Galore International Journal of Health Sciences and Research
Vol. 9; Issue: 1; Jan.-March 2024
Website: www.gijhsr.com
Original Research Article *P-ISSN: 2456-9321*

Hazard Identification and Risk Assessment for Dismantling of Phosphoric Acid Tank Using 100-Ton Crane & Scaffolding in a Chemical Industry

Pavan Kumar Varma V

Sr. Executive Operations, Sub-con of BV, Kakinada, India. Guest Faculty-Jawaharlal Nehru Technological University, Kakinada, India. Ph.D. Scholar – Tor Vergata University – Rome, Italy.

DOI: https://doi.org/10.52403/gijhsr.20240104

ABSTRACT

The dismantling of industrial equipment or machinery, especially within the chemical sector, poses unique challenges that require an in-depth assessment of potential hazards and risks. This study provides a comprehensive analysis of the Hazard Identification and Risk Assessment (HIRA) conducted for the dismantling procedure of a phosphoric acid tank in a chemical industry setting, using a 100-ton crane and scaffolding.

The (Hazard Identification and Risk Assessment) HIRA approach involves an extensive evaluation of various aspects involving the systematic identification of potential hazards, followed by a detailed evaluation of the risk involved. The risk assessment will be performed using quantitative methodology to estimate the likelihood and severity of identified hazards. Subsequently, potential mitigation methods are put forth to deal with the risks that have been identified with regard to each specific hazard. Key hazards in this activity include mechanical failures, environmental issues, human errors, and exposure to chemicals.

The findings of this study contribute valuable insights to the field of industrial safety, by providing a framework for conducting Hazard Identification and Risk Assessment (HIRA), particularly adapted to the dismantling of chemical storage tanks using heavy machinery and scaffolding. This study aims to enhance the overall safety culture in the chemical industry by promoting proactive risk management during complex dismantling activities.

Keywords: Hazard, Risk, Hazard identification, Risk assessment, Phosphoric Acid Tank dismantling.

INTRODUCTION

The chemical industry, known for its diverse range of processes and materials, is a crucial pillar of our modern society, providing essential products that power several sectors. Nevertheless, the industry faces significant challenges in terms of safety and risk management due to the inherent complexity and unpredictability of chemical processes. Accidents and incidents occurring in the chemical industry pose significant risks to both human life and the environment, while also potentially leading to substantial economic consequences.

The process of dismantling industrial chemical storage tanks involves careful evaluation because of the potential hazards associated with structural instability and the use of heavy machinery. This paper addresses the implementation of a systematic Hazard Identification and Risk Assessment (HIRA) approach to ensure the safety of personnel and the environment during the dismantling process of a phosphoric acid tank, using a 100-ton crane and scaffolding.

The objectives of this study are:

- Hazard Identification: Conduct an in-depth study to identify potential hazards associated with the dismantling process of phosphoric acid tank using a 100-ton crane and scaffolding.

- Risk assessment: Evaluate the probability and severity of identified hazard to quantify the associated risks which includes assessing the consequences.
- Development of Mitigation Strategies: Propose effective and efficient risk mitigation measures to minimize the probability of hazards and their potential impact on personnel, property and surrounding environment.

This study contributes by providing a useful information that can be used to improve current safety protocols and practices in the chemical industry for similar operations, thereby promoting a culture of continual improvement. As industries strive for excellence and sustainability, proactive Hazard identification & Risk assessment is becoming an important tool for making the future safer for everyone.

LITERATURE REVIEW

The dismantling of storage tanks in the chemical industry is a complex process that involves various hazards and risks. The purpose of this literature review is to explore existing knowledge on hazard identification and risk assessment in storage tank dismantling, particularly when cranes and scaffolding in the chemical industry.

Storage tanks' structural integrity might deteriorate over time because of corrosion and other factors. The risk of collapse, falling debris, and structural failures when dismantling such tanks is high. Reference studies **[1]** highlight the importance of conducting extensive structural assessments prior to dismantling. J.S. Arendt **[16]** explore quantitative risk assessment (QRA) approaches, which provide a quantitative examination of potential risks and their probabilities. These studies stress the significance of including QRA into storage tank disassembly processes for an extensive risk evaluation.

