Original Research Article

Risk Reduction Functions at Oil and Gas Facilities in the Niger-Delta Region, Nigeria

Abstract

This paper presents an investigation into the state of risk reduction functions, specifically focusing on safety barriers, within the oil and gas facilities in Niger-Delta region, Nigeria. With the industry's inherent hazards, including extraction, processing, and transportation risks, the investigation assessed the implementation of technical, operational, and organizational barriers. The methodology used involves a cross-sectional research design utilizing surveys and questionnaires validated by industry professionals.Reliability of collected data were evaluated by the test-retest method, yielding a Cronbach alpha reliability coefficient of 0.88, using XLSTAT version 16.Descriptive analysis and criterion mean aid in data interpretation. Findings highlight the diverse landscape of technical strategies, with crucial components like blow-out preventers and fire detection systems showing varying maintenance schedules across facilities. Operational and organizational barriers, such as personnel competency and policy presence, exhibit recognition but inconsistency in review intervals. Aligning with existing literature, discrepancies in maintenance practices underscore the need for standardized approaches. Regular and systematic maintenance of safety barriers emerges as pivotal in preventing catastrophic events. The study advocates for uniformity in practices, emphasizing the importance of collaborative efforts among stakeholders to foster a culture of safety and adherence to industry standards. This research provides insights into the current state of safety barriers, offering recommendations for standardization, regular training programs, and collaborative initiatives to enhance safety measures within the dynamic oil and gas landscape in the Niger-Delta region. It serves as a foundational study for further research aimed at fostering a safer operational environment and mitigating risks in the industry.

Keywords:Risk Reduction Functions, Safety barrier, hazards,blow-out preventers, fire detection systems, Oil & Gas Industry, Niger Delta

1. Introduction

The oil and gas industry is acknowledged as one of the most hazardous sectors globally, characterized by risks present across various stages such as extraction, processing, and transportation [1]. In the upstream sector of this industry, activities like well drilling operations pose numerous health and safety hazards, including safety, chemical, ergonomic, and environmental risks [2]. The awareness of these risks has spurred a continuous evolution in safety practices and regulatory frameworks within the sector [3]. From the profound impacts of incidents such as the Deepwater Horizon oil spill in 2010 to ongoing concerns regarding process safety, asset integrity, and environmental sustainability, the industry has been compelled to make substantial investments in risk reduction strategies [3]. This is primarily due to the potential for significant environmental damage, loss of life, and economic disruption resulting from any mishaps or disasters in the sector[4]. Consequently, risk reduction strategies have become a critical focus for industry stakeholders, governments, and society at large. Companies operating in the oil and gas sector face mounting pressure to adopt proactive and robust risk reduction measures. This imperative is not only to safeguard their own interests but also to meet the expectations of various stakeholders, including investors, governments, and the public [5]. These strategies encompass technical, operational, and managerial approaches aimed at enhancing safety, protecting the environment, and ensuring operational continuity [6]. One

pivotal safety measure that integrates these multifaceted approaches is the safety barriers system. Safety barriers encompass a broad spectrum of technical, operational, and organizational elements designed to either individually or collectively mitigate the likelihood of specific errors, hazards, or accidents occurring, or to minimize their consequences [7]. Technical barriers include aspects like equipment design, material properties, and human-machine interfaces, while operational barriers focus on factors such as personnel competence and workload. Organizational or managerial barriers involve policies, procedures, and regulatory frameworks that govern safety practices within the industry [8]. These safety barrier systems are crucial in the oil and gas sector for preventing leaks, fires, reducing fire loads, and ensuring safe evacuation procedures. Their diligent implementation has significantly contributed to reducing the risk of accidents globally. However, the specific application of these systems within the Nigerian oil and gas industry remains relatively understudied in the literature. This paper therefore identified the various safety barrier systems being used to prevent barrier failures (loss of primary containment) at oil and gas facilities in the Niger-Delta region of Nigeria. Through this, it filled the gap in understanding and provided insights aimed at enhancing safety practices and risk management strategies within the Nigerian oil and gas context.

2. Methodology

2.1 Study Area

Figure 1 shows the Map of Oil and Gas Facilities in Niger-Delta. Niger Delta comprises 9 states out of 36 states in Nigeria. Niger Delta is located within the southern region of Nigeria bounding with Atlantic Ocean and it is home to a diverse population of approximately 31 million individuals, belonging to over 40 distinct ethnic groups. The major occupation of the populace is fishing, farming and water transportation via speed-boats.

