

63. Characteristic Analysis of Hazardous Activities Associated with Oil and Gas Rig Assembling Operation: A Proportional Approach

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Abstract

This paper highlighted the level of severity and characteristics of potential hazardous activities correlated with rig assembling operation during on and offshore drilling operation through implementing quantitative and qualitative research approaches. In this paper, Malaysian, Saudi Arabian and Pakistani oil and gas industry has been selected on the bases of their annual production and extraction of petrochemicals. Targeted population of this study are 09 (nine) health and safety officers and 80 (eighty) oil and gas drilling crew members, selected based on their working experience and area of expertise in drilling operation, from selected oil and gas industries. For quantitative (Survey instrument) data analysis descriptive statistical methods have been utilized (Mean Range, Standard Deviation and Percentage) by using SPSS 22.0 software package. While, for the evaluation of qualitative (In-depth semi structured interview) findings, thematic analysis approach has been adopted for identifying potential hazards associated with rig assembling operation activities. According to the results based on the response from Malaysian oil and gas industry, circulating system installation activity has been reported as the most hazardous activity during onshore rig assembling, whereas, rig power system installation activity has been nominated as the most hazardous activity at offshore rig assembling operation. Likewise, participants from Saudi Arabian oil and gas industry have considered derrick and rig floor installation activity at onshore and rig power system installation at offshore site as cause of major incidents. Similarly, in the context of Pakistan, respondents have argued that the installation of handrail and ladders at onshore domain, while, installation of circulating system at offshore site is reported as associated with high occupational level of risk. Overall findings indicate that the response from Pakistani onshore domain with mean range 3.32 and Saudi Arabian offshore domain with mean range of 3.37 are considered as most hazardous operations as compared to other focused industries related with safety and ergonomic hazards at on and offshore rig assembling.

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1. Introduction

Petrochemical extraction and production industries contribute major part largely for the economical prosperity of every nation [1]. Drilling process is one of the most common and main operation at these

oil and gas industries. Due to the hazardous nature of oil and gas drilling operation, hundreds of people had has been died and injured annually due to the negligence of health and safety standards and protocols [2]. According to Megan in year 2013, the death rate among oil and gas workers (drilling crew) was nearly eight times higher than the all-industry rate of 3.2 fatalities for every 100,000 workers [3]. In well drilling, rig assembling operation and its associated activities are considered as the initial and most challenging tasks at on and offshore sites [4]. Reportedly, experts have highlighted that due to the lack of proper safety and health considerations, rig installation and moving management or contractors regularly expose their workforce to extreme danger in life threatening situations [5].

Offshore rig assembling operation is indicated as enormously difficult, generally, due to environmental factors and particularly, due to rig structure in deep seabed [6]. In year 2015, 32 people have been died and 42 have been critically injured during offshore rig operations in Azerbaijan due to huge fire and improper rescue plan [6]. Likewise, onshore rig installation has also been nominated as highly hazardous because it involves lifting risks and hazards related to the transportation of rig equipment and accessories, which lead to critical injuries. Most commonly reported hazards include; improper equipment handling, drop and fall of objects and accessories, hit by loaded crane and electrical welding hazards has been frequently reported by occupational safety and health administration (OSHA) [8]. These correlated hazards with rig assembling activities can be controlled through sufficient and detailed analysis of hazard characteristics and nature or range of its severity on large scale [9].

2. Problem Statement

Rig assembling operation is the most fundamental and vital operation for the extraction of crude oil and gases from the surface of land and deep sea horizon [10]. Due to the hazardous nature of this operation, numerous sub activities have performed for the successful implementation of and offshore rig platforms [11]. Rig assembling operation mainly consists of four major activities such as derrick and rig floor installation, handrail and ladder installation, rig power system installation and circulating system assembling activity, which are executed or conducted at on and offshore drilling sites [12]. Each rig assembling activity is associated with several types of physical and behavioural hazards which may result in severe injuries, life time disabilities and even fatalities [13].

