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STUDY AND ANALYSIS OF ACCIDENT CAUSATION THEORY FOR IMPROVING SAFETY PERFORMANCE IN OIL AND GAS INDUSTRY

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ABSTRACT

Hydrocarbon Industry stands any country's backbone for social strength and economic development. The oil and gas industry provides variety of products that help people in daily life everyday hence it is very important to tackle the problems faced during the operation of a drilling rig in order to prevent wastage of time and money as well as huge accidents like kick followed by blowout may take place. The literature is evident to say that there is not only high risk to personnel working in field but also to environment and assets in Oil & Gas Operations. As per the report of IOGP (International Association of Oil and Gas Producers) it is observed that percentage of accidents is second highest in drilling domain. The occurrence of accident pattern in Oil & Gas industry is to be considered otherwise than the traditional accident occurrence theories. Largely the causes of accident in hydrocarbon industry is due to failure of barriers which are primarily related to human behavior. Hence this research aims to propose a framework to understand the various factors like personal factors, job factors and unsafe acts and condition that affect the safety because of human attitude. Later a program is designed names Safety Awareness Program (SAP) by targeting the employees of various oil companies in Oman which will act as a moderating variable to know the impact of it at employee level such the work performance, individual performance is improved with results of accidents/fatalities in the industry if not the loss will occur if wrong decision might be taken, the loss of

billion and trillion dollars. The detailed analysis is done by self-structured questionnaire.

Keywords: accident theories; oil industry; safety awareness program.

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1. INTRODUCTION

From the annual reports of bench marked companies from 2016-2018, also from the case studies available approximate 100 disaster cases were analyzed and is known that the possible hazard during drilling are larger in number. The outcome indicates the change in control measures that is suggested in-order to have safe and healthy work environment at work place. A personnel working in the drilling rig have to be very disciplined and cautions during their working hours. Working at a drilling field requires sweat and patience, the amount of money and people at stake as oil and gas projects are usually very high and one mistake can cause a fortune. To make the study stronger several papers focusing on lesson learnt from disasters, accident causation models, behavior in anticipating the accidents in the industry with its root causes, inherent factors affecting the accident are taken into account.

Mostly accident don't just happen largely they are caused due to unsafe acts or due to unsafe conditions or combination (Choudhry et al., 2011)[1] (US Chemical Safety Hazard and Investigation Board, 2010) [2] above 80% workplace accidents are linked to unsafe behavior (Mergs, 2015)[3] and every risk is associated with different criteria based on environment, based on nature of rock,..(Necci et al., 2019) [4] .Failure to ensure the barriers is one of the cause for disasters in hydrocarbon industry and in barrier failure process failure of human factors is the core element (Martin &Black, 2015) [5].The finding of the paper states that largely the fatalities and incidents is documented in South East Asian and Middle Eastern region at drilling sites. The paper brings an idea that technical issues can be resolved at field only when sufficient technology (software) is available (Asad, 2019) [6].

Every year many drilling crews face challenging and life threatening situation due to safety concerns and health at sites (drilling). Therefore, drilling operations is considered to be thrice dangerous than construction and twice risky than other general industries. (Asad, 2019) [6].The research findings gave various issues of the accidents and injuries at workplace. The future studies recommended that it must consider investigating data methods such as behavioral observation. The other mediating elements such as emotional exhaustion, skills, motivation and work pressure, could be considered which strengthen the results.(Liu et al., 2020) [7]

Ali Hasan and Al-Shanini [8] states in process industries domino theory describes accident sequence as chain of five elements or factors (unsafe acts or conditions, fault of person, accident or injury, social and environmental) if one factor falls, the other four factors would surely fall. Human failure is one considered factor.

