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INVESTIGATION OF RISK AND SAFETY SCENARIO IN RISK MATRIX OF PETROLEUM PRODUCTION SYSTEM OF THREE GAS FIELDS, BANGLADESH

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ABSTRACT

The economic growth of Bangladesh largely depends on the petroleum industry. The most important part of petroleum industry is the production system. However, accident is a common scenario in the petroleum industry. In fact, several risks may be involved during the drilling, production, and transportation phase of this industry. In the case of comprehension, these risks associated at an early stage may acquire the appropriate measures aligned to them. This study investigates personnel perceptions about risk and safety involved in production system of the petroleum industry. To perform this research, the data were collected from three fields Kailashtila, Haripur & MSTE Plant operated by Sylhet Gas Fields Limited (SFGL), Bangladesh. The collected data were analyzed by IBM SPSS 20. The frequency analysis performed and risk matrix generated in this study. The Frequency analysis shows that the overall safety situations. Moreover, the results of the risk matrix pointed out the risk level as low, medium or high. At the end of study, based on the implicit risks, the necessary measures are recommended for the future security of the industry.

Keywords: Petroleum production system, Risk, Safety, Risk Matrix, Risk level identification.

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INTRODUCTION

Risk is any incident which can cause accident. According to ISO, Risk is characterized by reference to potential events and consequences or a combination of these (ISO,2009). Risk is a common term in petroleum production system. Accident may occur at any time in oil and gas industry from a little mistake or improper work. And also, Production can't be maximized without ensuring safety of the industry. So, it is the most vital part to prevent the occurrence of accident to save the industry as well as to save the workforces. For this, it is very important to give consideration on safety. Safety may be defined as the freedom from risk which is not tolerable (ISO,2014). Risk and safety study in oil & gas sector become a matter of highly concern after occurring several disastrous accidents such as Piper Alpha in the North Sea (1988), Alexander L. Kielland in Scotland (1980), Ocean ranger rig disaster (1982), Drillship Seacrest accident 1989) and so on (Mendes et al, 2014). Many researchers conducted their research work on risk and safety analysis of oil and gas sectors. Among them Rundmo (1992), Flin et al (1996), Mearns et al (2003;1998), Cox & Cheyne (2000), Suslick & Schiozer (2004) and so on. After occurring another disaster at Mumbai High North (2005), researchers Arezes & Miguel (2008), Jafari et al. (2009), Rasmussen (2013), Torres et al. (2017) provided some good works on safety research of oil and gas industry.

Most of the researchers conducted their research on risk & safety of petroleum operations based on perceived risk. Risk perception is the outcome of the processing, assimilation and evaluation of personal experiences, or information about risk, by individuals or groups in society, and it is the judgements of risk sources, evaluation of hazardous activities and technologies by individuals (Espeland,2010; ISO,2014). In Bangladesh, Petroleum field discovered in 1955 (Imam,2013). After starting production, it has been already faced some accidents (Nasir & Khan, 2014). So, it is very important to know the root cause behind the accident for the future of petroleum industry. This study will help to understand the perceived risk & safety of petroleum production system of three gas fields of Bangladesh. And also helps to demonstrate the risk level associated in such industry in risk matrix and point out actions which should be followed to minimize the level of risk. Hope, this study will be very helpful and create a new dimension in safety research of Bangladesh.

METHODOLOGY

Study Area & Data Collection

The data were collected from three gas fields operating by Sylhet Gas Fields Limited (SGFL). These are Haripur Gas Fields (also known as Sylhet gas fields), Kailashtila Gas Fields & Kailashtila MSTE plant (Figure-1). This study is a questionnaire based. Here, a list of questionnaire items was used for collecting contextual information for leading the research work. First, questionnaire was distributed by physically visiting among the personnel of gas fields working in different departments. After that, the response of the employees was collected for analysis. Approximately 95 questionnaires were distributed in three gas fields where response rate was 78% out of 100%. The respondents had the full freedom to participate in this survey willingly.

Figure-1: Study area (Google Map).

Questionnaire Items

The questionnaire relevant to the risk and safety of oil & gas industry was selected first. The inquiry items were adjusted from previous research work Rundmo (1992), Flin et al (1996), Mearns et al (2003) and Chutelkar & Mishra (2019). The risk related question included 17 items relevant to individual and installation risks, 18 items related to risks associated with work tusks and 13 quarry items related to safety & contingency measures of the workplace (Table-1). The questionnaire evaluation procedure was rating based. The personnel taking part in this survey was rated question based on their own opinion. The evaluations included ratings on a five-point rating scale for each test item. The scale for risk perception ranged from "very safe" to "very unsafe." The scale for safety and contingency aspects ranged from "very ideal" to "not at all ideal".