Figure 1: Map of Oil and Gas Facilities in Niger-Delta [9]

2.2 Data Collection and Analyses

This study utilized a cross-sectional research design[10], supplemented by the survey method. The study exclusively focused on oil and gas facilities located in the Niger Delta region, and only examined risk reduction strategies that are within the company's control. Information was acquired via a questionnaire. The questionnaire's content validity was assessed by oil and gas safety professionals and other individuals well-versed in survey research. Its reliability was evaluated by the test-retest method, yielding a Cronbach alpha reliability coefficient of 0.88, using XLSTATversion 16. The study employed descriptive analysis [11], utilizing a criterion mean of 2.50, to analyze the gathered data. The research utilized a purposive sampling strategy, selecting twelve oil and gas facilities that satisfied specific inclusive and exclusive criteria. This was conducted to obtain precise data for all the operations inside the oil and gas supply chain, as all facilities do not carry out every operation. In addition, a total of 132 persons were selected from the sampled facilities, with 11 individuals chosen from each institution. Hence, the sample size comprises 132 individuals, including facility managers, safety engineers, maintenance engineers, facility integrity managers, corrosion engineers, and safety coordinators from the selected facilities.

3. Results and Discussion

3.1 Technical Barriers

The analysis presented in Table 1 outlines the technical risk reduction strategies implemented in oil and gas facilities within the region. It provides insights into the maintenance frequencies of key technical components crucial for risk mitigation. For example, blow-out preventers and wellhead valves have varying maintenance schedules, with some facilities conducting checks monthly, quarterly, or yearly. On the other hand, flame/smoke detectors and alarm systems are consistently present but have diverse maintenance frequencies. These findings highlight the diverse range of technical risk reduction strategies in place in the region's facilities. Components such as blow-out preventers, wellhead valves, and surface-controlled subsurface safety valves are essential for primary containment in the oil and gas sector. However, the observed differences in maintenance schedules among facilities raise concerns while some facilities follow regular maintenance practices, others exhibit infrequent or inconsistent maintenance approaches. This variation underscores the need for standardized risk management practices, as emphasized in previous studies by [7], stressing the importance of consistent safety measures to prevent accidents. Literature, [12];[13], have also underscored the critical importance of regular and systematic maintenance of these technical barriers. The reliability and effectiveness of critical components like blow-out preventers heavily depend on their maintenance schedules[8]. Neglecting these components can compromise their functionality during critical scenarios, potentially leading to catastrophic events. Similarly, fire detection and extinguishing systems are crucial for preventing fire-related incidents. Discrepancies in their maintenance could impact operational readiness during emergencies, aligning with prior studies that emphasize the significance of regular testing and maintenance of fire safety systems ([14];[15]). The analysis of technical risk reduction strategies in the region's oil and gas facilities underscores the significance of standardized maintenance practices to ensure operational safety and prevent potential disasters. Addressing the variations in maintenance schedules and practices is essential for enhancing the reliability and effectiveness of critical components in the oil and gas sector.

Table 1:Analysis of technical barriers being used at oil and gas facilities in Niger Delta

		AVAILABILITY			HOW OFTEN DO YOU TEST/MAINTAIN				
	Technical Risk Reduction Strategy	Always available (%)	Not available (%)	Available when needed (%)	Monthly (%)	Quarterly (%)	Yearly (%)	Never (%)	On need basis (%)
1	Blow out preventer	53.9	42.3	3.8	13.3	33.3	46.7	6.7	-
2	Well head Valves (SSVs, Wing valves, Lower master valves, etc)	88.5	11.5	-	13.6	54.5	31.9	-	-