The research work done by tong is to analyze the connection between safety participation and compliance related to safety with the role of job plays and unsafe behavior, which is ample evidence showed the importance among workers in process companies or industries. The results shown that oil workers' that there is decrease in unsafe behavior with contribution of safety compliance and participation. However, psychological condition was confirmed as

moderator which helps in mitigation. Hence, suggested that psychological conditions of employees and related factors must be taken into account in order to reduce unsafe behavior (Tong et al., 2020) [9].(Ehiaguina & Moda, 2020)[10] stated poor safety culture at work place is one of the major factors that has an impact on employee's safety behavior at work place, which might directly result in accidents or injuries and helps in strengthening the culture which can improve performance of safety

2. PROBLEM STATEMENT AND RESEARCH MOTIVATION

Oil and Gas Industry is exposed for low probability and has high impact on accidents. However good (HEMS) Health, Safety, Environmental management systems in place, knowing the risk before planning for drilling, knowing the risk location during drilling, human factors at work place are ruling the prevention of accidents. However, it is not always similar in most of the cases. According to WOAD database in last few decades approximately 6000 accidents have taken place only in offshore. The attempt has been made in recording the accidents took place from 2016-2019 and in knowing their causes. When you use the repeated disasters taking place it gives a sign of alarm of failure in safety management to ensure proper barrier in place is the common root cause. Inadequate training, lack of supervision and competence are the reasons are failure to finding the hazards and risk assessment. The recent trends show that most of the accidents take place in oil industry are largely in drilling, production domain.

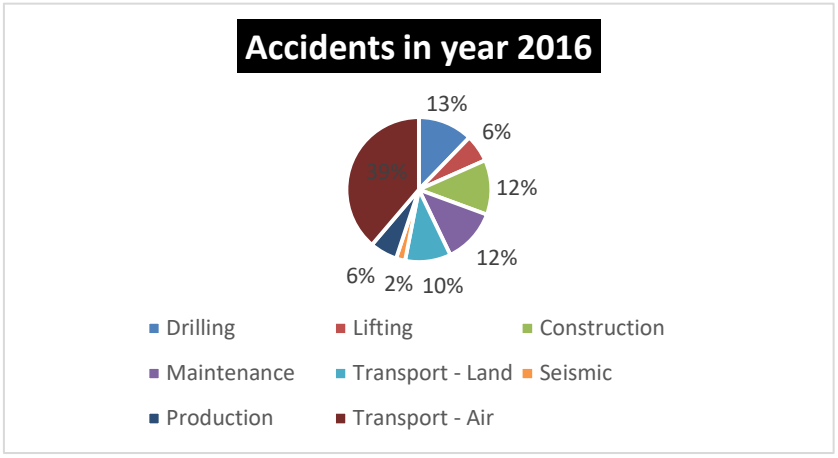

Figure 1 Accidents in domain area in 2016 (Source: IOGP bench mark report) [11]

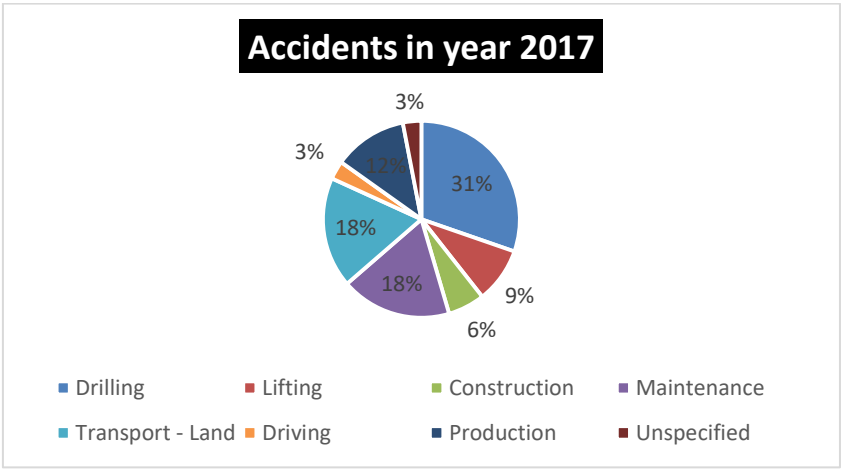

Figure 2 Accidents in domain area in 2017 (Source: IOGP bench mark report) [12]