Table-1: questionnaire items.

Individual and installation risks	Risks associated with work tasks/ activities	Safety & contingency measures of the workplace
• Falling objects / structural failure • Crushing by machines • Slippery surfaces • Live electrical equipment • Burns • Cold/ hot surfaces • Blow-out • Fire • Noxious gases • Sabotage • Escape routes • Evacuation facilities	• Startup installations and processes • Stop, reduce pace, run down a process • Handle material, manual control of process • Monitor production • Set up scaffolds, cranes, machines • Perform preventive maintenance • Perform repair work • Perform cleaning of	• Control and inspection routines in the safety work • Work instructions • Safety instructions • Follow up and measures taken after injuries and accidents have taken place • First aid training • Contingency training • Safety training • Order and cleanliness at

• Alarm systems • Medical services • First-aid • Slipping • Falling to lower level	machines and equipment • Perform manual lifting, handling • Perform mechanical lifting, handling • Participate in transportation of other material • Participate in function testing of equipment • Carry out inspection • Move about on the platform • Clean the premise • Non-routine operations • When drilling is taking place • Overall	the place of work • Access to emergency exits/escape routes • Protection and safety devices on machines and equipment • Marking and sign posting • Availability of personal safety equipment • Use of personal safety equipment

Data Analysis Procedure

It is known that in statistical analysis for comparing the perception of different individual, it is very easy to use closed-ended questions because closed ended questions have discrete responses, so, analyze of these responses can be done by assigning a number or a value to every answer. So, for gaining quantitative data this study has been designed with rating based closed-ended question or Likert Scale based items where individuals were rated the answer with their own perception. After collecting all of the data, these have been analyzed by using **SPSS Software** and **MS Excel 2013**. The statistical analysis was conducted by SPSS Software and the hypothetical analysis was conducted by MS Excel 2013. The analysis basically included the evaluation of frequency and generation of risk matrix. The frequency analysis was performed by using the descriptive statistics of analyze options of SPSS Software. The result of frequency expresses either the condition is safe or unsafe (Almquist et al,2017; Mearns et al, 2003; Flin et al, 1996; Rundmo, 1992). And, for generating risk matrix, crosstab options of descriptive statistics have been used to correlate the frequency of two dependent variable. At the end, using MS Excel the risk matrix is hypothetically generated (Johnsen et al., 2007; Brazier, 2016; Alam, 2019; Chutelkar & Mishra, 2019).

RESULTS & DISCUSSION

The Status of workforces feeling safe with risk sources

The individual's perceptions of threats from different risk sources are presented here (Table-2). The most of the personnel feeling safe 93.2% in case of crushing machine/ machine parts and lesser amount of people feeling safe in case of evacuation facility. This study also shows that alarm system, slippery surface, escape roots facility is comparatively poor than others. And the personnel feeling more unsafe in case of fire and noxious gas. The average percentages of feeling safe with risk sources is 81.3%. this percentage is quite larger than the previous study. In case of Flin et al. (1996) the value of personnel feeling safe was 65.9% and in case of Rundmo (1992) perception of feeling safe was 64.6%. From this result it would be concluded that the personnel of petroleum fields of BD feeling safer relative to others in most of the cases. If some cases including evacuation facilities are improving by proper treatments it would be excellent.

Table-2: The personnel of workplace feeling safe with risk sources.

Risks Sources	**% safe***	**%neither***	**%unsafe***	**% safe (Fin er al 1996)**	**%safe (Rundmo 1992)**
Blow-out	89.2	5.4	5.4	63	50
Fire	82.4	6.8	10.8	61	47
Noxious gases	83.7	5.4	10.8	67	55
Sabotage	82.4	12.2	5.4	63	75
Crushing by machines/machine parts	93.2	5.4	1.4	79	66
Fall to a lower level	74.3	5.7	0	80	62
Slipping	78.4	20.2	1.4	38	-
Slippery surfaces	74.3	24.3	1.4	-	43
Burns	78.4	16.2	5.4	68	-
Live electrical equipment	86.5	8.1	5.4	78	68
Cold/hot surfaces	91.9	8.1	-	49	74
Medical services	78.4	16.2	5.5	70	79
First-aid	83.8	10.8	5.5	-	79
Alarm systems	74.3	25.7	-	-	74
Escape routes	79.7	20.3	-	-	72
Evacuation facilities	58.1	41.9	-	-	59
Total (Average)	**81.3**	**14.1**	**4.6**	**65.9**	**64.6**

