

Severity of the Casing and Cementing Operation with Associated Potential Hazards in the Drilling Process in the On and Offshore Oil and Gas Industry: A Cross-Sectional Investigation into Safety Management

Razali Bin Hassan^{1*}, M. M. Asad¹, Q. M. Soomro² and F. Sherwani³

¹*Faculty of Technical and Vocational Education, Universiti Tun Hussein Onn Malaysia, 86400 Parit Raja, Batu Pahat, Johor, Malaysia*

²*Director, OSHTC - Occupational Safety and Health Training and Consultancy Pakistan*

³*Faculty of Electrical and Electronics Engineering, Universiti Tun Hussein Onn Malaysia, 86400 Parit Raja, Batu Pahat, Johor, Malaysia*

ABSTRACT

This paper discusses the major hazardous activities during the casing and cementing operation with potential associated hazards in the on and offshore oil and gas industries of Malaysia, Pakistan and Saudi Arabia. The researcher adopted the explanatory research approach for the quantitative (survey questionnaire) and qualitative research methods (semi-structured interview) in the data collection process. Eighty drilling crew were randomly selected for quantitative research, while three safety officers were purposively selected for qualitative research from each targeted industry. According to the findings of this study, running casing to wells and circulation cementing activity is considered highly hazardous at the offshore site. At the Saudi Arabian onshore domain, running casing to holes is more hazardous, while at offshore domains, installation of casing and casing accessories is more hazardous than in Malaysia and Pakistan. The participants from the Pakistani offshore industry reported that installation of casing and circulation of cementing activity were highly hazardous. In the context of overall casing and cementing operation among the focus industries, the Malaysian on and offshore oil and gas industry considers the casing and cementing operation as more hazardous compared to that of other industries, with a total mean range of 3.37 for onshore and 3.45 for offshore sites that lie under a moderate level of the mean range.

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E-mail addresses:

razalih@uthm.edu.my (Razali Bin Hassan),

mujtabaasad11@gmail.com (M. M. Asad),

qadir_mehmood@yahoo.com (Q. M. Soomro),

fahadsherwanis@gmail.com (F. Sherwani)

* Corresponding author

The dangers are associated with potential ergonomic, chemical and safety hazards during on and offshore operation.

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INTRODUCTION

Advancement in the oil and gas industry has evolved over time and the various uses of these fuels have likewise extended and turned into an essential part of today's worldwide economy (Blackley et al., 2014). Oil inevitably supplanted coal as the world's main fuel in the early 20th century (Bennear, 2015). The methods and procedures involved in producing and dispersing oil and gas are very unpredictable and critical and they require state-of-the-art technologies (Ingraffea et al., 2014). One of the major and most important operation in the oil and gas industry is the oil-well drilling process. In this process, an oil well is bored in the earth to conduct petroleum oil hydrocarbons to the surface. There are several operations and activities involved in the drilling operation. Each activity comes with physical, ergonomic, safety and chemical hazards that can cause injuries and also lead to immediate death (Blackley et al., 2014).

According to statistical data, most of the hazards were reported during the casing and cementing operation (Brenner & Cawley, 2015). The casing and cementing operation occurs intermittently during the drilling process initiated with the surface casing and intermediate casing and ending

with the production string, which takes place during well completion (Wiseman, 2009). The number of critical injuries and fatalities is high during installation of well surface casing in on and offshore drilling in the petrochemical extraction industry (Skogdalen & Vinnem, 2012).

PROBLEM STATEMENT

The casing and cementing operation is considered hazardous due to the nature of the job, in which drilling crew and workers have to deal with heavy casing accessories, tools and toxic and harmful drilling fluids such as oil base mud, silica and radioactive materials (Kargbo, Wilhelm, & Campbell, 2010). According to accident cases reported by the USA Occupational Health and Safety Department, many fatalities have been recorded due to loose casing due to wire rope and slings having fallen and become unstuck and tripping due to heavy casing accessories (Medina & Krasuk, 2015). Accidents during the casing and cementing operation are unpredictable and can differ greatly one from another due to the installation environment and installation equipment (Livingston et al., 2016). Although casing and cementing activity represents less than 10% of well cycle time, the injury rate during this phase is more than 10%; indeed, 50% of fatal accidents on a drill rig happen during casing, according to International Association of Drilling Contractors (IADC) (Medina & Krasuk, 2015). Before performing casing and cementing activities, special services crew and safety officials perform risk

assessment to avoid accidents but they are unable to fully eliminate the hazards. Consequently, researchers have suggested that because there is a need for adequate hazard identification, risks rising from the frontier conditions in which the cementing and casing operation is carried out need to be eliminated or controlled through pooling and comparing the severity and hazard level of the casing and cementing activities from different drilling fields, regions and affected industries i.e. multiple effective hazard identification approaches can be used (Asad & Hassan, 2015).

