Razali Bin Hassan, Muhammad Mujtaba Asad, Fahad Sherwani (Universiti Tun Hussein Onn Malaysia), **& Qadir Mehmood Soomro** (OSHTC Pakistan)

Determination of Occupational Hazards associated with TVET Activities in the Oil and Gas Industries

Abstract

Petrochemical drilling operations consists of the most complicated and complex activities specifically from the perspective of occupational safety and health of drilling crew and labour. Because of the involvement of state of the art electrical and mechanical equipment in drilling operations most of the untrained drilling crew are facing critical and life threatening injuries during the handling of high-tech equipments worldwide. Improper and insufficient methods and approaches for the estimation and reorganization of onshore and offshore drilling operations and its associated activities are one of the main reasons for hazardous events and accidents. Therefore, this paper emphasizes and proposes an effective mix-method approach for the identification of hazardous activities and potential hazards for Malaysian, Saudi Arabian and Pakistani onshore and offshore drilling sites by adopting a sequential explanatory research design approach. The outcome from this hazard determination approach will guide and provide reference to other petrochemical and hands-on industries, including the technical and vocational training sector which is focused on the work integrated learning (WIL). This research will involve the identification of risk factors quantitatively (Survey instrument) and qualitatively (What-If Analysis methodology). According to the overall findings, all drilling operations at onshore and offshore extraction sites are moderately hazardous in all the targeted industries that are associated with safety, ergonomic, chemical and environmental hazards. In this study, challenges which have been faced during data gathering are also indicated as a guide for new industrial researchers to develop sufficient strategies to overcome issues related to the selection of appropriate respondents, data collection approval and instrument validation.

Keywords: *Hazard identification, Explanatory research design, Occupational health and safety, Drilling operation, Oil and gas.*

1 Introduction

Oil and Gas production and extraction industries play an important role in the development and prosperity of national economy (Thomson & Boey 2015). But at the same time the nature of oil and gas extraction jobs at onshore and offshore domains are full of occupational health risks and dangers (Meng 2016). Every year hundreds of oil and gas drilling labourers have died and thousands have been critically injured due to the negligence and the lack of implementation of safety and health regulations and preventive measures (Elsom & Webb 2016). Major accidents which occasionally happen-at onshore and offshore drilling operation are due to a myriad of circumstances: huge and uncontrollable fire at the petrochemical sites,

falling from height at rig floor, contact with radioactive materials, skin infections due to silica, lung cancer due to inhalation of mercury fumes, and contact with drilling fluids and chemicals (Utvik & Jahre-Nilsen 2016).

There is also a significant gap in sufficient and effective hazard identification approaches and hazard assessment methodologies (Amir 2016). Therefore, in this paper researchers have proposed a new hazard identification methodology with possible challenges for hazard identification at Malaysian, Pakistani and Saudi Arabian onshore and offshore oil and gas drilling industries to reduce the probability of accidents and hazardous incidents in an appropriate and effective way. Similarly this study will also enhance the work integrated learning (WIL) approach for hazard identification and training activities which may effectively help industries to train oil and gas drilling crews and safety officers thereby reducing the potential hazards prior to the actual operation.

2 Problem Statement

Oil and gas drilling processes, which begin with rig assembling and generally end up on well control monitoring operations, are full of uncertainty and safety and health risks (Bennear 2015). A complete drilling process consists on seven onshore and nine offshore operations such as rig assembling, well drilling, tripping, casing and cementing, equipment maintenance, well control, H_2S monitoring, marine operation and helicopter operation. According to occupational health and safety association report 2010-2013, oil and gas drilling operations are eight times more dangerous than construction and general industries (Retzer 2015). Due to the life threatening injuries and accidents oil and gas productivity is also decreased (Retzer 2015). Oil and gas industries spend huge amounts of their budget on the safety of their exploration workers, but due to the unpredictable occupational and environmental hazards many strategies become unsuccessful and insufficient. Similarly, other physical and hands-on working professionals also have major concerns with health and safety prevention through proper and systematic evaluation of potential hazards**.** This is especially so in the technical and vocational education field (Koo 2012). As shown by previous researchers and industrial analysts, industries should implement multiple approaches for the estimation of potential hazards and event identification using well-planned methodologies based on field experts' opinion from different industries and regions (Hillier 2015).