Previously, researchers have highlighted the lack of effective approaches for the assessment and identification of the most common potential hazards and their characteristics which can cause severe injuries and life time disabilities during rig assembling activities [11]. These risk assessment and hazard reorganization will guide health and safety officials and practitioners to implement appropriate preventive measures for the reduction and elimination of rig assembling hazards [14]. There is also a sheer need of identification of frequently occurring hazardous events during the execution of onshore and offshore rig assembling activities worldwide which can guide and provide awareness to newly recruited drilling workforce for taking suitable actions and safety precautions [15]. In accordance to these issues, this paper identified some of the most hazardous rig assembling activities during onshore and offshore drilling operation. It also indicates about the characteristics of associated potential hazards and life threatening risks due to the aforementioned hazardous rig assembling activities at Malaysian, Saudi Arabian and Pakistani oil and gas industries.

3. Research Objectives

The main aim of this study is to achieve the following research objectives:

- To identify the most hazardous activities associated with rig assembling operation during on and offshore drilling process among Malaysian, Saudi Arabian and Pakistani oil and gas industries.
- To analyze the characteristics of the related potential hazards associated with the rig assembling operation at Malaysian, Saudi Arabian and Pakistani oil and gas industries.

4. Research Questions

This study seeks answers of the following research questions:

- What are the major hazardous activities during rig assembling operation among on and offshore oil and gas industries in Malaysia, Saudi Arabia and Pakistan?
- What are the potential hazards associated with rig assembling operation among on and offshore oil and gas industries in Malaysia, Saudi Arabia and Pakistan?

5. Methodology

In this mix-method based analytical study, for the quantitative research analysis, a total of eighty (80) oil and gas drilling crew members, having both on and offshore working experience, have been chosen through random sampling approach from three targeted oil and gas industries; Malaysia (PETRONAS), Saudi Arabia (Saudi Aramco) and Pakistan (OGDCL) as shown in table 1. While, for the qualitative research analysis, a total of three (03) health and safety drilling professional experts from each country have been conveniently selected for in-depth semi structured interview from each of the mentioned focused industries. For the detailed analysis of quantitative data, descriptive statistical technique (Mean, Standard deviation and Percentage) has been employed through statistical package of social sciences SPSS.22. Whereas, for the interpretation of qualitative research, thematic analysis method has been used for analyzing the characteristics of the most common potential hazards during on and offshore rig assembling operation.

Table 1. Study Respondents

Country	Industry	No of Respondent	
		Quantitative	Qualitative
Malaysia	PETRONAS	80	03
Saudi Arabia	Saudi Aramco	80	03
Pakistan	OGDCL	80	03
Total		240	09

6. Quantitative Results and Analysis

To conduct the quantitative analysis of first and second research objectives and research questions of this study, descriptive statistical research approach has been adopted for the identification of hazardous nature of rig assembling activities among on and offshore oil and gas industries in Malaysia, Saudi Arabia and Pakistan. Thus, for the justification and answer of the research question, a table of specifications is adapted from Landlell 1997, as shown in table 2, as a guide to measure the nature of hazardous activity during rig assembling operation based on the level of mean range [16].

Table 2. Level of Hazardousness

Category	Mean Range	Hazardousness Level
1	1.00-2.33	Low
2	2.34-.3.67	Moderate
3	3.68-5.00	High

- **Identification of Hazardous Activity during Rig Assembling Operation**

According to the descriptive statistical findings from Malaysian oil and gas industries based on quantitative survey response, as shown in table 3, the most hazardous onshore activity in which the drilling crew tackled with critical injures and wounds during rig assembling is during rigging up circulatory system on rig which is lying under moderate level of mean score range of 3.47 and standard deviation of 0.554. Whereas, the installation of rig power system is reported as most potentially hazardous offshore activity during rig assembling, which is under moderate level of mean score of 3.27 and standard deviation of 0.675.

Table 3. Quantitative Results of Rig Assembling Operation at Malaysia

Activities	Onshore	Offshore
Derrick and Rig Floor Installation	Mean=3.07 SD=0.858	Mean=3.22 SD=0.697
Handrail and Ladder Installation	Mean=3.10 SD=0.632	Mean=3.35 SD=0.579
Rig Power System Installation	Mean=3.27 SD=0.678	Mean=3.42 SD=0.675
Rigging-up Circulating System	Mean=3.47 SD=0.554	Mean=3.35 SD=0.662
Total	3.22	3.33

Likewise, the response from on and offshore Saudi Arabian oil and gas industries have indicated rigging up circulating system activity as most hazardous at onshore operation with a moderate level of mean score range which is 3.55 and standard deviation of 0.905 . While for offshore operation, drilling crew have been experienced most accidents and injuries during the installation of handrail and ladder on rig activity which is under moderate level of mean range with a mean score of 3.42 and standard deviation of 0.667 as shown in table 4.

