. A systematic and methodical approach to data collection was applied to ensure consistency and credibility of the findings, thereby supporting a robust analysis of workplace safety conditions.

2.2 Data Collection Method

2.2.1 Field Observation

Field observations were conducted in the waterbase manufacturing area through systematic site inspections to identify potential workplace hazards. The inspections focused specifically on the tank cleaning process, including relevant work stages, equipment, and work practices. Field observations were conducted over a period of four weeks from September to October 2025. A total of five tank cleaning operations were observed. Each observation session lasted approximately 4-5 hours, covering the full cleaning cycle from LOTOTO implementation until tank exit. Observations were conducted once or twice per week depending on production scheduling. This method enabled real-time assessment of worker behavior, equipment use, and environmental conditions under actual operating situations.

2.2.2 HIRARC

Hazard Identification, Risk Assessment, and Risk Control (HIRARC) is a systematic framework used to identify workplace hazards, evaluate the likelihood and severity of associated risks, and implement appropriate control measures to reduce or eliminate those risks. The HIRARC assessment was conducted by the researcher in collaboration with the company's Safety and Health Officer who is registered with DOSH Malaysia. Atmospheric testing was verified by a certified Authorized Gas Tester (AGT).

2.3 Data Analysis

Field data analysis was conducted using the Hazard Identification, Risk Assessment, and Risk Control (HIRARC) framework. Hazard identification was carried out by breaking down the tank cleaning process into sequential work activities using task analysis. Each activity was systematically examined to identify potential physical, chemical, ergonomic, and confined space hazards. Observed unsafe acts, unsafe conditions, and deviations from standard operating procedures were recorded during field inspections. The identified hazards were cross-checked with relevant literature and company safety documents to ensure completeness and consistency.

Risk assessment was performed using a 5×5 qualitative risk matrix. Severity was rated on a scale of 1 (minor injury) to 5 (fatality or permanent disability), while likelihood was rated from 1 (rare occurrence) to 5 (frequent occurrence). The risk value was calculated by multiplying severity and likelihood (Risk = Severity × Likelihood). Risk levels were categorized as Low (1–5), Medium (6–12), and High (15–25) to prioritize necessary control measures.

Appropriate control measures were then identified in accordance with the hierarchy of controls. Existing controls were reviewed, and additional measures were proposed where necessary to effectively manage identified risks and enhance safety in tank cleaning operations.

3. Results and Discussion

This section presents the results obtained from the HIRARC analysis conducted on waterbase tank cleaning operations in an adhesive manufacturing facility. The objective was to systematically identify occupational hazards, assess their associated risk levels, and evaluate existing control measures. Observations were collected through field inspections, site walkthroughs, and review of operational procedures, reflecting real industrial

practices. Tank cleaning activities expose workers to a range of physical, chemical, ergonomic, and confined space hazards. A comprehensive assessment of the tank cleaning process led to the identification of fourteen distinct activities. From these activities, sixteen specific hazards were identified and analyzed. Detailed breakdowns of these findings are presented in the HIRARC Tables 1, 2, and 3 below.

Table 1 *Hazard Identification*

No	Work Activity	Hazard	Effect
1	LOTOTO implementation	Failure or improper application of LOTOTO	Crushing, entrapment, fatal injury
2	Isolation of utilities	Residual pressure or stored energy	Sudden release of energy causing injury
3	Draining remaining product	Splashing of the residue	Eye or skin irritation
4	Opening and closing of tank manhole	Heavy lifting, sharp edges, awkward handling	Cuts, hand injury
5	Ventilation of tank	Inadequate air circulation	Oxygen deficiency
6	Atmospheric testing (Gas testing)	Inaccurate, error in testing or device	Entry into unsafe and hazardous atmosphere
7	Confined space condition	Oxygen depletion during work	Collapse, fatality
8	Descending ladder	Slip or loss of balance	Fracture, head injury
9	Manual scraping of adhesive	Repetitive motion	MSD, muscle fatigue
10	Standing while manual cleaning	Awkward posture	Fall inside confined space
11	Skin contact with adhesive	Dermal exposure	Irritation
12	Heat accumulation	Heat stress	Dizziness, collapse
13	Rinsing inside tank	Wet and slippery surfaces	Fall inside confined space
14	Exiting tank via ladder	Fatigue during climb out	Fall, serious injury