Likewise, previous researchers also indicated the need for sufficient and appropriate approaches for the reorganization of potential hazardous activities and associated hazards to reduce the possibility of accidents and sever injuries (Russo 2015). Consequently, focus of this research is to provide a grounded methodology for the identification of potential hazards and activities for onshore and offshore drilling operation among Malaysian, Saudi Arabian and Pakistani oil and gas industries. Similarly the outcome of this research can also be useful for assessing the risk and hazards in other technical and vocational industries and educational institutes for the protection of trainee students or workers in an effective and reliable way.

3 Research Objectives

The main objectives of this proposed research are:

1. Identification of potential hazardous drilling activities among on- and offshore oil and gas industries in Malaysia, Pakistan and Saud Arabia.
2. Recognition of potential hazards associated with hazardous activities among on- and offshore oil and gas industries in Malaysia, Pakistan and Saud Arabia.

Similarly, the aim of this research is to seek answers to the following research questions reflected in the abovementioned research objectives:

a) What are the hazardous drilling activities among on and offshore oil and gas industries in Malaysia, Pakistan and Saud Arabia?
b) What are the most potential hazards associated with hazardous activities among on- and offshore oil and gas industries in Malaysia, Pakistan and Saud Arabia?

4 Proposed Methodology

Plenty of preparation should be done to produce a best quality research study in order to ensure all plans can be done in an orderly and systematic manner (Jacson 2015). To implement this study, the following parts are discussed in terms of study design, sample size, study instrument development, research approach and data analysis strategies.

4.1 Research Design

In this study researchers have adopted the sequential explanatory research method for the identification of hazardous activities and potential hazards associated with oil and gas drilling operation in order to obtain maximum information from the data to answer and justify research questions. Both quantitative and qualitative results have been analyzed separately to answer the research questions (RQ1 and RQ2) as shown in figure 1 [adopted and modified from Creswell (2015).]

Likewise, qualitative data (Semi Structured Interviews) were collected and analyzed in the second of the sequence which helped to explain and elaborate the quantitative (questionnaire) results which were obtained in the first phase. Then, the corresponding findings are compared in order to expand-the understanding of the research to determine if there are similarities and differences. The qualitative data and their analysis refine and explain those statistical results by exploring participants' views in more depth and detail (Creswell 2015).

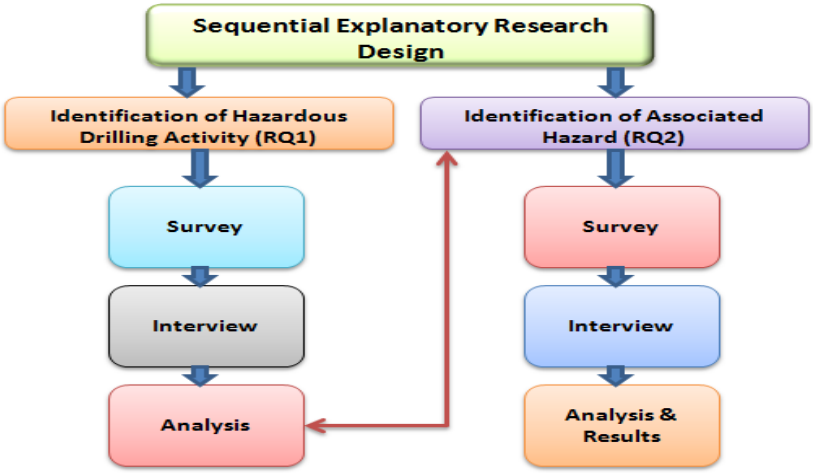

Figure 1: Sequential Explanatory Research Design of Study

4.2 Development of Research Instruments

A proper study instrument or measuring instrument is essential to achieve the objectives of the study (Salimin 2015). In this study a survey instrument was used for identifying the hazardous activities and their associated potential hazards at on and offshore oil and gas drilling operation as shown in figure 2.