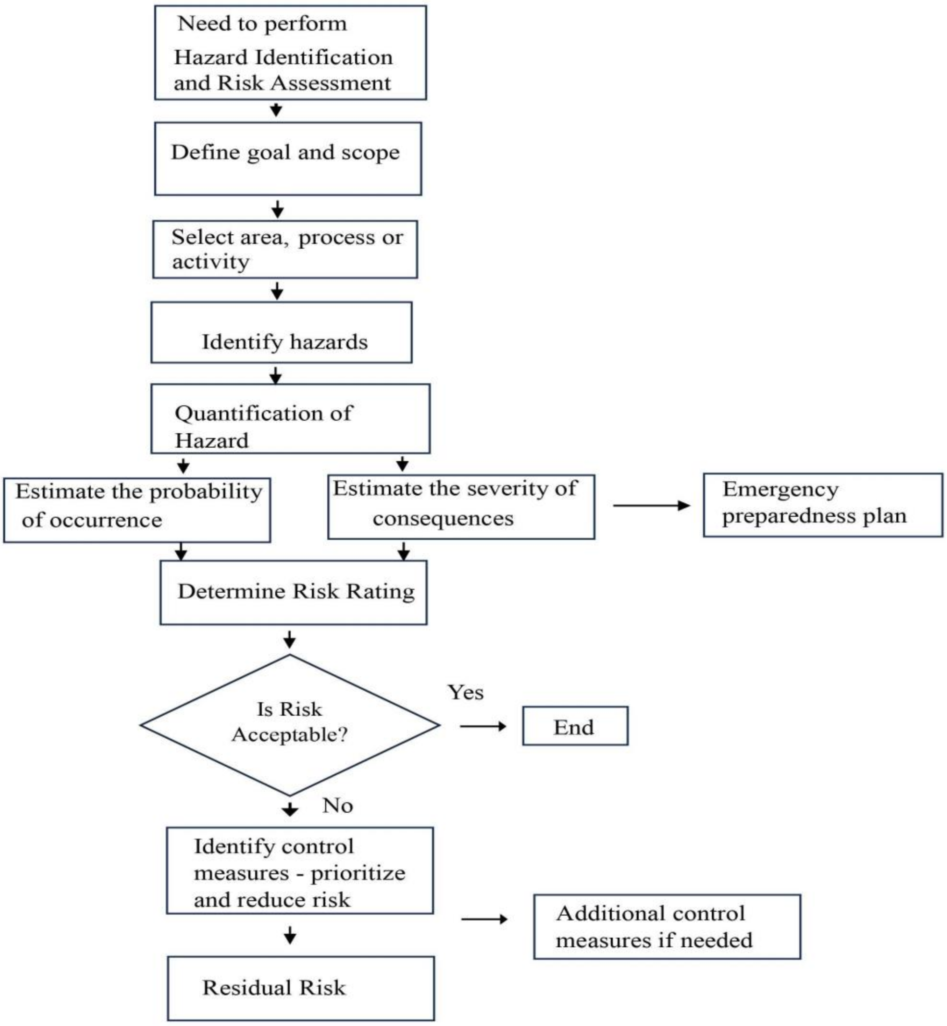
While scaffolding is essential for providing access during the dismantling of storage tanks, poor erection result in collapses, falls, and incidents involving being struck by objects. The need of adequate scaffolding design, erection, and regular inspections is highlighted in the research conducted by Cao Wang et al. **[10]** and the Occupational Safety and Health Administration **[6].**

The use of cranes presents inherent hazards and risks, involving the potential for crane collapse, load failure, and electrocution. The importance of competent crane operators, periodic equipment inspections, and strict compliance to safety rules and regulations during dismantling operations are highlighted in the analysis published by the Crane Institute **[17]** and Ricci and Turner **[14]**. There are additional risks involved when using cranes to dismantle storage tanks. Research on incidents involving cranes conducted by Patel et al. **[12]** and Li et al. **[13]**. It's essential to use personal protective equipment (PPE) effectively. Garcia and Smith **[15]** research highlights the importance of PPE. Turner and Davis **[14]** research highlights how training initiatives can help reduce the number of incidents/accidents that occur during industrial dismantling activities.