Table 2 *Risk Assessment*

No	Types of Hazards	Hazard	Severity	Likelihood	Risk Value	Risk Rating
1	Health Hazard	Splashing of the residues	3	3	6	Medium
		Inadequate air circulation	5	3	15	High
		Inaccurate, error in testing or device	5	2	10	Medium
		Oxygen depletion during work	5	3	15	High
		Dermal exposure	3	2	6	Medium
		Heat stress	4	3	12	Medium
2	Ergonomic hazard	Heavy lifting	3	2	6	Medium
		Awkward handling on tank manhole	3	2	6	Medium
		Repetitive motion	3	3	9	Medium

Progress in Engineering Application and Technology Vol. 7 No. 1 (2026) p. 862-869

		Awkward posture	3	3	9	Medium

Table 2 (continued) *Risk Assessment*

No	Types of Hazards	Hazard	Severity	Likelihood	Risk Value	Risk Rating
3	Safety Hazard	Failure or improper application of LOTOTO	5	3	15	High
		Residual pressure or stored energy	4	2	8	Medium
		Sharp edges of the tank manhole	3	2	6	Medium
		Slip or loss of balance during the use of ladder	4	3	12	Medium
		Slippery surface inside the tank	4	4	16	High
		Fatigue during climb out	4	3	12	Medium

Table 3 *Risk Control*

No	Work Activity	Hazard	Control Measure
1	Setting ventilation of tank	Inadequate air circulation	**Engineering (3):** 1. Forced mechanical ventilation throughout work (portable blower) **Administrative (4):** 1. Confined space permit system 2. ventilation verification before entry **PPE (5):** None required if atmosphere is safe
2	Operating in confined space condition	Oxygen depletion during work	**Engineering (3):** Continuous ventilation during work **Administrative (4):** 1. Pre-entry and periodic atmospheric testing 2. Standby person present the entire operation **PPE (5):** Safety harness with lifeline
3	LOTOTO implementation	Failure or improper application of LOTOTO	**Administrative (4):** 1. Formal LOTOTO procedure; lock, tag and try-out verification by authorised personnel 2. Permit approval Authorized entrant compulsory authorization

Table 3 (continued) *Risk Control*

No	Work Activity	Hazard	Control Measure
4	Liquid residue on floor	Slippery surface inside the tank	**Engineering (3):** Drainage of liquid residues where practicable prior to work **Administrative (4):** 1. Prior to work, ensure residue at minimal condition. 2. Progressive cleaning; housekeeping during work **PPE (5):** Slip-resistant safety footwear such as Wellington Safety Boots
5	Draining remaining product	Splashing of the residues	**Engineering (3):** Design the valve diameter or detachable connection **Administrative (4):** 1. Controlled draining procedure 2. Slow valve opening **PPE (5):** 1. Chemical-resistant gloves 2. Face shield or safety goggles 3. Apron
6	Atmospheric testing	Inaccurate, error in testing or device	**Administrative (4):** 1. Testing by certified Authorized Gas Tester 2. Always alert on the equipment calibration schedule 3. Document test results **PPE (5):** None (relies on testing accuracy)
7	Skin contact with adhesive during working	Dermal exposure	**Administrative (4):** 1. Hygiene practices 2. washing facilities **PPE (5):** 1. Chemical-resistant gloves 2. Disposable coverall

Progress in Engineering Application and Technology Vol. 7 No. 1 (2026) p. 862-869

Table 3 (continued) *Risk Control*

No	Work Activity	Hazard	Control Measure
8	Heat accumulation in confined space during working	Heat stress	**Administrative (4):** 1. Work-rest schedule 2. Time limitation inside tank 3. Hydration breaks 4. Personnel rotation **PPE (5):** Lightweight, breathable PPE
9	Isolation of energy sources	Residual pressure or stored energy	**Engineering (3):** Pressure release/bleed-off before isolation **Administrative (4):** 1. Stringent Lock Out, Tag Out, Try Out (LOTOTO) procedure 2. Verification of zero energy state before entry Permit-to-work system
10	Opening and closing tank manhole	Sharp edges of the tank manhole	**Engineering (3):** Edge protection or covers where practicable **Administrative (4):** 1. Safe handling procedure 2. Tool use instead of hands to open **PPE (5):** Cut-resistant gloves
11	Opening and closing tank manhole	Heavy lifting	**Engineering (3):** Use of lifting aids (hinges, handles) where suitable **Administrative (4):** 1. Buddy system (team lifting) Lifting technique training
12	Opening and closing tank manhole	Awkward handling on tank manhole	**Administrative (4):** 1. Task planning; controlled opening/closing sequence 2. Sufficient manpower 3. Ergonomic hazard awareness **PPE (5):** Grip gloves