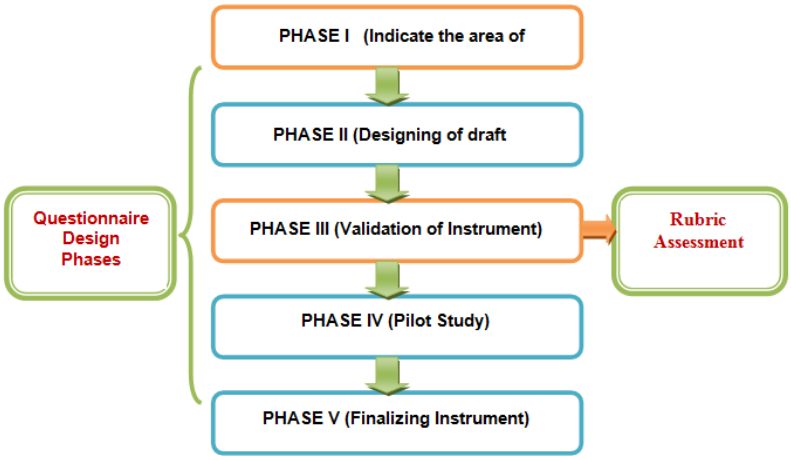

Figure 2: Instrument Development Approach

This study instrument has been developed based on the latest literature review and on standard oil and gas drilling operations for all items. The contents of the survey questionnaire were validated by health and safety professionals and experts. The survey instrument has been divided in to three major sections:

- Section 1: Demographic Information (Industry Origin, Drilling Domain, Experience, Designation)
- Section 2: Drilling Operations (Seven (7) Onshore Operations and Nine (9) offshore Operations).

- Section 3: Open-Ended Question (Respondents Opinion on Most Hazardous Drilling Operation and their associated potential Hazards)

4.3 Sampling

The research sample for this study was a group of randomly selected health and safety experts and drilling crews from major onshore and offshore oil and gas industries from Malaysian, Saudi Arabian and Pakistani. These three countries and industries are chosen for data collection because of the variety of environmental aspects and different international safety Acts and Regulations e.g National Institute of Safety and Health (NIOSH).

For the quantitative study 240 respondents were chosen to answer the questionnaire for identifying the hazardous drilling activities and their associated hazards. For the qualitative study, three health and safety experts from each industry were selected for in-depth interview using a 'what-if-analysis' approach. Details are shown in Table 1.

Table 1: **Respondent of the study**

Industries from Countries	Quantitative	Qualitative
Malaysia	80	3
Pakistan	80	3
Saudi Arabia	80	3
Total	**240**	**9**

4.4 Qualitative Research Approach

For the identification of risky activities and potential hazards associated with those activities researchers adopted a qualitative approach (What-if Analysis) to extract meaningful and detailed information through in-depth semi-structured interviews from health and safety experts. What-If Analysis is an effective method for determining hazard controls by asking questions on the basis of potential hazards, for making judgments regarding the acceptability of those risks, and determining a recommended action for those risks as judged by field experts (Dix & Murray 2015). Because of the nature of this hazard identification technique researchers are required to identify the associated hazards related to on and offshore drilling activities prior to appropriate controls.

With reference to recognition of hazardous activities and associated potential hazards a thematic analysis approach with tabular representation has been used for interpreting the findings of all drilling operations. The main themes have been developed on the bases of the characteristics of hazards at both drilling domains. Whereas, sub themes for each activity

have been sorted on the bases of indicated hazards as determined by experts from Malaysian, Saudi Arabian and Pakistani oil and gas industry (See Figure 3).