This paper identifies major potential hazardous activities in the casing and cementing operation carried out by on and offshore drilling crew in the Malaysian, Saudi Arabian and Pakistani oil and gas industries. The quantitative and qualitative research approaches are used.

RESEARCH OBJECTIVE

The main purpose of this study was to identify the most hazardous activities in the casing and cementing operation involved in the drilling process of the offshore and onshore oil and gas industries of Malaysia, Saudi Arabia and Pakistan. The main objectives of this study were:

1. To identify hazardous activities during the casing and cementing operations involved in the on and offshore drilling operation of the Malaysian, Saudi Arabian and Pakistani oil and gas industries;
2. To analyse the potential hazards associated with the casing and

cementing operation involved in the drilling process of the Malaysian, Saudi Arabian and Pakistani oil and gas industries.

RESEARCH QUESTION

The main purpose of this study was to seek answers to the following research questions:

1. What are the major hazardous activities during the casing and cementing operation in the drilling process in the on and offshore oil and gas industries in Malaysia, Saudi Arabia and Pakistan?
2. What are the potential hazards associated with drilling activities during the casing and cementing operation in the drilling process in the on and offshore oil and gas industries in Malaysia, Saudi Arabia and Pakistan?

METHODOLOGY

The population used in this study were health and safety experts and drilling crew from major onshore and offshore oil and gas industries from Malaysia (Petronas), Saudi Arabia (Saudi Aramco) and Pakistan (OGDCL). These three countries were selected for data collection because of the variety of environmental aspects and the different international safety act and regulatory bodies like OSHA that are involved.

The explanatory mix method approach was adopted in this quantitative study where 80 drilling crew were randomly selected to answer the research questionnaire to identify the most hazardous activities during the on

and offshore casing and cementing operation in the drilling process. For the qualitative study, three health and safety experts from each industry were selected through purposive sampling to participate in a semi-structured interview as shown in Table 1.

Table 1
Participants of the study

Country	Industry	No of Respondents	
		Quantitative	Qualitative
Malaysia	Petronas	80	3
Pakistan	OGDCL	80	3
Saudi Arabia	Saudi Aramco	80	3
Total		240	9

Instrument Development

The correct study instrument or measuring instrument was essential to achieve the research objectives¹². The instruments used in this study were a survey questionnaire and interview questions validated by health and safety experts. In this research study, both qualitative and quantitative methods of data collection were used for the justification of results and findings. The researcher designed the survey questionnaire and interview questions based on the casing and cementing activities that were identified in previous research and the health and safety regulatory body OSHA, and validated by five drilling professionals using the rubric assessment approach. Thus, the quantitative research instrument was divided into nine sections using a 4-point Likert scale for onshore and offshore oil and gas drilling activities such

as rig assembling, well drilling, tripping, hole cementing and casing, equipment maintenance, well control, hydrogen sulfide (H₂S) and chemical monitoring, marine operation and helicopter operation.

DATA ANALYSIS

The quantitative research data were analysed using the Statistical Package for the Social Sciences 20 software for descriptive statistical techniques, mean, standard deviation and level of percentage for presenting and justifying achieved outcomes. As Babbie (1990) concluded, the descriptive analysis is an often used process in survey research. For the qualitative data analysis, the thematic analysis approach was used for each casing and cementing activity. Details of the analysis are listed below in Table 2.

Table 2
Research question analysis approach

Research Question	Approach	Method of Analysis
Research Question One	Quantitative	Descriptive Analysis
Research Question Two	Qualitative and Quantitative	Descriptive and Thematic Analysis

RESULTS AND DISCUSSION

First Research Question: Identification of Hazardous Activities

To answer the first research question, a table of specifications was adapted from Landell (1997) as a guide to measure the appropriateness level of the mean range of hazardous activities in the casing and cementing operation at the on and offshore oil and gas industries in Malaysia, Saudi Arabia and Pakistan. The levels according to range are shown in Table 3.

Table 3
Appropriate levels

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

Malaysian context

According to the descriptive statistical results obtained from the survey questionnaire of the Malaysian oil and gas industry drilling crew as shown in Table 4, the installation of casing accessories is considered more hazardous in the onshore operation, with a mean score of 3.52, which is below the moderate level of the mean range according to Table 3. Meanwhile, for the

offshore casing and cementing operation, the installation of casing tools activity, circulating and cementing is considered highly hazardous at offshore sites rather than at onshore sites, with both having a moderate level of mean range i.e. 3.50.