MATERIALS & METHODS

The Hazard Identification and Risk Assessment (HIRA) process for the dismantling of a Phosphoric Acid Tank in a chemical industry, using a 100-ton crane and scaffolding, involves a systematic approach to identify potential hazards, assess the associated risks, and implement effective controls. The quantitative approach was chosen based on the nature of the study. The method begins by conducting an in-depth review of the project scope, including the dismantling process, the equipment used, and the specific characteristics of the Phosphoric Acid Tank. This assessment is carried out through physical observations, human interactions, surveys, and the verification of relevant documents.

The subsequent flow diagram will provide a comprehensive illustration of how this study is conducted.



(Figure 1: Flow diagram of Hazard Identification and Risk Assessment)

Table 1: Risk Assessment:

RISK MATRIX							
PROBABILITY	**Very Likely**	5	Low	Medium	High	High	High
	Likely	4	Low	Low	Medium	High	High
	Possible	3	Low	Low	Medium	Medium	High
	Unlikely	2	Low	Low	Low	Low	Medium
	Very Unlikely	1	Low	Low	Low	Low	Low
			1	2	3	4	5
			Insignificant nt	**First Aid case/Mino r Injury**	**Moderate**	**Major (lost time injury & Partial Disablements)**	**Extreme (Fatality/Tot al Disablement s)**
		SEVERITY					

Risk	Risk Level	Action taken
00-08	Low Risk	May be acceptable but review task to see if Risk can be reduced further
09-14	Medium Risk	Task should only be undertaken with appropriate management authorization.
15-25	High Risk	It should be redefined or further control measures put in place to reduce Risk.

Table 2: Probability and Severity Rating

Level	Probability	Criteria for Likelihood on Risk Matrix	Level	Severity	Criteria for Severity on Risk Matrix
1	Very Unlikely	May only occur in exceptional circumstances, simple processes & no previous incidence of noncompliance	1	Insignificant	No Injury / Slight
2	Unlikely	Could occur at some time (less than 25% chance of occurring)	2	First Aid case/Minor Injury	Minor Injury / No Hospitalization
3	Possible	May occur at some time (25% - 50% chance of occurring)	3	Moderate (MTC/RWDC)	LTI cases / Hospitalization
4	Likely	Will probably occur in most circumstances (50% - 75% chance of occurring)	4	Major (LTI & Partial Disablements)	Single fatality / Partial Disablements
5	Very likely	Can be expected to occur in most circumstances (more than 75% chance of occurring)	5	Extreme (Fatality/Total Disablements)	Multiple Fatalities / Total Disablements

Procedure of dismantling of phosphoric acid tank

The first step involves desludging the tank before proceeding with the rubber lining peeling
process. The peeling of the rubber lining begins at the bottom side of the tank and progresses upwards, covering an area of 1.5 meters in height. Once the rubber lining is removed from the bottom side, a 1m x 4m pocket is cut on opposite sides of the tank to provide access for work inside. Following this, the agitator's bottom segments, including the blades and shaft, are removed. The dismantling process continues with the removal of the agitator gear box, motor, and structural support, using crane.

Then, scaffolding is erected inside the tank, reaching a maximum height of 9 meters, to facilitate the removal of rubber lining and simultaneous cleaning of sludge and waste. The scaffolding also provides support from the bottom to the center of the agitator mounting bed.

Once the rubber peeling activity is completed, the scaffolding inside the tank is dismantled.

Subsequently, scaffolding is erected around the phosphoric acid tank exterior, with a maximum height of 8.5 meters. Welding activities are then carried out to connect the platform horizontal beams to the vertical supports and top roof rafters. Following this, pipe supports on the south side, as well as the railing on the north and west sides, are removed by gas cutting.