Table 4. Quantitative Results of Rig Assembling Operation at Saudi Arabia

Activities	Onshore	Offshore
Derrick and Rig Floor Installation	Mean=3.32 SD=0.729	Mean=3.2 SD=0.729
Handrail and Ladder Installation	Mean=3.20 SD=0.882	Mean=3.7 SD=0.667
Rig Power System Installation	Mean=3.10 SD=0.981	Mean=3.35 SD=0.863
Rigging-up Circulating System	Mean=3.554 SD=0.905	Mean=3.47 SD=0.750
Total	3.20	3.37

In the context of Pakistani oil and gas industry, based on the quantitative response from participants as shown in table 5, it indicates that mostly the workers get injured at onshore drilling sites during sitting up handrails and ladders activity with a mean score of 3.45 and standard deviation of 0.749 which is lying under moderate level of mean range. Whereas, according to the response from drilling crew and safety officers at offshore rig assembling operation, most of the hazards have been reported during the lifting of circulatory system at offshore rig with a moderate level mean score of 3.67 and standard deviation of 0.474.

Table 5. Quantitative Results of Rig Assembling Operation at Pakistan

Activities	Onshore	Offshore
Derrick and Rig Floor Installation	Mean=3.42 SD=0.780	Mean=3.22 SD=0.697
Handrail and Ladder Installation	Mean=3.45 SD=0.749	Mean=3.25 SD=0.110
Rig Power System Installation	Mean=3.07 SD=0.729	Mean=3.25 SD=0.742
Rigging-up Circulating System	Mean=3.37 SD=0.740	Mean=3.67 SD=0.474
Total	3.32	3.34

- **Characteristic Analysis of Potential Hazards Associated with Rig Assembling Operation**

Table 6 indicates the cumulative findings of potential hazards associated with rig assembling operation at Malaysian, Saudi Arabian and Pakistani Oil and gas industries. According to descriptive analysis, 65% of respondents from Malaysian oil and gas industry and Saudi Arabia, 75% which is highest from Pakistani onshore oil and gas industry considered safety hazards are potential hazards during rig assembling. Similarly, 68% of the respondents from Malaysia, 53% of the respondents from Saudi Arabia and 40% of the respondents from Pakistani oil and gas industries specified that the category of safety hazards are cause of injuries during offshore operation. While, 35% of respondents from Malaysian oil and gas industry, 47% of the respondents from Saudi Arabian and 25% of the respondents from Pakistani onshore oil and gas industry, which is lowest among all onshore sites, indicated that ergonomic hazards are

potential hazards. Likewise, 32 % of the respondents from Malaysia and 35% of the respondents from Saudi Arabia and 60% of the respondents from Pakistani oil and gas industries reported that the ergonomic hazard are the reason of mishaps at offshore sites during rig assembling.

Table 6. Hazard Associated with Rig Assembling Operation

Country	Domain	Safety Hazard	Ergonomic Hazard
Malaysia	Onshore	65%	35%
	Offshore	68%	32%
Saudi Arabia	Onshore	65%	47%
	Offshore	53%	35%
Pakistan	Onshore	75%	25%
	Offshore	40%	60%

7. Qualitative Results and Analysis

In order to find out the perception of health and safety drilling professionals regarding potential hazards which occur mostly during on and offshore well drilling operation semi structured interview has been conducted. For the analysis of qualitative data, thematic analysis approach has been implemented for semi structure interviews from targeted respondents by assigning code numbers for recognizing the industry and country, as shown in table 7.

Table 7. Respondents Interview Code

S.NO	Malaysia	Saudi Arabia	Pakistan
1	MY01	SA1	PK1
2	MY02	SA2	PK2
3	MY03	SA3	PK3
Total	03	03	03

- **Safety Hazards Associated with Derrick and Rig Floor Installation**

According to the in-depth interview response from drilling health and safety experts from Malaysian, Saudi Arabian and Pakistani oil and gas industries as shown in fig 1, it has been illustrated that, most potential hazards among all targeted industries during on and offshore derrick and rig floor installation is due to crane lifting activity during rig assembling operation. Similarly, participant MY1, SA2 and PK2 have equally emphasized that crane lifting hazards cause stuck and trap hazards which lead to serious injuries and body fractures during onshore rig assembling. Whereas, in the reference of offshore rig assembling operation, interview participant MY2, SA1 and PK2 has argued that, stuck by loaded crane and contact with loaded crane which can physically harm the drilling workforce during derrick and rig floor installation.

