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Occupational Hazard and Risk Assessment for Confined Space Rescue Operation at Cement Manufacturing Industries

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Abstract

Hazard identification during rescue in confined spaces is crucial to promptly recognize and mitigate evolving risks, ensuring the safety of both rescuers and individuals in distress, especially in dynamic environments where conditions can change rapidly. The objective of this study is to identify hazards connected to the rescue operation of a preheater cyclone for a person who has collapsed while working in the cement manufacturing industry. A preheater cyclone in cement manufacturing is typically considered as a confined space. Several techniques were used to complete the hazard identification such as conducting field observation, interview with expert, hazard identification checklist, document review and literature review. Upon completion of the assessment, a comprehensive total of 27 hazards were identified, encompassing a spectrum of categories including physical, chemical, biological, ergonomic, and psychosocial hazards. A total of 27 hazards were identified, with 24 falling under the category of safety-related hazards, and the remaining three categorized as health-related hazards. Specifically, within the identified hazards, 24 were ascribed to physical hazards, two were attributed to chemical hazards, one was associated with biological hazards, while ergonomic and physiological hazards each accounted for one hazard. This comprehensive classification underscores the diverse nature of the identified risks, necessitating targeted strategies for mitigation across multiple hazard categories.

1. Introduction

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Notwithstanding the regulations and standards that are already in place for activities involving confined spaces, fatal accidents and injuries still occur on a yearly basis. According to the Industry Code of Practice for Safe Working in A Confined Space, a confined space is an enclosed or partially enclosed space at atmospheric pressure that was not designed as a workplace [1]. It is liable at any time to have an atmosphere that contains potentially dangerous quantities of harmful substances, suffer from an oxygen deficiency, or cause engulfment, and may have restricted access. Working inside of a confined space is a dangerous employment that puts the worker's health and safety in jeopardy on a regular basis. The occurrence that takes place in a confined area may be categorized as poisonous atmospheres, fire and explosion, engulfment in free-flowing solids or liquids, or other physical dangers such as falls from high heights or entrapment in equipment. The efficient and safe execution of rescue operations within the confined space of a preheater cyclone in cement manufacturing is paramount, particularly when responding to the collapse of an individual. Occupational health and safety have emerged as a primary problem, especially in high-risk industries [2]. Manufacturing cement is an example of one of these types of industries. The production of cement on a vast scale has major repercussions for both human health and the natural environment because of the dredging and quarrying that must take place. The Confined Space Accident Statistics for Malaysia are shown in Fig 1 and include the years 2009 until 2019 [3]. Lack of knowledge or competence, inadequate risk assessment papers, and the absence of a Safe Work Procedure were identified as root causes by the Department of Occupational Safety and Health (DOSH) examination.

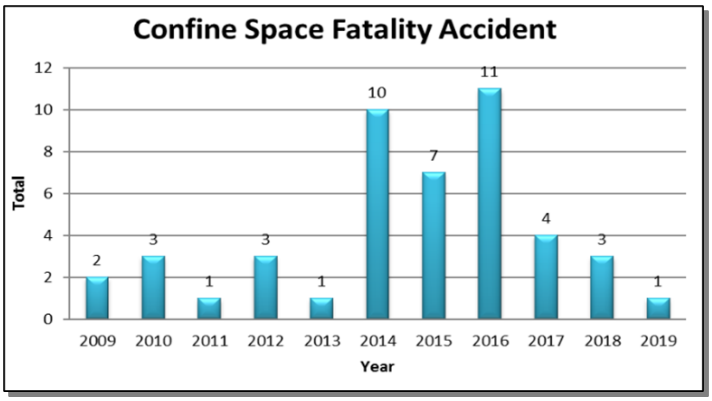

Fig. 1 *Confined Space Accident Statistics 2009-2019*

In the demanding realm of industrial operations, the potential for emergencies, such as a collapse within the preheater cyclone, necessitates a meticulous and strategic approach to rescue operations. Hazard identification during these critical interventions is paramount for ensuring the safety of both rescuers and those in distress. This introduction delves into the imperative nature of hazard identification during rescue operations within the confined space of a preheater cyclone, underscoring the significance of pre-emptive risk assessment, meticulous planning, and real-time adaptability associated with confined space rescues and underscore the critical role of hazard identification in mitigating potential risks and ensuring the success of rescue endeavours.

According to the ICOP 2010, individuals are required to conduct a risk assessment technique before entering a confined space. However, it's crucial to note that this evaluation should not be overly generalized; instead, it needs to be thorough and specific to accurately identify potential risks and ensure safety. The requirement for a confined space rescue operation risk assessment is essential to ensure the safety of rescuer and victims involved in such operations. Risk assessment is necessary to identify and evaluate potential hazards and risks associated with confined spaces, enabling the development of effective strategies for rescue and emergency response plan.