Table 3 (continued) *Risk Control*

No	Work Activity	Hazard	Control Measure
13	Ascending the ladder	Fatigue during climb out	**Administrative (4):** 1. Work-rest regime 2. Personnel rotation 3. Standby assistance during climb out **PPE (5):** Safety harness with lifeline always connected
14	Descending ladder	Slip or loss of balance during the use of ladder	**Engineering (3):** Secured ladder with anti-slip base **Administrative (4):** 1. 3-point contact training 2. Ladder inspection before use **PPE (5):** Slip-resistant safety footwear such as Wellington Safety Boots
15	Bending and kneeling inside the tank during cleaning	Awkward posture	**Engineering (3):** Long-handled cleaning tools to reduce bending **Administrative (4):** 1. Job rotation 2. Time limitation for static posture Cleaning technique training
16	Scrubbing and cleaning inside the tank	Repetitive motion	**Engineering (3):** Ergonomic hand tools **Administrative (4):** 1. Work-rest cycle 2. Task rotation 3. Cleaning technique training

The findings indicate that waterbase tank cleaning operations in the adhesive manufacturing company involve multiple work activities with significant occupational safety and health risks. Fourteen work tasks were identified, during which sixteen hazards were observed, primarily related to confined space entry, chemical residues, wet and slippery surfaces, manual handling, and equipment use. Many of these hazards were recurring across different stages of the cleaning process, indicating that the risks are inherent to the operation rather than isolated events.

Risk assessment using the HIRARC framework showed that most hazards were classified as low to medium risk, while four hazards were rated as high risk. Medium-risk hazards were mainly associated with routine exposure, such as repetitive manual cleaning, ergonomic strain, and intermittent contact with chemical residues, which may lead to long-term health effects if not adequately controlled. High-risk hazards were largely linked to

confined space conditions, limited ventilation, and potential chemical exposure, where the severity of consequences could be serious or life-threatening.

Control measures were developed in accordance with the hierarchy of controls to reduce the identified risks. Engineering controls, including improved ventilation, safer tank access, and mechanical cleaning aids, were prioritised to minimise direct worker exposure. Administrative measures such as confined space permit systems, standard operating procedures, training, and supervision were also recommended, with personal protective equipment serving as supplementary protection. Overall, the application of the HIRARC framework enabled systematic risk prioritisation and supports improved safety management for waterbase tank cleaning operations in the adhesive manufacturing industry.

4. Conclusion

This study concludes that waterbase tank cleaning operations in an adhesive manufacturing company present significant occupational safety and health risks. Using the Hazard Identification, Risk Assessment, and Risk Control (HIRARC) framework, various physical, chemical, and operational hazards were systematically identified, particularly those associated with confined space entry, limited ventilation, chemical exposure, wet surfaces, and manual cleaning activities.

The risk assessment showed that most hazards were classified as low to medium risk, mainly due to routine exposure and repetitive work. However, several hazards were identified as high risk, especially those related to confined space conditions and potential chemical exposure, which may result in severe or life-threatening consequences. While existing control measures reduce some risks, further improvements in engineering controls and supervision are required.

Overall, the application of the HIRARC framework proved effective in systematically assessing and managing risks associated with tank cleaning operations. The findings highlight the importance of structured hazard identification, accurate risk evaluation, and appropriate risk control measures to enhance occupational safety and health performance in the adhesive manufacturing industry.

Acknowledgement

The author would like to express gratitude towards the Faculty of Engineering Technology, Universiti Tun Hussein Onn Malaysia, for its support.

Conflict of Interest

Authors declare that there is no conflict of interests regarding the publication of the paper.

References

1) Dermawan, B. C., & Asy'ari, M. K. (2025). Full scale task risk assessment of crude oil tank cleaning job using qualitative risk matrix and control in pt. saka (indonesia-pangkah) limited. IOP Conference Series Earth and Environmental Science, 1473(1), 12042. https://doi.org/10.1088/1755-1315/1473/1/012042
2) Falakh, F., & Setiani, O. (2018). Hazard Identification and Risk Assessment in Water Treatment Plant considering Environmental Health and Safety Practice. E3S Web of Conferences, 31, 6011. https://doi.org/10.1051/e3sconf/20183106011
3) Sakti, A. S. A., & Nuryanto, N. (2024). Analysis of Health and Safety in The Production Floor of CV. XYZ Using Job Safety Analysis Method and the Hazard Identification Risk Assesment and Risk Control Approach. E3S Web of Conferences, 517, 15004. https://doi.org/10.1051/e3sconf/202451715004
4) Djunaidi, M., & Umami, H. (2024). Occupational health and safety analysis using job safety analysis and hazard identification risk assessment and risk control methods. E3S Web of Conferences, 517, 15003. https://doi.org/10.1051/e3sconf/202451715003