Safe *=safe + very safe, neither* = neither safe nor unsafe, unsafe*= unsafe + very unsafe

The risk situation of petroleum fields associated with work tasks/ activities

The workforce feeling safe or unsafe during work tasks/ activities displayed in Table-3. The total percentages of workforce feeling safe with work tasks/activities is 87.04% which is little bit high than T. Rumndo's result 83.77% and very high than the result of Fin et al on the UK offshore oil and gas industry (76.4%). In petroleum fields of Bangladesh very small amount of people feeling unsafe (0.32% only) with the work tasks. On the other hand, 12.64% feeling neither safe nor unsafe.

Safety condition of workplace based on employee's perception

The most important things of maximizing production are ensuring safety of the production system. The overall safety condition and contingency measures of three gas fields are displayed in (Table-4). The total idealism of workplace based on result is 72.26% where not ideal safety condition found as 4.26%. And 23.08% respondents were not sure either ideal or not ideal safety situation in the fields. The more security noticed in case of work instruction. On contrary, comparatively less value of protection found in case of use of personal safety equipment, contingency training, first aid training, availability of personal safety equipment.

Table-4: Safety condition of workplace based on employee's observation.

The safety and contingency measures	% Ideal*	%Neither*	% Not ideal*
Control and inspection routines in the safety work	70.3	24.3	5.4
Work instructions	90.5	9.5	0
Safety instructions	74.3	16.2	4.1
Follow up and measures taken after injuries and accidents have taken place	70.3	28.4	1.4
First aid training	64.9	33.8	1.4
Contingency training	62.4	23	14.9
Safety training	72.9	23	4.1
Order and cleanliness at the place of work	73	23	4
access to emergency exits/escape route	75.7	20.3	4
Protection and safety devices on machines and equipment	85.1	14.9	-
Marking and sign posting	73	22.9	4.1
Availability of personal safety equipment	66.3	27	6.7
Use of personal safety equipment	60.8	33.8	5.4
Total (Average)	72.26	23.08	4.26

Ideal= ideal+ very ideal, Neither = neither ideal nor not ideal, Not ideal= not ideal+ not at all ideal.

Table-3

Work tasks/activities	**% Safe***	**%Medium***	**%Unsafe***	**Fin et al(1996)**	**% Safe***
Startup installations and process	100	0	0	74	81
Move about on the platform	83.8	16.2	0	87	85
Perform repair work	94.6	5.4	0	83	86
Stop, reduce pace, run down a process	91.9	8.1	0	81	87

Handle material, manual control of process	100	0	0	75	66
Monitor production	100	0	0	86	94
Set up scaffolds, cranes, machines	94.6	5.4	0	79	-
Perform preventive maintenance	77	23	0	84	89
Perform cleaning of machines and equipment	89.2	10.8	0	82	90
Perform manual lifting, handling	89.2	10.8	0	76	84
Participate in transportation of other material	75.7	24.3	0	60	56
Participate in function testing of equipment	78.4	21.6	0	71	81
Carry out inspection	82.5	17.5	0	82	92
Non-routine operations	68.9	27	4.1	60	-
When drilling is taking place	81.1	17.6	1.4	56	-
Clean the premises	87.8	12.2	0	80	-
Overall	85.1	14.9	0	83	98
Total (Average)	**87.04**	**12.64**	**0.32**	**76.4**	**83.77**

Risk level and required actions

The risk involved with production system of three gas fields represented in risk matrix. This graphical representation expresses the level of risk associated with production system in a tabular form. The level of risk may be defined as very low, low, moderate, high and very high. When the level of risk very low then no immediate action is required. In case of low risk some concern should be given. For moderate risk some actions required within a timeframe. And when risk level is high then actions should be taken immediately. And in case of high-risk production should be stopped till eliminating the risk (Alam,2014). Figure-2 represents some result. The level of risk is moderate for slippery surface and slipping. For this case, actions should be taken within a timeframe. Similarly for other cases.