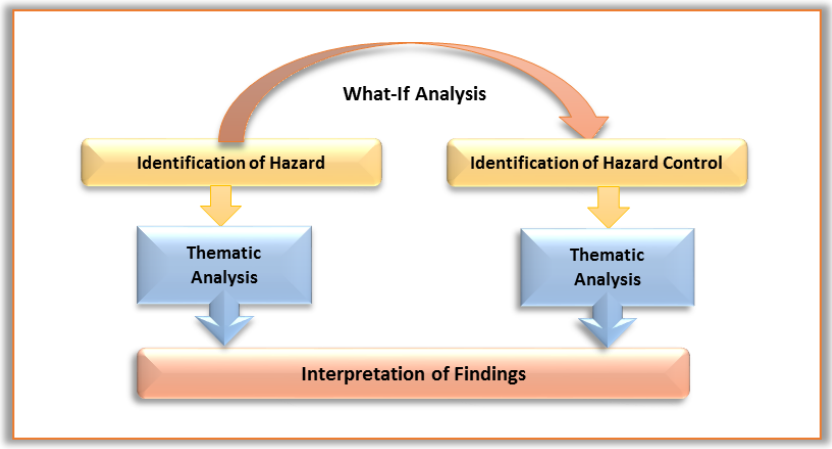

Figure 3: Flow Chart of What-If Analysis

4.5 Data Analysis

The gathered data was analyzed quantitatively and qualitatively by using the SPSS 22 both for the descriptive statistical techniques and the thematic analysis approach as used in qualitative research modeling.

Mean and standard deviation scores (see below) were used as analysis tools to determine the level of hazardousness of identified hazardous activities and potential hazards among on- and offshore oil and gas industries for drilling operation. As per Nardi (2015), the descriptive analysis (Mean and Percentage) is an often used process for the purpose of survey research. In this study data analysis was proceeded on the basis of- the study questions shown in Table 2.

Table 2: **Data Analysis Approach**

Research Question	Data Analysis Approach
RQ1: What are the hazardous drilling activities among on and offshore oil and gas industries in Malaysia, Pakistan and Saud Arabia?	Quantitative: Mean Score Qualitative: What-If Analysis Approach Thematic Analysis

RQ2: What are the most potential hazards associated with hazardous activities among on and offshore oil and gas industries in Malaysia, Pakistan and Saud Arabia?	Quantitative: Mean Score Qualitative: What-If Analysis Approach Thematic Analysis

5 Potential Challenges

Data collection is one of the most challenging and time consuming job that prevents researchers from completing their research (e.g. project report, dissertation) on time. Based on the nature of this research, data was gathered from multiple industries from different region and faced several challenges in the data collection process which are explained below.

5.1 Selection of appropriate respondents

One of the main challenges during data collection process is the selection of appropriate respondents for research (Salkind 2005). In this study, the initial challenge for the researchers was to sort out the most appropriate respondents from targeted on- and offshore oil and gas industries based on their field expertise and experience. Respondents to the proposed quantitative part of research were drilling crew members, derrickmen, and tool pushers. Likewise, for the quantitative study all respondents were well experienced and knowledgeable skilled workers in the field of occupational safety of drilling operations: safety manager, officer, and supervisor. Table 3 shows the details of respondents' designation.

Table 3: **Respondents Designation**

Quantitative Respondents (Designation)	**Qualitative Respondents (Designation)**
Drilling Crew Derrickman Tool Pusher	Safety Supervisors
	Safety Officers
	Safety Managers

5.2 Approaching for approval

Similarly, another challenge during data gathering was approaching and getting permission from potential respondents and experts from targeted industries. But in this project researchers have not accrued any confidential information from industries because researchers used their own research instrument for quantitative and qualitative data collection. However, the approval process for conducting research took some time depending on the availability of field experts and targeted respondents.