The next step involves gas cutting the shell of the tank at a height of 500mm from the top. The cutting is performed in sections of 2 meters with a 0.5-meter gap. The hoppers (2 in total, weighing approximately 250kg each) are then dismantled. They are lifted using wire rope slings attached to the 100T crane's hook. Subsequently, the motor, gearbox drive, and a 2-meter length solid shaft (weighing around 1.2 tons) are dismantled. These components are also lifted using wire rope slings attached to the 100T crane's hook. After cutting the roof, the top roof section, along with a 500mm height shell (weighing approximately 10 tons), is dismantled. The platform is supported with additional slings to prevent wobbling during the lifting process. Any remaining shell segments are then cut and removed using gas cutting. These shell segments, measuring 12 meters by 4 meters, are hooked to the crane hook using wire rope slings. Finally, the scaffolding around the tank's exterior is dismantled, and the bottom base plate is cut and removed.

RESULTS

Sl no	**Activity**	**Sub Activity**	**Potential Hazards**	**Accident/ Injury type**	**Probability**	**Severity**	**Risk Rating**	**Existing Controls**	**Probability**	**Severity**	**Risk Rating**	**Additional Controls**	**Risk Index**
1	Dismantling of phosphoric acid tank by usin100 ton crane and scaffolding	Scaffolding Erection	Slips, Trips	Sprains, Strains, Cuts, Fractures,	4	3	12	Barricading entire workplace, Housekeeping, should wear Personal protective equipment, Toolbox talks	2	3	6	On job and periodical trainings should be provided. Standard working procedures should be followed	Low
			Using damaged full body harness- Fall hazard	Fractures, head injury	4	3	12	Full body harness inspection is mandatory before using by a competent person, must use full body harness with double lanyard, safety shoe and helmet, trainings	2	3	6	Lifeline arrangement with 1” PP rope with knots for every one meter for safety harness anchoring, inspections	Low
			Damaged or rusted pipelines	Minor cuts, lacerations, abrasions, skin	5	2	10	Physical verification of pipes must be	2	2	4	Trainings should be provided, regular	Low

				irritation,				done before starting the job. PPE should be used- Hand gloves, safety shoes, goggles, mask and helmet.				inspections	
			Uneven surfaces	Sprains, Strain, hand, legs and ankle fractures	4	4	16	Physical Inspection to fix uneven surfaces before the start of work, personal protective equipment should be used, sign boards should be used	2	4	8	Trainings should be provided	Low
			Material falling from height	Fractures, Head injuries, crush injuries, cuts, abrasions	3	4	12	Activities should be done under supervision of competent person, should use proper personal protective equipment , barriers,	2	3	6	Posters and sign boards, toolbox talks, supervision	Low

								guardrails, safety nets					
			Fall of personnel from height.	head and spine injuries, fractures and broken bones, sprains, strains	3	5	15	There should not be more than 25mm gap between working platforms, also they should be fixed properly tied with binding wire at all sides rigidly and locked with double side locking with scaffolding pipes, should use fall arrest systems along with personal protective equipment, guardrails and barriers.	2	5	10	Toolbox talks, Communication, emergency response plan and team	Moderate
			Trapped the fingers / legs between provided	crushing of hands and legs, sprains	4	2	8	Must wear proper personal protective equipment - shoes,	2	2	4	Trainings, safe working practices	Low

			platforms					gloves, helmet. tool box talks					
			Tilting of working platforms	Leg, Hand, Head injuries, sprains, strains	3	3	9	If any abnormality is noticed, immediately work should be stopped and inform. Must wear personal protective equipment along with full body harness	2	3	6	Continuous supervision , inspections, trainings	Low
			Improper /absence/ damaged railings on working platform	Leg, hand and head injuries, sprains, strains, fractures	3	4	12	Inspection should be done by a competent person to ensure top rail, mid rail, toe board are in good condition, personal protective equipment , should place do not use tag, barricading	2	4	8	Warning signs, trainings, safe working practices, inspections	Low
		Welding & Gas cutting	Electrocution	Shock, burns, fatal	3	5	15	Earthing, Insulation, checklist, personal	1	5	5	Preventive maintenance, Regular inspections,	Low