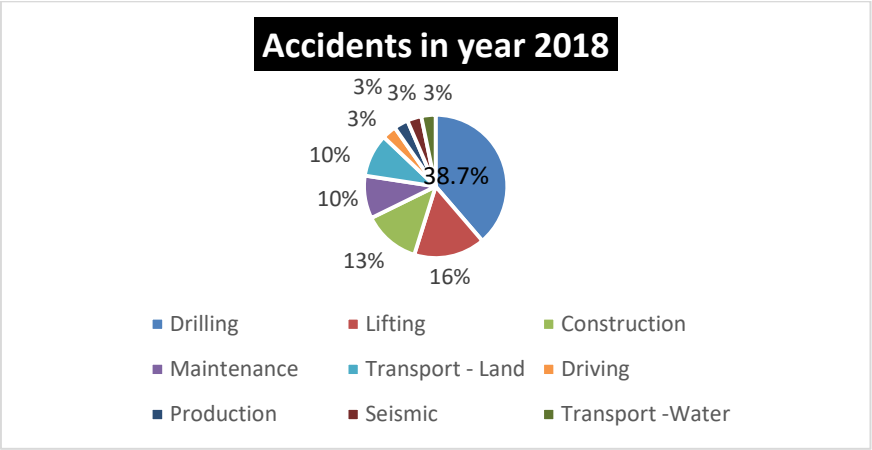

Figure 3 Accidents in domain area in 2018 (Source: IOGP bench mark report) [13]

If we see the above graph most of the accidents in Oil and Gas Industry are in upstream largely related to drilling. To minimize the accidents an attempt to give the training is made at employee level and also to remove the technical barrier. A technical software is needed which helps in calculating the various parameters that is directly linked to drilling which will help the engineer to do the drilling in safer and in healthy way.

3. PRELIMINARY LITERATURE REVIEW

Theoretical literature shall be reviewed which gives a strong foundation on various concepts. Literature helps to get acquainted with research problems and may also provide guidelines in selection of best research approach.

The research would go through in following scale:

3.1. Lesson Learn from Disasters

(Mergs, 2015)[2] mentioned in research that above 80% workplace accidents are linked to unsafe behavior and every risk is associated with different criteria based on environment, based on nature of rock,..(Necci et al., 2019) [14]. The reason is not clear always the reason what and why it is measured. There are various terms which creates a confusion among practitioners and researchers. (Source: Environmental Protection Agency, USA are: use of six centralizers instead of twenty-one, (Hopkins, 2012; NCBP, 2011)[15]. Jain &Yerramilli (2012)[16] in his research paper explained about major blow out that took place in Krishna Godavari basin which caused in innumerous risks in linking to loss of human lives, material and environment pollution because to the heterogeneity of subsurface geology complexity for the wells. Failure to ensure the barriers is one of the cause for disasters in hydrocarbon industry and in barrier failure process failure of human factors is the core element (Martin &Black, 2015) [17]. Every year many drilling crews face challenging and life threatening situation due to safety concerns and health at sites (drilling). Therefore, drilling operations is considered to be thrice dangerous than construction and twice risky than other general industries. The paper brings an idea that technical issues can be resolved at field only when sufficient technology (software) is available (Asad, 2019) [18].

3.2. Occurrence of Accident, Prevention Models

The research findings gave various issues of the accidents and injuries at workplace in hazardous industry which is expected as complex which demanded the need of qualitative measures which helps in problem of practical nature. The results shall be more accurate if the

database of injuries and accidents shall be considered in analysis. Unfortunate such database is practically difficult to access and might be possible theoretically. The future studies recommended that it must consider investigating data methods such as behavioral observation. The other mediating elements such as emotional exhaustion, skills, motivation and work pressure, could be considered which strengthen the results.(Liu et al., 2020) [19]. T**he** main drawback is people/organization doesn't take the age and experience into account while evaluating the risk. The operational risk having crucial tasks, especially during drilling actions (Abimbola et al., 2016[20]) limit to only risk categories like organizational risk, security risk, natural risk and technical risk.