5.3 Validation of Instrument

Likewise, one of the major tasks before finalizing data collection is the validation of research instrument from experts of that particular field. In data collection, validity of the instrument and data are important considerations, which a researcher should pay attention to (Salkind 2005). In this study the validation of the instrument was challenging due to the busy schedule of proposed experts from industry. Researchers have personally contacted experts by phone and email and requested feedback and suggestions for the content validation of the research instrument from their perspective.

6 Results and Findings

6.1 Quantitative Findings and Analysis

For the justification and answer of the first research question, a table of specifications was adapted from Landlell 1997 as guide to measure the appropriateness level of mean range of hazardous drilling operations at on- and offshore oil and industries in Malaysia, Saudi Arabia and Pakistan. This level as produced according to the range specified in Table 4.

Table 4: **Mean Ranges for Risk Level Categories**

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

The overall results of first objective and research question as shown in Table 5 and Figure 4, indicate that the respondents believe that rig assembling operation is considered as a hazardous process in on- and offshore drilling. The respective mean values illustrate that offshore rig assembling operation are more hazardous than those onshore. The highest mean is reported for Pakistan offshore oil and gas operation with mean score of 3.7 for offshore rig assembling operation.

Similarly, for well drilling operation the overall results also indicate that the range of mean scores of the targeted countries are within the moderate range of mean score. Pakistani onshore well drilling operation mean score (3.42) is highest among rest countries but is at a moderate level of the mean range. For the tripping operation data shown in Table 5 and Figure 4, indicate that the drilling crew from the Pakistani on and offshore industry considered tripping operation as more hazardous when compared to Malaysia and Saudi Arabia. Pakistani respondents have mean score 3.57 at offshore and 3.38 at onshore, both of which are in the moderate range.

Likewise, for hole cementing and casing operation, respondents from Malaysian on and offshore sites consider it the more hazardous operation when compared to Saudi Arabia and Pakistan, with means of 3.36 for onshore and 3.45 for offshore: both means are in the

moderate level (Fig. 4). As per overall result of first objective, it has identified that Drilling equipment maintenance operation overall show means in the moderate category for on- and offshore drilling processes. While Malaysian onshore drilling crews considered equipment maintenance activity as slightly more hazardous than Saudi Arabian and Pakistani respondents of this study, which carry moderate level of mean range which is 3.44. In the context of well control operations results indicate means scores of each group is within the moderate category. However, Pakistani onshore drilling crew consider it more hazardous (3.58) than the other operators.

Correspondingly, hydrogen sulphide and chemical monitoring operations are also indicated as one of the moderately hazardous operations during on- and offshore drilling. Those operations are associated with chemical and safety hazards in all targeted industries. The mean based on responses from Saudi Arabian offshore drilling crew and health and safety officers is highest (3.52) followed by Malaysia and then Pakistan.

According to results, respondents from Saudi Arabian offshore industry considered marine operation more hazardous (mean 3.54) when compared to responses from Malaysia and Pakistan. Finally, helicopter operations are considered more hazardous by the Malaysian offshore oil and gas respondents than those of their colleagues from Saudi Arabia and Pakistan. However, the mean score for each respondent group was in the moderate category.

Table 5: **Quantitative Results of Hazardous Drilling Operation**

Drilling Operation	**Malaysia**		**Saudi Arabia**		**Pakistan**	
	Onshore	**Offshore**	**Onshore**	**Offshore**	**Onshore**	**Offshore**
Rig Assembling operation	3.22	3.36	3.19	3.41	3.34	3.7
Well Drilling operation	3.16	3.39	3.23	3.37	3.42	3.34
Tripping Operation	3.26	3.44	3.29	3.44	3.38	3.57
Hole Cementing and Casing operation	3.36	3.45	3.27	3.44	3.35	3.34
Equipment Maintenance Activity	3.35	3.44	3.35	3.41	3.41	3.31
Well Control operation	3.39	3.37	3.44	3.44	3.58	3.52
H_2S and Chemical Monitoring	3.37	3.20	3.42	3.52	3.43	3.38