1.1 Research Objective

This research aims to identify hazard at preheater cyclone during confined space rescue operation. Next, to determine risk assessment using HIRARC method during confined space rescue operation and lastly to propose a rescue plan on confine space at preheater cyclone in a cement manufacturing industry.

2. Research Method

For this research, the process of examining work area and work task is to identify all the hazards and undesired events that are inherent in the job is referred as hazard identification. Several techniques were used to complete the hazard identification such as conducting field observation, hazard identification checklist, interview workers, document review and literature review.

2.1 Hazard Identification Checklist

In this research, a hazard identification checklist was employed to systematically identify and evaluate potential hazard associated during preheater cyclone rescue operation. The checklist not only encompassed established and conceivable hazard but also specific sources of hazard to each work activity. The methodology involved a meticulous examination of each identified hazard on the checklist, considering whether it presented any form of risk. This approach was applied to assess both existing and potential hazards within the preheater cyclone rescue operation.

2.2 Field Observation

In the context of this research, field observation consisted of a more general walk around with the sole focus being on preheater cyclones in the cement manufacturing industry. Workplace observations were essential to this research because they are the method that is proven to be the most effective in determining the kinds of behaviors that are associated with an increased risk of occupational injury. It considers the ways in which these behaviors interact with the potentially dangerous environment. For the purpose of collecting visual observations of the activities and locations, photos were taken both in the research area as well as in other relevant locations. In this research, the method of inspection consisted of a general walk all around the worksite (preheater cyclone area) and observing the workflow of the plant in order to detect situations of failing to comply with safety requirements.

2.3 Semi-Structured Interview

Since this research aims to explore the perception, knowledge, experiences, and perspective from the related respondents, it is essential that the views from them to be revealed. Thus, the aim of conducting interviews is to develop a clear insight of practices from these industry players who are knowledgeable in confined space rescue operation. This research involved the selection of one firefighter from Fire and Rescue Department of Malaysia (BOMBA) and two competent confined space rescuers commissioned by DOSH from the cement manufacturing industry.

3. Result and Discussion

Department of Occupational Safety and Health (DOSH, Malaysia) discovered that the majority of accidents that occurred in confined spaces were caused by the employer's inability to create and provide a safe work system for employees who were working in confined space. Several accidents and injuries related to confined space work show that workers access to confined space without proper training and personal protective equipment, exposing themselves to high levels of hazard [4]. Working in confined spaces introduces significant hazards, including chemical, physical, and biological threats. Chemical risks may arise from the presence of hazardous substances, while physical dangers involve issues like engulfment or entrapment in the restricted environment. Biological threats can emerge from the growth of microorganisms in poorly ventilated spaces. To mitigate these risks, it's essential to conduct thorough risk assessments, provide adequate training, implement proper ventilation, and establish emergency response plans. Regular monitoring helps identify and address potential hazards, ensuring the safety of individuals working in confined spaces. [5]

The outcome of this evaluation reveals the existence of 27 potential hazards during preheater cyclone rescue operation for collapse of person. These findings are based on data from field observation, hazard identification checklist and interviews with experts. The first step that needs to be taken in order to comprehend and evaluate the risk is to identify the potential activities that contribute to the hazard in the working environment. This is the prerequisite for understanding and evaluating the risk. This study was carried out by evaluating the risk that is associated with the rescue operation that took place at the preheater cyclone. The classification of work activities that involve confined space rescue operations for collapse of person at the Preheater Cyclone in Cement Manufacturing Industries is depicted in Fig 2 below.

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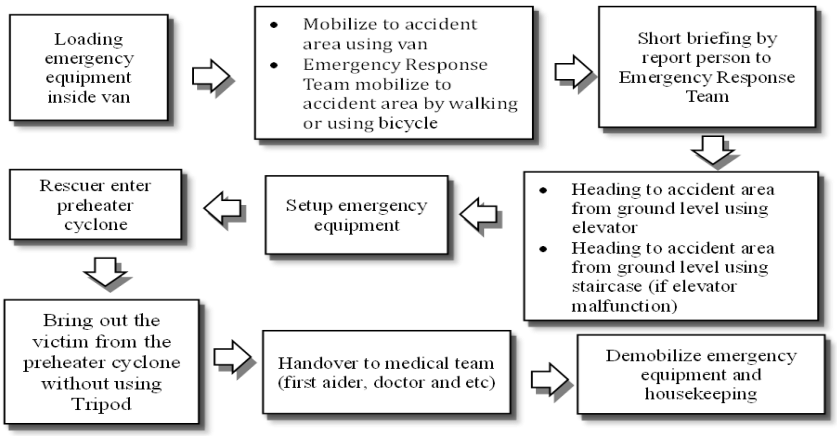

Fig. 2 *Sub activity classification for Preheater cyclone rescue operation for collapse of person*.