								protective equipment , toolbox talks				trainings	
			Heat and Radiation	Burns, eye injuries	3	4	12	Suitable personal protective equipment should be used such as welding helmet, gloves, shoes, protective clothing. Pep talks	1	4	4	Trainings, safe work practices	Low
			Fumes and Gases	Inhalation-coughing, irritation, suffocation, short term and long term respiratory issues (occupational asthma, metal fume fever etc..)	3	4	12	Adequate and suitable ventilation should be provided (exhaust ventilation) , suitable personal protective equipment, pep talks, should be done under supervision .	2	4	8	Trainings, regular inspections, safe work practices	Low
			Physical hazards-slips, trips, falls	Manual handling of equipment's - musculoskeletal injuries,	3	3	9	Use appropriate personal protective equipment , trainings should be	2	3	6	Safe work practices	Low

				sprains strains				provided on handling techniques					
			Fire and Explosion- sparks and hot metal, gases can cause fires	Burns, inhalation of fumes, smoke, amputations, fatal	3	5	15	Keep the work area clear of incompatibles, follow safe operating procedures, equipment should be spark proof, fire proof coatings in the work place, firefighting systems, rescue team,	2	4	8	Safe work practices, Trainings, supervision, inspections.	Low
			Noise	Headache, nausea, irritation, fatigue, pain, tinnitus, short term and long term effects	3	3	9	Use proper personal protective equipment – ear plugs or ear muffs, inspect the equipment before use	1	3	3	Trainings, warning signs equipment inspection and maintenance	Low
		Grinding	Contact with grinding dust (particulates)	Eye, skin, throat irritation. Coughing, respiratory problems, chronic lung	3	4	12	Suitable ventilation system should be used (exhaust), personal protective	2	4	8	Safe working procedures, warning signs and posters, trainings	Low

				diseases				equipment , pep talks, housekeeping					
			Contact with grinding machine wheel, wheel breakage	Cuts, lacerations and abrasions, amputations. Impact injuries, may lead to fatal	3	5	15	Machine guarding, inspecting before use, checklist, suitable ppe, safe operating procedures as per instruction manual, toolbox talks.	2	4	8	Preventive maintenance, safe practices, trainings	Low
			Electrocution	Shock, burns, fatal	3	5	15	Earthing, Insulation, checklist, personal protective equipment , toolbox talks	1	5	5	Preventive maintenance, Regular inspections, trainings	Low
			Fire and Explosion- sparks generated can ignite flammables	Burns, inhalation of fumes, smoke, amputations, fatal	3	5	15	Keep the work area clear of incompatibles, follow safe operating procedures, equipment should be sparking proof, fire proof coatings in	2	4	8	Safe work practices, Trainings, supervision, inspections.	Low

								the work place, firefighting systems, rescue team,					
		Lifting the load With100T Crane By using Wire rope Slings & Shackles	Equipment failure – mechanical failure of crane - wire ropes, slings or shackles	Struck by falling objects, Crush injuries, fractures, amputations, fatal	4	5	20	Inspection of crane and accessories (wire ropes, slings, shackles) before use, inspection checklist, safe working load should be clearly marked, following safe work procedures, under supervision of competent person, personal protective equipment	2	5	10	Education and Trainings, periodical maintenance of equipment’s, emergency response plan	Moderate
			Communication issues	Personnel injury, material collapse	3	3	9	Standard communication system should be followed, only competent person	2	3	6	On job training should be provided	Low