Marine operation	*NIL*	3.37	*NIL*	3.54	*NIL*	3.36
Helicopter operation	*NIL*	3.48	*NIL*	3.43	*NIL*	3.25

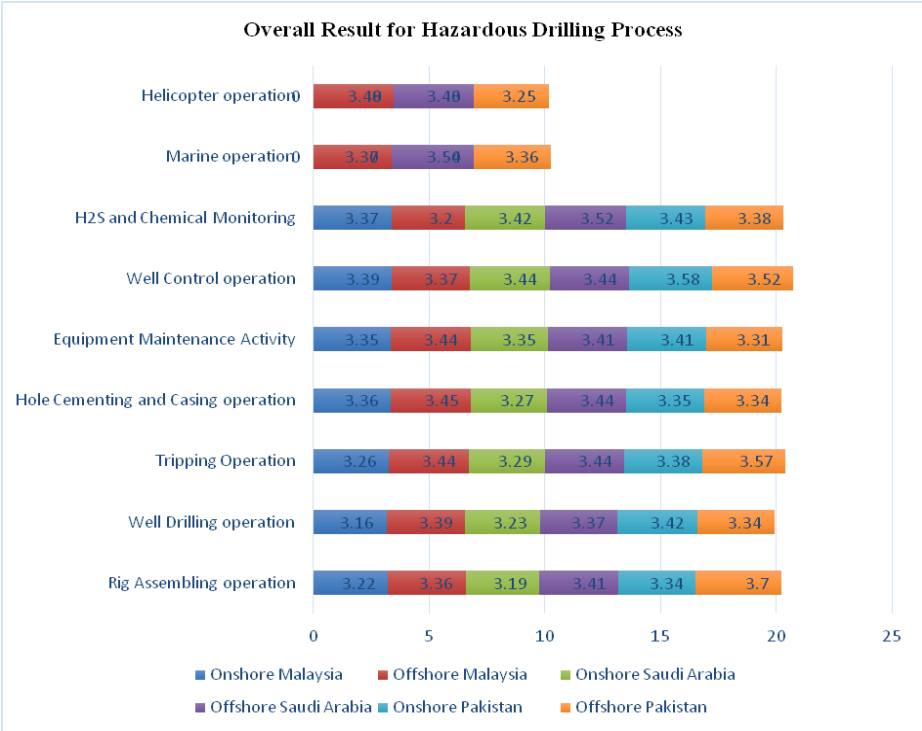

Figure 4: Bar Chart of Hazardous Drilling Operations

6.2 Qualitative Findings and Analysis

In this study, qualitative data analysis and "what if" analysis risk assessment approach has been adapted for semi structured interviews. In the qualitative research section every respondent (Drilling Safety Professionals) was assigned a confidential code number for recognizing the industry and country based on their designation during data analysis and interpretation, as shown in Table 6.

Table 6: **Respondent of Study**

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

The following discussion refers to data outlined in Table 7. The qualitative findings for rig assembling operation respondents have indicated safety and ergonomic hazards as a major cause of injuries. Although, for well drilling operation participants of in-depth interview have highlighted chemical and safety hazards as most potential hazards in all targeted industries. Whereas, safety hazards have been reported as one of the major cause of accidents during tripping activities. Similarly, chemical and safety hazards have considered as potential risk in hole-cementing and H_2S and chemical operations. From the feedback of participants in the targeted oil and gas drilling industries well control and equipment maintenance operation suggest safety and ergonomic hazards as life-threatening and cause of major injuries. Qualitative respondents have a point of agreement on safety and environmental hazards as major causes of injuries during offshore drilling during marine and helicopter operations as shown in table 7.