Saudi Arabian context

According to the on and offshore Saudi Arabian oil and gas industry drilling crew, as shown in Table 4, running the casing to hole is the most hazardous activity, and injuries were experienced by the onshore drilling workforce with a mean score of 3.57. This was below the moderate level of the mean range as seen in the table of mean range specifications. Likewise, in offshore operation, installation of casing accessories was thought by drilling crew to be more hazardous and the cause of major accidents with a moderate level of mean score, 3.57.

Pakistani context

In reference to the Pakistani oil and gas industry based on the quantitative response from respondents as shown in Table 4, more hazards were observed during the circulating and cementing operation compared to during other activities at onshore drilling sites, with a moderate level of mean score,

3.67. Also, the survey response for offshore cementing and casing operation indicated that installation of casing tools activity was

seen as being the most hazardous, with a moderate level of mean score, 3.62.

Table 4
Mean of response from targeted industries

Activities	Hole Casing and Cementing Operation					
	Malaysia		Saudi Arabia		Pakistan	
	Onshore	Offshore	Onshore	Offshore	Onshore	Offshore
Installation of casing tools	3.40	3.50	3.12	3.55	3.35	3.62
Running the casing into the well hole stage	3.27	3.45	3.50	3.25	3.10	3.35
Installing the casing accessories	3.52	3.35	3.45	3.57	3.30	3.40
Circulating and cementing risk factor	3.27	3.50	3.02	3.40	3.67	3.00
Total	3.36	3.45	3.12	3.44	3.35	3.34

According to the overall quantitative results, almost all the activities were moderately hazardous, but respondents from the Pakistani oil and gas industry indicated that the installation of casing is considered more hazardous during onshore casing and cementing operation, with a moderate mean range of 3.35. However, respondents from Saudi Arabia highlighted that casing installation activity at the offshore domain with a mean score of 3.55 was more hazardous than that carried out in the Malaysian and Pakistani oil and gas industries. Similarly, in rating the activity of running the casing into the well hole, respondents from Saudi Arabia reported it as being a risky activity at onshore sites, with a moderate mean range of 3.50. In the context of offshore sites, respondents from the Malaysian oil and gas industry reported that they experienced the running casing

to hole activity as being highly hazardous compared with a moderate mean range of 3.45.

Respondents from the onshore Malaysian oil and gas industry specified that installation of casing accessories was more hazardous than that carried out in Saudi Arabia and Pakistan, with a moderated mean range of 3.52. Respondents from Saudi Arabian offshore sites also considered this activity as being hazardous, with a mean value of 3.57. Furthermore, the circulating and cementing activity was recorded as being more risky at onshore sites according to respondents from the Pakistani oil and gas industry, with a mean range of 3.67. Respondents from Malaysia identified this as the source of major injuries during offshore operations, giving it a mean value of 3.50.

Second Research Question: Potential Hazard Associated with Hole Cementing and Casing operation

Table 5 shows the potential hazards associated with hole cementing and casing operation at Malaysian, Saudi Arabian and Pakistani oil and gas drilling sites. According to the findings, 45% of respondents from Malaysian, 38% from Saudi Arabian and 35% from Pakistani onshore oil and gas industry have considered ergonomic hazards are potentially hazardous during hole cementing and casing operation. A total of 33% of the respondents from the Malaysian and 48% from the Saudi Arabian and 25%

from the Pakistani oil and gas industries reported that ergonomic hazards were the cause of injuries during offshore operations.

A total of 55% of the respondents from the Malaysian onshore oil and gas industry, 52% from the Saudi Arabian and 65% from the Pakistani indicated that safety hazards such as falling, getting stuck and tripping were potential hazards, while 67 % of the respondents from the Malaysian, 52% from the Saudi Arabian and 75% from the Pakistani offshore oil and gas industries answered that safety hazards were potential hazards during the hole cementing and casing operations.

Table 5
Hazard Associated with On and Offshore Cementing and Casing Operation

Country	Domain	Ergonomic Hazard	Safety Hazard
Malaysia	Onshore	45%	55%
	Offshore	33%	67%
Saudi Arabia	Onshore	38%	62%
	Offshore	48%	52%
Pakistan	Onshore	35%	65%
	Offshore	25%	75%

Qualitative Results

A thematic analysis of the semi-structured interviews was conducted. Each participant was assigned a code number for recognising the industry and country based on designation during data analysis and interpretation, as shown in Table 6.

Table 6
Respondents of the qualitative study

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

Ergonomic and Safety Hazards Associated with Installation of Casing Tools

The qualitative findings showed that the participants agreed that hazards such as slipping and falling were related to handling of heavy casing that could harm the workers during running the casing into the hole, as shown in the block diagram (Figure 1). Participants MY1 and MY2 from Malaysia stated that there were safety hazards to take note of during onshore casing installation, while participant MY3 from Malaysia and PK3 from Pakistan agreed on the safety hazards at offshore operation as shown in the table. Participant SA2 from the Saudi Arabian oil and gas industry referred to injuries suffered by the drilling crew to their face and hand, such as crushing, during handling heavy casing.