								should perform rigging and signaling operation, personal protective equipment should be used					
			Adverse weather condition s – impact the stability of crane	Collapsing or collisions might happen which lead to personnel injury/fatal and property damage	3	5	15	Suspend crane operations during adverse conditions, Outriggers shall be fully extended & load bearing pads shall be used during lifting operation, toolbox talks, personal protective equipment	2	5	10	Emergency preparednes s plan, trainings, safe crane operation plan,	Moder ate
			Wobblin g of cutting sheets/ Structure during Dismantli	Cuts, lacerations and abrasions, amputation s. Impact injuries,	3	5	15	Guide ropes to be provided on both sides and ensure properly fixed.	2	5	10	Proper trainings should be provided	Moder ate

			ng might strike nearby personnel	may lead to fatal				(Only certified Ropes to be used), Ensure proper locking of structure/Sheet with slings. personal protective equipment should be used. Ensure skilled rigger and signaler is deputed for the operation.					
		Cutting & Removal of Top roof Sheet, Trusses & Shell plates - dismantled.	Fall of truss pieces, plates or sheets	Personnel injuries – cuts, amputations, abrasions. Property damage	4	4	16	Barricade the area, ensure proper communication, use netting or catch platforms, all the personnel should wear proper personal protective equipment, supervision	2	4	8	Follow safe work practices, material handling trainings	Low

		Dismantling of Scaffolding	Fall of material / Hit by falling material- (tools, equipmen t's, scaffold material)	Hand, leg, head Injuries, fractures, cuts and abrasions	4	3	12	Debris nets should be used, use tool lanyards to secure tools, personal protective equipment should be used such as hard hat, shoes, gloves, goggles, barricading the area.	2	3	6	Material handling trainings, posters and sign boards,	Low
			Lack of clear communi cation	Personnel injury, material collapse	4	3	9	Communic ation devices should be used, standard rigging and signaling procedure should be followed under the supervision of a competent person, toolbox talks, personal protective equipment should be	2	3	6	Trainings, safe work practices, emergency prepared plan	Low

								used,					
			Collapse of scaffolding due to structural instability during dismantling, human errors	Personnel injuries, crushing and impact injuries, entrapment, fatal, property damage	3	5	15	Visual inspection before dismantling, using appropriate tools, dismantling process should be top-down approach in a sequential order section by section, guardrails and fall protection systems, materials should lower at clear drop zones using hoists or lowering lines, supervision, ppe, communication.	2	5	10	Proper trainings should be provided on material handling, there should be a clear plan, emergency preparedness and response, inspections and safety checklist.	Moderate

Table 3: Risk Assessment Sheet

DISCUSSION

This study identified a wide range of hazards associated with the dismantling of a phosphoric acid tank using a 100-ton crane and scaffolding in a chemical plant. It is evident that there are several potential hazards and risks associated with dismantling that need to be carefully addressed to ensure the safety of personnel, property and the environment. The use of a crane involves potential hazards associated with equipment failure, load stability and crane operation. The use of scaffolding involves a unique set of challenges, such as falls, structural instability, un-safe acts, conditions and material handling. In order to address these, a comprehensive hazard identification and Risk assessment strategy is implemented.

The methodology adopted in this study offers significant value to the field. By using quantitative risk assessment technique, this study has built an effective framework for evaluating the potential risks associated with the dismantling activities.

This study highlights the significance of worker training and awareness programs to manage hazards and risks efficiently. By highlighting the role of competent employees and their commitment to safety initiatives, this study emphasizes the human factor in hazard prevention.

The inclusion of specific safety procedures for the usage of a 100-ton crane and scaffolding provides valuable information for industrial professionals involved in similar operations. Continuous monitoring and periodic assessments are vital aspects for ensuring the maintenance of a safe working environment. The implementation of regular safety inspections and audits, feedback systems, effective communication, and a culture of reporting near misses and a commitment to safety at all levels of the organization can contribute to a dynamic safety framework.

LIMITATIONS

The present study focuses on a particular activity that is confined to the context of a chemical industry. The efficacy of hazard identification and risk assessment may be dependent upon site-specific variables, including infrastructure, equipment conditions, and environmental considerations. The dismantling process involves dynamic factors which are susceptible to rapid change. This study may not fully capture the evolving nature of risks during the operation. To deal with the unexpected risks that may arise throughout the dismantling process, continuous monitoring and evaluation may be required.