Table 7: **Qualitative Results of Potential Hazards**

Drilling Operations	**Potential Hazards**	**Malaysia**	**Saudi Arabia**	**Pakistan**
What-If Approach				
Rig Assembling operation	Safety	35%	25%	60%
	Ergonomic	65%	75%	40%
Well Drilling operation	Chemical	30	40	20%
	Safety	70	60	80%
Tripping Operation	Safety	40	30	15%
		60	70	85%
Hole Cementing and Casing operation	Chemical	30	60	20%
	Safety	70	40	80%
Equipment Maintenance Activity	Chemical	25	15	40%
	Safety	40	45	30%
	Ergonomic	35	30	20%
Well Control operation	Safety	10	20	45%
	Ergonomic	25	40	15%
H_2S and Chemical Monitoring	Chemical	65	40	30%
	Safety	35	60	70%
Marine operation	Safety	45	15	30%
	Environment	55	85	70%
Helicopter operation	Safety	35	45	20%
	Environment	65	55	80%

7 Conclusion

In terms of overall findings, oil and gas drilling operations at onshore and offshore drilling operations are moderately risky and potentially hazardous for labour involved in extraction process due to the unpredicted hazards (Safety, Chemical, Ergonomic and Environmental) at Malaysian, Pakistani and Saudi Arabian sites. Similarly, insufficient and one-dimensional methods for the recognition of hazardous activities and potential hazards are also one of the major causes of inadequate and unsafe events in physical and hands-on jobs. Therefore, in this paper researchers have focused on the development of an effective and multi-dimensional method for the identification of onshore and offshore hazardous drilling activities and associated hazards by adopting sequential exploratory research for multiple extraction industries from different origins. These findings and methodology also can be used for reference and implemented for the identification of any risk factor and hazard in any oil and gas and general industry settings for reducing the probability of life threatening events and hazards.

8 Future Recommendation for Work Integrated Learning Intended for Occupational Safety in TVET

The implementation of occupational health and safety standards in all manufacturing, production and educational industries should be the first and main priority of employers. Nowadays occupational health and safety related studies are highly encouraged by technical and vocational education & training (TVET) stakeholders and industrial experts for managing safe and comfortable working environment during hazardous jobs. Also, in the TVET sector work integrated learning approaches for occupational safety and health training activities are considered as an indispensable issue for consideration prior to commence any practical and hands on industrial task for the sake of protection of technical and non-technical staffs at industry or educational institutes.

Similarly, in this study the main targeted population is physical workers who perform hands on drilling operation. Consequently, proposed research methodology of this paper also can be used for assessment of level of hazardousness for technical and vocational hands on training activities in a sufficient way. Whereas, these hazardous risk and hazard identification approaches will assist drilling workers and safety officials to carry out this particular strategy prior to all drilling operations for onsite zero accident commitment.

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Author(s) Profile

Assoc. Prof. Dr. Razali Bin Hassan

Faculty of Technical and Vocational Education,
Universiti Tun Hussein Onn Malaysia, Batu Pahat, Johor Malaysia.

E-mail:razalih@uthm.edu.my
http://www.uthm.edu.my/v2/content/view/89/99/lang

Muhammad Mujtaba Asad (Engr)
PhD Researcher (OHS Drilling Oil and Gas)
Research Cluster: Infrastructural Development in TVE

Faculty of Technical and Vocational Education.
Universiti Tun Hussein Onn Malaysia, Batu Pahat, Johor Malaysia.

E-mail: mujtabaasad11@gmail.com, hb130127@uthm.edu.my
https://www.linkedin.com/in/engr-muhammad-mujtaba-asad-52158a88

Qadir Mehmood Soomro
Director and HSE Manager(Saudi Aramco)

Occupational Safety and Health Training and Consultancy (OSHTC)
Hyderabad, Pakistan

E-Mail: qadir_mehmood@yahoo.com
https://ae.linkedin.com/in/qadir-mehmood-soomro-gradiosh-nebosh-tutor-78648029

Fahad Sherwani (Engr)
PhD Researcher (Bio-Med Engineering)

Faculty of Electrical and Electronics Engineering
Universiti Tun Hussein Onn Malaysia, Batu Pahat, Johor
Malaysia.

E-mail: fahadsherwanis@gmail.com
https://pk.linkedin.com/in/fahad-sherwani-23b57537