Hazards were identified by closely observing work activities along the entire process of rescue operation. As many as 27 potential hazard was identified A comprehensive list of potential hazards associated with these work activities is presented in Table 1 below.

Table 1 *Hazard Identification of Preheater Cyclone Rescue Operation for collapse of person*

No	Sub Activity	Hazard	Hazard Category	Event and Consequences
1	Loading emergency equipment inside van	Heavy equipment such as SCBA, stretcher, ropes	Ergonomic	- Back and shoulder pain
2a	Mobilize equipment to accident area using van	Uneven road	Physical	-Crash accident injuring the driver, passengers, cyclist, and pedestrians. -Minor fractures
		Blindspot at Kiln area	Physical	-Hit by lorry -Sprains, minor fractures
		Damage vehicle	Physical	-Broken bones and fractures -Hit structure, cyclist, pedestrians
2b.	Emergency Response Team mobilize to accident area. Remarks: ERT used bicycle heading to accident area.	Speeding vehicle involving lorry, excavator, and forklift	Physical	-Hit by vehicles
		Strong wind and Heavy rain	Physical	-Slip and fall due to slippery road
		Slippery road due to limestone, clinker, coal, oil spillage	Physical	-Slip and fall -Minor cuts, bruises
		Lorry blind spot at Kiln area	Physical	-Hit by lorry
3	Short briefing by reporting person to Emergency Response Team	Excessive noise from cement mixer machine and hacking job	Physical	-Hearing impairment
		Excessive dust from cement mixer	Chemical	-Difficult to breath, skin problem and eye damage

				-Silicosis
4a	Heading to accident area from ground using elevator	Damage elevator	Physical	-Entrapment -Minor cuts and bruises
4b	Heading to accident area from ground using staircase (If elevator malfunction)	Falling emergency equipment to underground	Physical	-Major head injuries
		Heavy emergency equipment	Ergonomic	-Back and shoulder pain
		Long distance repetitive movement using staircase	Physical and Ergonomic	-Muscle fatigue and strain in lower back and leg -Slip, trips, and fall
		Rescue ropes entangled to feet	Physical	-Slip, trips, and fall -Deep cut, bruises
5	Setup emergency equipment at nearest accident area	Slippery floor due to oil spillage	Physical	-Slip and falls -Bruises
		Congest walkway	Physical	-Trip and falls -Minor cuts and bruises
6	Rescuer enter preheater cyclone Preheater cyclone height: 10 meter Remark: ERT to check incident area from outside to confirm the entrance.	Excessive noise from cement mixer machine and hacking job	Physical	-Hearing Impairment -Stress
		Heavy equipment such as SCBA	Ergonomic	-Fatigue -Back and shoulder pain
		Insufficient lighting	Physical	-Slip and falls -Head Injury
		Poor scaffold condition	Physical	-Collapse of structure -Broken bones, bruises, and death
		Hanging object from coting and castable	Physical	-Minor head injury
		Insufficient oxygen	Physical	-Slowing down of pulse rate, disorientation, unconsciousness, and death
		Hazardous chemical/gases such as hydrogen sulphide, methane and etc	Chemical	-Can cause drowsiness, headaches, weakness, disability, and death
		Engulfment	Physical	-Fatality
7	Rescuer bring out the victim from the preheater cyclone without using rescue equipment (Tripod and Winch)	Narrow space	Physical and Psychosocial	-Entanglement -Entrapment -Fatigue and stress
		Damage SCBA	Chemical	-Expose inhale toxic gases, smoke, or other harmful substances. -Lack of oxygen can cause death
		Damage safety harness/lanyard	Physical	-Fall of person -Born fractures and death
		Heavy victim	Ergonomic	-Fatigue -Back and shoulder injury
		Contact with bodily blood/fluids	Biological	-Bacterial infection

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8	Handover to medical team (First aider, doctor and etc)	Contact with bodily blood/fluids	Biological	-Bacterial infection
9	Demobilize Emergency Equipment and Housekeeping	Uneven road	Physical	-Crash accident injuring the driver, passengers, cyclist, and pedestrians.
		Blindspot	Physical	-Hit by lorry -Sprains, minor fracture
		Speeding vehicle	Physical	-Loose control -Minor cuts, bruiser, fractures
		Heavy equipment SCBA, stretcher, ropes and etc	Physical	-Back and shoulder injuries

One of the key pillars of the industry's commitment to safety is its dedication to conducting thorough risk assessments. These assessments are routinely carried out to identify and evaluate potential hazards specific to preheater cyclone rescue operation for collapse of person. By taking a proactive approach, the industry can develop targeted control measures that effectively mitigate the challenges associated with rescue operation. Table 2 shows recommended risk control of Preheater Cyclone Rescue Operation for collapse of person.