CONCLUSION

The Hazard Identification and Risk Assessment (HIRA) carried out for the dismantling of the phosphoric acid tank in a chemical plant, using a 100-ton crane and scaffolding, provided significant results regarding potential hazards, risks and the necessary measures for risk minimization. The comprehensive analysis conducted highlighted multiple hazards linked to the dismantling process, emphasizing the importance of employing a systematic approach for ensuring the safety of personnel, property, and the surrounding environment.

The success of the dismantling process relies not only on the efficient execution of activities, but also on an uncompromising commitment to the highest safety standards. Through a collective effort to address and mitigate identified risks, it is possible to effectively manage the challenges associated with the dismantling of the chemical storage tanks, ensuring a safe and secure working environment for everyone involved.

Declaration by Author

Acknowledgement: None

Source of Funding: None

Conflict of Interest: The authors declare no conflict of interest.

REFERENCES

1. IS 15656: Hazard Identification and Risk Analysis- Indian Standard/Code of Practice/IS 15656:2006. ICS 13.100
2. Introduction to Health and Safety at Work - Phil Hughes, Ed Ferrett-6th Edition/Health and Safety Management Systems/Do-Page97, Work Place Hazards and Risk Control/Page172.
3. Occupational Safety and Health Administration (2022). Chemical Residue Analysis Requirements in Tank Decommissioning. A Guide for Employers/OSHA-3645.
4. Occupational Safety and Health Administration (OSHA): Hazard Identification and Risk Assessment-osha.gov/safety management/hazard identification.
5. American Petroleum Institute (API)-Structural Integrity Assessment Guidelines/API 653.
6. Occupational Safety and Health Administration (OSHA). (2021). Scaffolding Safety.
7. P. S. Lowe (2017). Structural Health Monitoring for Tank Integrity Assessment of Above Ground Storage Tank. Sensors 2017/17(11), 2542.
8. ISO 45001: Occupational Health and Safety Management Systems/2018/ISBM 978-92-67-10788-2.
9. Rasmussen, J. (2019). Proactive Risk Management/Risk Management Framework/Theoretical Issues in Ergonomics Science/Vol.21, 1630495.
10. Cao Wang, et al. (2020). Scaffolding Safety in Construction., System reliability-based limit state design of support scaffolding systems. Engineering Structures/Science direct/Vol.216, 110677.
11. Canadian Centre for Occupational Health and Safety (CCOHS)
12. Patel, R., et al., Johnson R.B. (2019). "Analysis of Crane-Related Accidents in Construction Projects. Journal of Construction Safety/Vol.25(3).
13. Li, Y., et al., Hakkinen. (2018). "Crane Accidents and Their Prevention: Analysis of Crane Accidents- Causes and Preventive Measures. Journal of Occupational Accidents/Safety Science /Vol.3.
14. Turner, S., & Davis, G., Ricci. F (2016)., "Effectiveness of Occupational Health and Safety Training: A Systematic Programs in Industrial Settings. "Journal of Workplace Learning/28(8).455-477.
15. Garcia, J., & Smith. J (2020). Safety Guidelines for Chemical Industry Tank Dismantling- Personal Protective Equipment. Journal of Industrial Safety/25(3).
16. J.S. Arendt (1990). Application of Quantitative Risk Assessment in Chemical Process Industry-Tank Decommissioning. Reliability Engineering and System Safety/Vol.29/issue1/133-149.
17. Crane Institute (CI). Mobile Crane Safety Manual/Association of Equipment Manufacturers/MNL14.

How to cite this article: Pavan Kumar Varma V. Hazard identification and risk assessment for dismantling of phosphoric acid tank using 100-ton crane & scaffolding in a chemical industry. *Gal Int J Health Sci Res*. 2024; 9(1): 26-43. *DOI: https://doi.org/10.52403/gijhsr.20240104*

******