Occurrence of Injuries/Accident			Slipping				
			Consequences				
			Very safe	Safe	Medium	Unsafe	Very Unsafe
slippery Surface	Likelihood	Very Unsafe	Moderate	Moderate	High	Very High	Very High
		Unsafe	Low	Moderate	Moderate	High	Very high
		Neither	Low	Moderate	Moderate	High	High
		Safe	Very Low	Low	Moderate	Moderate	High
		Very Safe	Very Low	Very Low	Low	Moderate	Moderate

Occurrence of Injuries/Accident			Perform Repair Work				
			Consequences				
			Very safe	Safe	Medium	Unsafe	Very Unsafe
Safety Training	Likelihood	Very Unsafe	Moderate	Moderate	High	Very High	Very High
		Unsafe	Low	Moderate	Moderate	High	Very high
		Neither	Low	Moderate	Moderate	High	High
		Safe	Very Low	Low	Moderate	Moderate	High
		Very Safe	Very Low	Very Low	Low	Moderate	Moderate

Occurrence of Injuries/Accident			Work Instruction				
			Consequences				
			Very safe	Safe	Medium	Unsafe	Very Unsafe
Monitoring Production	Likelihood	Very Unsafe	Moderate	Moderate	High	Very High	Very High
		Unsafe	Low	Moderate	Moderate	High	Very high
		Neither	Low	Moderate	Moderate	High	High
		Safe	Very Low	Low	Moderate	Moderate	High
		Very Safe	Very Low	Very Low	Low	Moderate	Moderate

Occurrence of Injuries/Accident			Safety Training				
			Consequences				
			Very safe	Safe	Medium	Unsafe	Very Unsafe
Fire	Likelihood	Very Unsafe	Moderate	Moderate	High	Very High	Very High
		Unsafe	Low	Moderate	Moderate	High	Very high
		Neither	Low	Moderate	Moderate	High	High
		Safe	Very Low	Low	Moderate	Moderate	High
		Very Safe	Very Low	Very Low	Low	Moderate	Moderate

Occurrence of Injuries/Accident			Use of PPE				
			Consequences				
			Very safe	Safe	Medium	Unsafe	Very Unsafe
Availability of PPE	Likelihood	Very Unsafe	Moderate	Moderate	High	Very High	Very High
		Unsafe	Low	Moderate	Moderate	High	Very high
		Neither	Low	Moderate	Moderate	High	High
		Safe	Very Low	Low	Moderate	Moderate	High
		Very Safe	Very Low	Very Low	Low	Moderate	Moderate

Occurrence of Injuries/Accident			Escape Routes				
			Consequences				
			Very safe	Safe	Medium	Unsafe	Very Unsafe
Alarm System	Likelihood	Very Unsafe	Moderate	Moderate	High	Very High	Very High
		Unsafe	Low	Moderate	Moderate	High	Very high
		Neither	Low	Moderate	Moderate	High	High
		Safe	Very Low	Low	Moderate	Moderate	High
		Very Safe	Very Low	Very Low	Low	Moderate	Moderate

Figure-2: Risk Matrix representing the Risk Level

CONCLUSIONS & RECOMMENDATIONS

Conclusions

The study was directed to investigate the perceived risk and safety on petroleum industry of three gas fields. The results can be concluded as:

- The total percentages of personnel of gas fields feeling safe with risk sources is about 81.3% which is higher than previous study Flin et al (65.9%) and Rundmo (64.6%).
- The workforce of studied fields feeling secured is about 87.04% which is also higher than the results of Flin et al (76.4%) and Rundmo (83.77%)
- The overall idealism of safety and contingency measures of studied petroleum fields 72.26%. It should be improved as soon as possible.
- The risk level for slippery surface and slipping is moderate. Actions should be required in this case within a time frame.
- In case of Fire and safety training, availability of personal protective equipment (PPE) and use of PPE risk level also moderate. Required measures also should be taken for both cases immediately.
- The risk level in case of monitoring production and work instruction, safety training and perform repair work is low. For both of cases, no actions required but concern should be given.
- In case of alarm system and escape routes, risk level is low. So, no actions should be required for this case.

Recommendations

At the end it could be added that, Slippery surface cause slipping and so, a special concern should be given to reduce it as much as possible. The available personal safety equipment should be used properly for carrying out duties like monitoring production, handling equipment, function testing equipment which may keep safe from several accidents including falling objects, structural failure etc. Several training such as safety training, first aid training, contingency training should be improved. If a future study conducted including a large number of fields, it would be very helpful and added a new dimension on safety research. And accidents associated with perceived risks will minimize.

Acronyms

BAPEX=Bangladesh Petroleum Exploration and Production Company Limited.

BD= Bangladesh.

ISO= International Organization for Standardization

MMSCFD= Million Cubic Feet per Day.

MSTE= Molecular Sieve Turbo Expander.

UK= United Kingdom.

SGFL= Sylhet Gas Fields Limited.

Petrobangla= Bangladesh Oil Gas & Mineral Corporation.

PPE=Personal Protective Equipment.

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