Table 2: Risk control of Preheater Cyclone Rescue Operation for collapse of person

No	Sub Activity	Hazard	Risk Control
1	Loading emergency equipment inside van	Heavy equipment such as SCBA, stretcher, ropes	- Buddy System - Ensure that Rescuer and ERT are adequately trained and certified.
2a	Mobilize equipment to accident area using van	Uneven road	-Warning signs to alert drivers, cyclist and pedestrians. - Regular inspections of the road surface. - Maintain and repair the road surfaces consistently
		Blindspot at Kiln area	-Install convex mirror at lorry entrance and exit routes.
		Damage vehicle	-Vehicle inspection before used. -Vehicle maintenance twice a year
2b.	Emergency Response Team mobilize to accident area. Remarks: ERT used bicycle heading to accident area.	Speeding vehicle involving lorry, excavator, and forklift	-Enforce plant speed SOP 15KM/H consistently. - Plan and manage traffic flow during emergency.
		Strong wind and Heavy rain	-Stop work during heavy rain. - Use van for pickup
		Slippery road due to limestone, clinker, coal, oil spillage	-Daily road housekeeping -Use of road sweeping machine for maintaining clean and safe roadways - Wear safety helmet and safety shoes.
		Lorry blind spot at Kiln area	-Install convex mirror at primary entrance and exit of the vehicle
3	Short briefing by reporting person to Emergency Response	Excessive noise from cement mixer machine and hacking job	- Wear earplug/earmuff inside plant.

	Team	Excessive dust from cement mixer	- Wear N95 Dust mask
4a	Heading to accident area from ground using elevator	Damage elevator	- Implement a routine inspection and maintenance schedule for elevators
4b	Heading to accident area from ground using staircase (If elevator malfunction)	Falling emergency equipment to underground	- Put signage and barricade the accident area.
		Heavy emergency equipment	- Rescuer and ERT are adequately trained and certified. - Conduct training for Rescuer and ERT team - Conduct emergency drills once a year - Buddy systems
		Long distance repetitive movement using staircase	- Buddy systems - Additional manpower to carry emergency equipment.
		Rescue ropes entangled to feet	- Train rescuers in proper rope coiling techniques. -Ensure the rope is coiled and keep its length away from the floor
5	Setup emergency equipment at nearest accident area	Slippery floor due to oil spillage	- Clearly mark the area with warning signage and barricade the work area. - Regular floor inspection by SHO/SHE team - Housekeepinh before and after work. - Wear safety shoes
		Congest walkway	-Housekeeping before and after work
6	Rescuer enter preheater cyclone Preheater cyclone height: 10 meter Remark: ERT to check incident area from outside to confirm the entrance.	Excessive noise from cement mixer machine and hacking job	-Wear earplug/earmuff
		Heavy equipment such as SCBA	- Ensure the rescuer are adequately trained. - Rescuer are fit to work.
		Insufficient lighting	-Install additional lighting inside preheater cyclone. - Wear headlamp
		Poor scaffold condition	- Inspect the scaffolding with a competent scaffolder/SHO/SHE team - Erection, modification and disassembly of scaffolding are carried out by qualified and trained personnel. - Wear full safety body harness
		Hanging object from coting and castable	-Wear safety helmet with chin strap
		Insufficient oxygen	- Wear proper SCBA and shall be tested before use. - Install ventilation system - Before entry conduct gas monitoring by AGTES
		Hazardous chemical/gases such as hydrogen sulphide, methane and etc	- Provide the rescuer with a personal gas detector. - Ensure proper ventilation system - Wear proper SCBA and get it tested before use.