The interview participants also acknowledged falling from the stabbing board as a hazard. Well control was also highly hazardous and, most of the time, affected personnel lost their lives due to deep head injuries if they were not wearing proper personal protective equipment. Participant MY2, SA1 and PK3 highlighted falling from stabling and well control as potential hazards at offshore sites but Participant SA3 from Saudi Arabia considered onshore sites to be more hazardous.

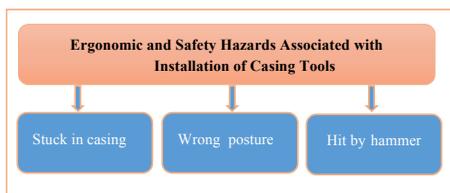


Figure 1. Block diagram for ergonomic and safety hazards

Safety and Ergonomic Hazards Associated with Installing the Casing Accessories

Participants from Malaysia, Saudi Arabia and Pakistan identified dropping accessories such as entralisers, scratchers, guide shoes and float collars as hazards during installation of casing accessories in the interview. Participants MY1 and MY2 from Malaysia and SA2 from Saudi Arabia highlighted dropping accessories as hazards and pointed to critical injuries suffered by crew on the feet and hands during offshore casing accessories installation, but Participant PK1 from Pakistan during the interview referred to dropping objects as a hazard at onshore sites, as shown in block diagram Figure 2.

Likewise, pinched points and wrong body posture were hazards that have a high probability of occurrence at offshore sites. According to Participants MY1 from Malaysia and SA1 from Saudi Arabia, these hazards could cause crushed fingers and legs or hand fractures. Meanwhile, Participants PK1 and PK3 from Pakistan pointed out that pinched points and wrong body posture were hazards during onshore casing accessories installation. However, Participants MY2 from Malaysia and SA3 from Saudi Arabia stated that pinched points were likely to happen at both on and offshore sites.

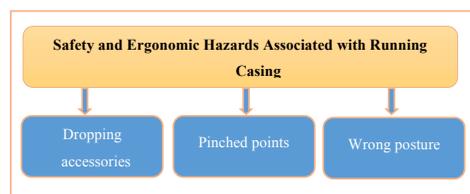


Figure 2. Block diagram for ergonomic hazards

Chemical Hazards Associated with Circulating Cementing and Casing Accessories

The qualitative findings showed that the participants had indicated cement and additive dust as hazards associated with the activity of circulating cementing and casing accessories. Participants MY2 from Malaysia and PK2 and PK3 from Pakistan indicated that cement dust hazards during onshore cementing activity could cause respiratory and shortness of breath. Participants MY3 from Malaysia and SA1 and SA2 from Saudi Arabia pointed out the hazards experienced during offshore cementing activity, as shown in Figure 3.

The participants also agreed that they had observed hazards due to chemical exposure and blowout during cementing. Participant MY3 from Malaysia and participant SA1 from Saudi Arabia agreed that chemical hazards are repeatedly reported at onshore sites, and that these hazards led to health problems such as skin infections and burns.

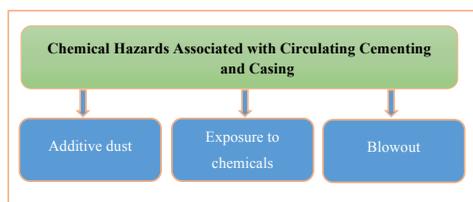


Figure 3. Block diagram for chemical hazards

CONCLUSION

The qualitative and quantitative results obtained from this study on the Malaysian, Saudi Arabian and Pakistani oil and gas industries indicated four activities as being

hazardous in on and offshore sites. The participants of the study were drilling crew and safety professionals from the three countries. The respondents from Malaysia considered the hole casing cementing operation as being the most hazardous operation, with a total mean range of 3.37 for onshore and 3.45 for offshore sites, both lying under the moderate level of the mean range, and were associated with potential ergonomic, chemical and safety hazards during on and offshore operations. The qualitative findings showed that safety hazards related to installation of casing tools such as getting stuck in casing, wrong body posture and being hit by tools and equipment were also prominent. In the activity of running casing into holes, the participants reported that dropping, pinched points and wrong body posture at both on and offshore sites were hazards. In addition, additive dust, chemical exposure and blowout hazards were equally prominent as hazards during the activities of circulating cementing and casing accessories in the Malaysian, Saudi Arabian and Pakistani on and offshore sites.

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