3.3. Behavior and Attitude of Individual in Prevention of Accidents

The research work done by tong is to analyze the connection between safety participation and compliance related to safety with the role of job plays and unsafe behavior, which is ample evidence showed the importance among workers in process companies or industries. The results shown that oil workers' that there is decrease in unsafe behavior with contribution of safety compliance and participation. However, psychological condition was confirmed as moderator which helps in mitigation. Hence, suggested that psychological conditions of employees and related factors must be taken into account in order to reduce unsafe behavior (Tong et al., 2020) [21]. BBS systems train employees to look for the root causes of their accident-prone behavior and enables to recognize behavioral trends that cause them to get involved in safety accidents/incidents. It transfers control of the event into the hands of the employee so that the employee becomes proactive with regard to individual safety rather than a victim of environmental conditions (JasiulewiczKaczmarek et al., 2015).

3.4. Inherent Factors Affect Accident

(Gordon, 1998) in his paper took human factors as (Individual Factors, Group Factors, Organization Factors) [22] (El Bouti & Allouch, 2018) in his paper took human factors as (Individual Factors, Group Factors, Organization Factors) [23]. (Galis et al., 2018)[24] states 'BBS training is required once in a year for the employees which in positive results because of their level of commitment and their knowledge which is directly seen in safety performance' but the limitation with it is BBS implementation in the company has financial issues, top management support seems a barrier at the top that obstructs BBS implementation [25]. (Zhang et al., 2019)the author focused largely on safety behavior improvement and the condition of mental health of employees. The evaluation is done by taking the results from two set of questionnaire in order to know the sustainability as a key factor in hydrocarbon industry. Further the author suggests the future researchers to develop human factors and other behavioral science approaches which helps in improving sustainable development along with safety performance in hydrocarbon industry [26].

4. MAJOR THEORIES OF ACCIDENT

Accident causation model is methodical method of determining the causes of accident. The coincidence of various activities which is complex in a single time and space is called as accident. Determination of causes leading to it is difficult since so many variables are involved in it.

In early 20th century the existence of systematic examination of causes of accidents has begun and development of it started with simple linear "domino model," which explains about behavior of an individual and situation surrounding the accident. Further the advancement of it to place too complex linear models and then to complex non-linear models keeping time factor in mind time.

The development of various models is still on. There are various theories of accident causation which are listed below:

- Heinrich theory
- Human Factor theory
- Accident or Incident theory
- Epidemiological theory
- Systems theory
- Behavior theory

5. PROPOSED CONCEPTUAL FRAMEWORK

The conceptual framework will go in stage as mentioned below:

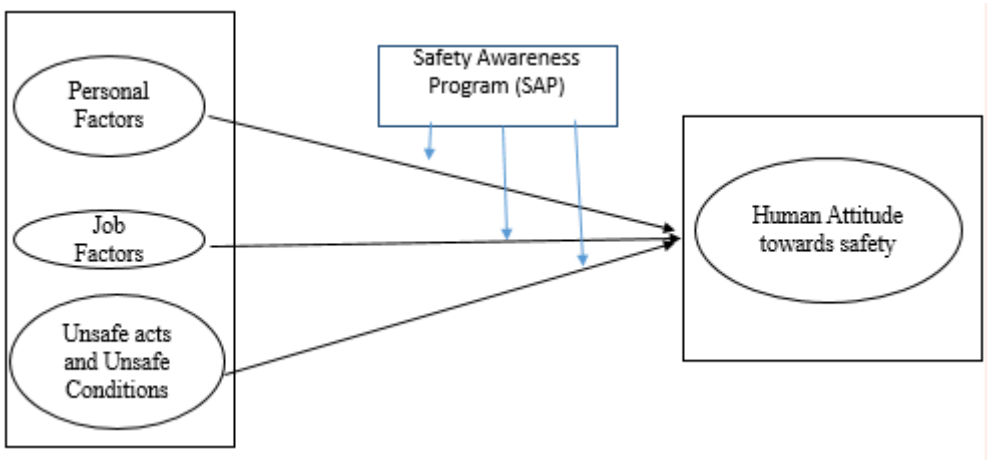

Figure 4 Conceptual framework of stage 3

Better understanding of various factors that affect the human attitude towards is the general purpose of study. The impact of it is done by moderating variable safety training. Resulting from such objective related to BBS, the following research hypothesis are developed and are proposed to be tested. Research hypothesis is a hypothetical statement of relationship between two or more variables. It is testable having tentative problem to the relationship between those variables that create.

6. PROPOSED RESEARCH METHODS

6.1. Data collection, Population and Sample

The data is collected from a particular population group and in this research, the oil industry employees are largely focused. A close ended questionnaire was used in gathering phase of the study. The population of this study is the employees of oil companies in Oman different levels of experiences and their roles. It includes the combination of junior and manager levels people to be interviewed for the variables and human performance indicators. A, B, C, D and E with the help of Green Valley and Trading LLC in Oman.

6.2. Data Analysis Method

SPSS software was first used to analyze descriptive statistics of demographic information such as age, work-experience, work location, and job category. The reliability of measured items was tested using the Cronbach's alpha measure to know how closely associated the set items measured are as a group. Tested items with Cronbach's alpha of 0.70 and above is

known generally to be good [29]. The percentage of responses for each item used to measure safety management practices, safety compliance and safety participation, was examined in order to understand the extent to which participants agree or disagree with the question before the structural equation modelling was carried out.

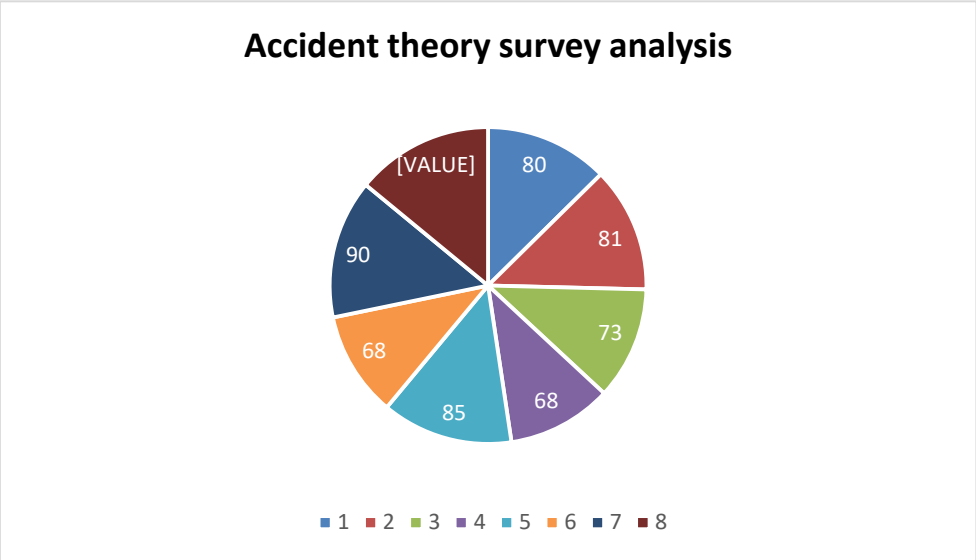

Figure 5 Analysis of accident theories

- All accidents are preventable (approx. 80%)
- Most of the theories are not fully satisfying (approx. 81%)
- Importance of barrier in accident prevention (approx. 73%)
- Failure in identification of hazard is the cause of accident occurring (approx. 68%)
- Inadequate root cause analysis or lack of skills deficiency (approx. 85%)
- Hazards vary from one work location to another (approx. 68%)
- Lack of leadership
- Standard operating procedure and implementing lessons learnt (approx. 89%)
- Attitude of work force having direct relation with accident (approx. 90%)