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		Engulfment	- Train rescue personnel thoroughly in confined space rescue procedures, emphasizing engulfment risks, warning sign recognition, and appropriate response measures. - Conduct a comprehensive risk assessment considering factors like unstable materials and hazardous substances in confined spaces. Customize the rescue plan to address specific conditions.
7	Rescuer bring out the victim from the preheater cyclone without using rescue equipment (Tripod and Winch)	Narrow space	- Entry supervisor to oversee the external and internal conditions of the confined space for the duration of the rescue operation. Implement audio and visual surveillance to guarantee the well-being of rescuer condition during rescue operation. - Conduct regular training sessions including simulations and drills to ensure that team members are competent in confined space rescue techniques.
		Damage SCBA	-Perform through pre-operation checks on the SCBA - Establish communication for reporting and addressing damaged SCBA using a walkie talkie.
		Damage safety harness/lanyard	-Safety harness inspection by SHO/SHE team before start work
		Heavy victim	-Ensure rescue team members are trained and competent in heavy victim rescue techniques. - Clear communication and coordination among rescue team members.
		Contact with bodily blood/fluids	- Wear nitril gloves, face masks, protective eyewear, and gowns if necessary.
8	Handover to medical team (First aider, doctor and etc)	Contact with bodily blood/fluids	-Wear nitril gloves, face masks, protective eyewear, and gowns if necessary.
9	Demobilize Emergency Equipment and Housekeeping	Uneven road	-Warning signs to alert drivers, cyclist and pedestrians - Regular inspection of the road surface. - Maintain and repair the road surface consistently.
		Blindspot	- Install convex mirror at lorry entrance and exit routes.
		Speeding vehicle	-Enforce plant speed SOP 15KM/H consistently
		Heavy equipment SCBA, stretcher, ropes and etc	-Buddy system

4. Conclusion

The outcomes of this study enable the identification of potential hazards in the course of rescue operations at the preheater cyclone. Analyzing the levels of hazards associated with various activities and proposing risk control measures can contribute to minimizing these hazards. Confined spaces can have rapidly changing conditions, especially during emergencies. Identifying hazards during rescue is essential to assess evolving risks and make informed decisions to ensure the safety of both the rescuers and the individuals in need of assistance. A total of 27 potential hazards were identified, which were subsequently categorized into safety and health hazards, physical, chemical, biological, ergonomic, and psychosocial in nature. Twenty-four safety-related hazards and three health-related hazards have been identified. Twenty-four of the twenty-seven hazards identified are physical in nature, two are chemical in nature, one is biological in nature, one is ergonomic in nature, and one is physiological in nature.

In conclusion, the process of hazard identification serves as a cornerstone for maintaining a safe and secure working environment, particularly in settings such as preheater cyclones within the cement manufacturing industry. Through systematic hazard assessments, potential risks can be identified, categorized, and thoroughly understood. This proactive approach enables the development and implementation of targeted risk mitigation measures and robust safety protocols.

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References

[1] Department of Occupational Safety and Health, Industry Code of Practice for Safe Working in a Confined Space, Ministry of Human Resource Malaysia, 2010 (ICOP,2010). Malaysia (1994). Occupational Safety and Health Act 1994. Retrieved on 22 May 2023 From https://www.dosh.gov.my/index.php/legislation/acts-legislation/23-02-occupational-safety-and-health-act-1994-act-514/file

[2] Chaib, R., Verzea, I., Cozminca, I., & Benidir, M. (2015b). Preserving and improving the safety and health at work: Case of Hamma Bouziane cement plant (Algeria). Safety Science, 76, 145–150. https://doi.org/10.1016/j.ssci.2015.01.014

[3] Amin, Z., & Mohammad, R. (2023). Bowtie analysis for risk assessment of confined space at sewerage construction project. Progress in Energy and Environment, 24(1), 22–34. https://doi.org/10.37934/progee.24.1.2234

[4] Botti, L., Duraccio, V., Gnoni, M. G., & Mora, C. (2015). A framework for preventing and managing risks in confined spaces through IOT technologies. In *CRC Press eBooks* (pp. 3209–3217). https://doi.org/10.1201/b19094-423

[5] Stojković, A. (2013). OCCUPATIONAL SAFETY IN HAZARDOUS CONFINED SPACE. Safety Engineering, 3(3). https://doi.org/10.7562/se2013.3.03.05

[6] Selman, J., Spickett, J. T., Jansz, J., & Mullins, B. J. (2018). An investigation into the rate and mechanism of incident of work-related confined space fatalities. Safety Science, 109, 333–343. https://doi.org/10.1016/j.ssci.2018.06.014

[7] Selman, J., Spickett, J. T., Jansz, J., & Mullins, B. J. (2019). Confined space rescue: A proposed procedure to reduce the risks. Safety Science, 113, 78–90. https://doi.org/10.1016/j.ssci.2018.11.017

[8] Amin, N. Z., & Mohammad, N. R. (2023). Bowtie analysis for risk assessment of confined space at sewerage construction project. Bowtie Analysis for Risk Assessment of Confined Space at Sewerage Construction Project, 24(1), 22–34. https://doi.org/10.37934/progee.24.1.2234