Secondly, Welding of derrick units is also mutually recognized as potential hazard which can be a source of eyes irritation due to welding flash or lightning and can also cause blurred vision or colour blindness problems. As participants MY2, SA1 and PK3 have indicated that, rig units welding also leads to extremely dangerous hazards which can be life threatening for all staff at onshore rig. Meanwhile, interview participant MY3, SA3 and PK3 have pointed out that, welding hazards have the highest probability to affect the eyes and skin during welding activity at offshore sites, if there is a presence of flammable liquids or gases nearby.

Thirdly, most of the interview participants from targeted industries have specified limited workspace hazard during installation of derrick and rig floor at on and offshore drilling site. According to interview respondents, MY3, SA3 and PK1 has mutually nominated, limited and confined space hazard, during onshore rig assembling based on their working experience in drilling operation. Alternatively, in the perspective of offshore derrick and rig floor assembling, interview respondents MY1, SA2 and PK2 have emphasized that limited workspace hazards mainly resulted to fall from height, slipping and tripping hazards on rig floor, which is the most common cause and also one of the highly reported hazard during offshore drilling operation.



Fig.1. Block Diagram for Derrick and Floor Installation

- **Safety Hazards associated with Installation of Handrails and Ladders**

Interview participants from almost all targeted industries have pointed out hazards such as, falling person and object while operating at heights, which is also considered as frequently occurring hazard during performing this activity. Similarly, respondents MY1, SA1 and PK1 have argued that the falling from ladder or lifting crane is due to mechanical failure or improper handling during installation of handrails and ladders at on and offshore rig assembling operation as shown in fig 2. It is mutually stressed by the participants that the falling from height hazards has potential to cause severe head and shoulder injuries to assigned workers as they use to ignore recommended safety measures during handrails and ladder installation.

Furthermore, health and safety expert MY3 from Malaysian and PK3 from Pakistani onshore oil and gas industries have agreed on hazards due to poor housekeeping on site which is directly correlated with fall, slip and trip hazard that results in various workspace injuries during handrail and ladder installation. Consequently, due to the interaction with these hazards, workers fracture their upper and lower limbs leading to permanent disabilities. While, interview participant SA3 have emphasized on improper housekeeping hazards such as slip and trip on rig floor during installation of handrail and ladder activity at on and offshore sites.



Fig.2. Block Diagram for Handrail and Ladder Installation

- **Safety Hazards Associated with Installation of Rig Power System**

In Contrast, respondents MY1, SA3 and PK3 have common arguments on electrical hazards which lead to electrocution of the workers during welding operation at on and offshore rig power system installation. Whenever, electric wires are stripped or damaged from some extents which badly affect the installation crew. These electrical hazards are also associated with short circuits which result in huge fires on site, if flammable chemicals are leaked near by the fire. Also, the toxic fumes from the fire have the ability to cause respiratory and lungs problem to the power installation crew.

Subsequently, falling object during lifting is also generally recognized as a potential hazard according to the interview of respondents from targeted on and offshore oil and gas industries as illustrated in fig 3. Interview participants, MY2, SA1 and PK1 have nominated, falling hazard during power system lifting which leads to critical fractures like head, hand and back fractures at onshore rig assembling. However, respondents MY3, SA2 and PK2 have mutually accentuated falling objects hazard due to lack of proper handling of equipment and tools or utilization of wrong lifting approach during offshore operation.

Likewise, stuck by electric power cords is specified as the source of tripping and slipping hazard as highlighted by the respondents from the targeted countries during interview sessions. As participant MY1, SA2 and PK2 have emphasized that if power cords are uncovered which is usually happened when it's not properly inspected by the rig management or safety officer, therefore, the drilling crew have to face high voltage electrocution and even on spot death due to high electric current.