7. RESULTS

Table I describes the demographic information of the study participants. Looking at the percentage on the extent to which management agree or disagree to each item measured, some of their responses were of significance. Under safety management practices, over 50% of all participants were found to agree or strongly agree to Q13 “My supervisor puts pressure on me to get the job done on time” and again over 60% of all participants agree or strongly agree to Q16 “My supervisor has difficulty motivating the team to work safely”. For items measured under safety compliance. Over 60% of all participants agree or strongly agree to Q4 “I ignore safety regulations to get the job done on time” and similarly over 60% of all participants agree or strongly agree to Q5 “In some instance I feel pressured to put production before safety in this installation” while for safety participation, over 60% of all participants agree or strongly agree to Q8 “I feel if I say too much about safety I might get fired”.

The reliability test carried out revealed that items used to measure safety management practices (26 items) and safety participation (11 items) were higher than $\alpha > 0.7$ and items used to measure safety compliance (8 items) were below the $\alpha < 0.7$. However, the total

Cronbach's Alpha for all 45 items ranges from moderate to high [33]. The first analysis in structural equation modelling was the path model identification. During model identification, the total number of estimated sample moment parameter (27), was more than the numbers of distinct parameters (23). The degree of freedom (df) is the differences between both parameters (27-23 = 4) and is greater than zero (df =>0), as a result the model was over identified. The maximum likelihood estimation was applied to yield optimal parameters of all studied variables, in order to assess the distributional properties.

Table 1 Participants demographic characteristics

Characteristics	Frequency (%)	Standard Deviation	Mean
GENDER			
Male	58.9	SD=0.497	M=1.41
Female	41.1		
AGE			
18-25	18.4	SD=1.105	M=2.62
26-35	28.8		
36-45	27.5		
46-55	22.9		
56-65	2.2		
66-75	0.2		
EMPLOYMENT TYPE			
Part time	19.7	SD=0.799	M=2.49
Full Time	11.9		
Contract	68.4		
WORK EXPERIENCE			
0-5	30.7	SD=1.029	M=2.17
6-10	35.1		
11-15	22.7		
16-20	10.0		
25-30	1.3		
Others	0.2		
JOB CATEGORY			
Production	6.8	SD=2.113	M=4.15
Engineering	33.6		
Drilling	14.5		
Maintenance	20.3		
Operators	4.5		
Admin/Management	18.6		

Although there was a significant ($p < 0.005$) direct estimated impact of safety management practices to both safety participation and safety compliance, safety management practices had a higher direct estimated impact on safety participation (0.37) than safety compliance (0.23). Work experience had a significant direct estimated impact of safety participation ($p < 0.005$) and a non-significant direct estimated impact on safety climate ($p > 0.005$). Age had a significant estimated impact on safety compliance ($p < 0.005$) and not significant to safety participation ($p > 0.005$). Gender does not have any significant impact on both safety compliance and participation ($p > 0.005$).

8. CONCLUSION

The conclusion of this paper has been reached to the vitality of conducting an in-depth research to proposing a new multi-theoretical framework which consists of Domino theory, accident or incident theory and behavior based theory. The occurrence of accident pattern in Oil & Gas industry is to be considered otherwise than traditional accident occurrence theories

if barrier model is not developed along with detailed risk register is not made. Largely the causes of accident in hydrocarbon industry is due to failure of barriers which are primarily related to human behavior. The Inherent human factors which influence accidents, largely includes unpredictable work pattern – rotations shift pattern, overload of work, fatigue, stress, living conditions, pay cuts during recession, working offshore condition, physical condition at work place. Lack of job security (career prospects and reward), lack of training prospects, change in business, which was not the case before, and courses on safety training since employee are not updated with time enough are also some of the other factors which influence the accidents.

RECOMMENDTAIONS

The research study based on finding the reasons of occurrence of accidents, finding the proper barrier system available, accident analysis techniques implemented, various risk assessment techniques incorporated, how human attitude behaves at workplace in avoiding the accidents and attempt to make a software by which technical challenges can be overcome must be addressed.

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