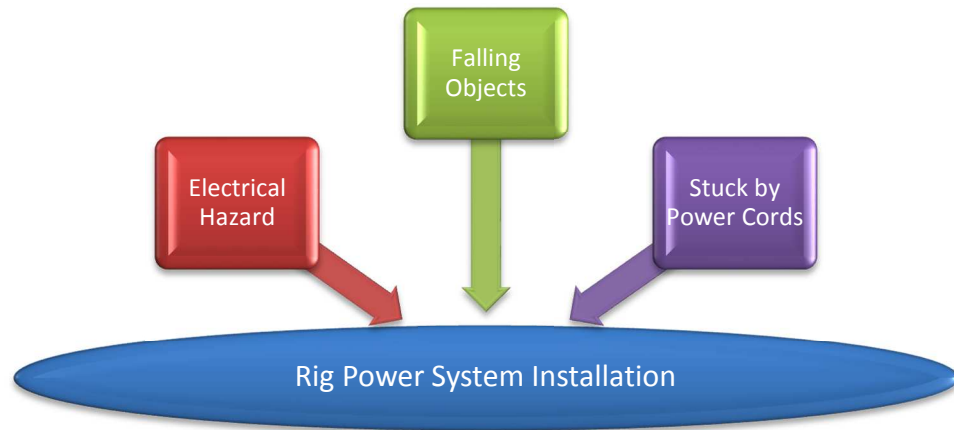


Fig.3. Block Diagram for Rig Power System Installation

- **Ergonomic and Safety Hazards associated with Rigging up the Circulating System**

Based on the qualitative findings regarding hazards related with rigging up circulating system during on and offshore rig assembling, participant MY1, SA1 and PK1 had point of agreement that the wrong load lifting hazard is the major cause of spinal cord injuries at onshore activity. Similarly, in the context of offshore participant MY2, SA2 and PK3 have identified that the improper lifting hazards repeatedly reported due to the negligence of workers to proper lifting techniques as standardized by Occupational health and safety administration (OSHA). Due to the negligence of standardized lifting techniques, drilling crew suffered with back pain, strains and spinal disk problems and in some cases, they are even paralyzed due to blood clotting.

Correspondingly, participant MY2, SA3 and PK3 from targeted industries have collective compliance on stuck by load and moving objects hazard during rigging up circulating system at onshore rig assembling operation. Meanwhile, participant MY3, SA1 and PK2 has indicated that stuck by moving object due to alignment of the tank and stuck by hammer are the main reasons of physical injuries and body fractures at offshore sites rather than onshore during installation of circulatory system activity as shown in fig 4. Likewise, drop and fall objects from heights due to technical and mechanical problems, especially when the driller used to pick up Kelly, has frequently acknowledged as the common hazard among response from approximately all respondents from Malaysia, Saudi Arabia and Pakistan. Similarly, participant PK3 has highlighted that, due to improper latching of Kelly or top drive with elevator links these incident to happen which leads to bone fractures and deep wounds.

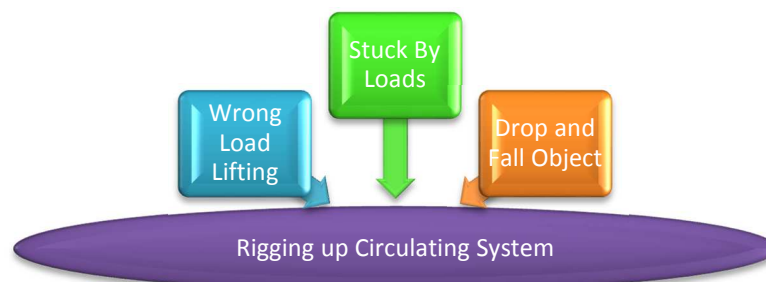


Fig.4. Block Diagram for Rigging up Circulating System

8. Conclusion

The overall results of this paper indicated that, the respondents of this study suggested that, the rig assembling operation is a moderately hazardous operation at on and offshore drilling. But from the mean value of each activity, it can be observed that the offshore operation is more hazardous than onshore operation during rig assembling in Malaysian, Saudi Arabian and Pakistani oil and gas industries. Based on the quantitative and qualitative results, the highest mean value is reported by Saudi Arabian drilling crew as they have broad working experience at offshore oil and gas operation with a moderate range of mean score which is 3.37 at offshore rig assembling. Whereas, participants from Pakistani onshore rig assembling domain have highest level of mean range as compared to Malaysian and Saudi Arabian rig crew, which is 3.32 and lies under moderate level of mean range. According to these findings, the respondents also highlighted the safety hazards such as falling, drop object, confined space, and stuck by wires and burns during welding at on and offshore rig installation. Similarly, potential ergonomic hazards like wrong load and rig accessories lifting hazards have also been identified during this explanatory research at on and offshore rig assembling operation.

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