3	Surface Controlled sub surface safety valves	88.5	11.5	-	18.2	50	31.8	-	-
5	Flame/Smoke Detectors	100	-	-	38.5	50	11.5	-	-
6	Alarm & PA systems	100	-	-	38.5	26.9	34.6	-	-
7	Flammable Gas Detection	100	-	-	34.6	50	15.4	-	-
8	Process Containment Integrity-Interconnecting Hydrocarbon Piping's inspection system	92.3	7.7	-	8.4	20.8	50	-	20.8
9	Process Containment Integrity-Transportation/Export Pipeline's inspections system	96.2	3.8	-	20.8	12.5	45.8	4.2	16.7
10	Process Containment Integrity: Pressure Vessels & Large Storage Tanks, Exchangers, Machineries containing hazardous process fluids inspections system	96.2	3.8	-	4	16	72	-	8
11	Deluge/Foam systems	96.2	3.8	-	38.5	11.5	50	-	
12	Emergency Shut Down Systems/valves	96.2	3.8	-	12	32	56	-	
13	Process Safety function transmitters	96.2	3.8	-	32	28	40	-	
14	Liquid/Gaseous Extinguishing systems	96.2	3.8	-	36	44	20	-	
15	Relief Systems: PSVs, Bursting discs, venting devices etc	100	-	-	8.4	15.4	76.2	-	

16	Fire Pumps	96.2	3.8	-	84	8	8	-
17	Fire Hydrants/Monitors/Hose Reels	96.2	3.8	-	80	20	-	-
18	Corrosion Prevention and Monitoring: Cathodic Protection and System, Corrosion Monitoring & Corrosion Inhibitor Injection System	96.2	3.8	-	33.3	29.2	33.3	4.2
19	Ballast System and Stability Management: Ballast control system, pumps, piping's and Load management computer systems	80.8	19.2	-	38.1	23.8	38.1	-
20	Pipelines & Risers (Flexible Risers, Umblicals FPSO to Buoy where applicable)	69.2	30.8	-	11.1	16.7	72.2	-
21	HVAC System & Fire Dampers	96.2	3.8	-	32	48	16	4
22	Emergency Depressurization (Blowdown valves, Flare systems)	92.3	7.7	-	25	5	13	-
23	HIPPS System (Surface/Subsurface)	81.8	19.2	-	23.8	33.3	42.9	-
24	Ignition Prevention System	81.8	19.2	-	38.1	28.6	33.3	-
25	Lifeboats (TEMPSC) & Boat Landings: TEMPSC (free fall type) & TEMPSC (davit launch type)	84.6	15.4	-	45.5	9.1	45.4	-

3.2 Operational and Organizational Barriers

The operational strategies outlined in Table 2 shed light on key aspects such as personnel competency, adaptable work environments, and manageable workloads within the oil and gas sector. The data reveals a unanimous emphasis on the importance of ensuring personnel competency (100%) and providing suitable work environments (88.5%). However, there are discrepancies in review intervals, indicating varying practices in periodicity and incident-based reviews among respondents. On the organizational front, Table 3 presents strategies encompassing policies, standard operating procedures (SOPs), and change management procedures. The majority of respondents affirmed the presence of relevant policies (96.2%) and SOPs (100%), albeit with differing review frequencies. Similarly, management of change procedures exhibited periodic reviews with varying intervals and incident-based occurrences. Personnel competency and work environment adaptability emerged as fundamental pillars for operational safety in hazardous industries, as highlighted by [4]. The findings underscore the widespread recognition of these aspects in the region's facilities. However, the discrepancies in review intervals for both operational and organizational strategies suggest a lack of standardized practices. Regular reviews are pivotal in ensuring the effectiveness of operational and organizational barriers, as emphasized by[5]. Inconsistencies in review schedules could hinder the agility required to address evolving risks and regulatory changes. The literature consistently advocates for regular assessments, adherence to industry standards, and proactive maintenance of safety barriers. The observed discrepancies in maintenance frequency align with the notion that inconsistencies in safety practices pose significant challenges to risk mitigation efforts, as noted by [16]. The operational and organizational strategies identified in the study underscore the critical importance of personnel competency, adaptable work environments, and robust policies and procedures in ensuring operational safety within the oil and gas sector. Addressing the discrepancies in review intervals and promoting standardized practices are essential steps towards enhancing safety and risk management practices in the industry.

Table 2: Analysis of operational barriers being used at oil and gas facilities in Niger Delta

		AVAILABILITY		HOW OFTEN DO COMPANY REVIEW							
	Operational Risk Reduction Strategy	**A (%)**	**N/A (%)**	**Quarterly (%)**	**Yearly (%)**	**Every two years (%)**	**Every hitch (%)**	**3 years interval (%)**	**4 years interval (%)**	**5 years interval (%)**	**Never (%)**
1	Ensuring Personnel competency	**100**	**0**	**3.8**	**69.2**	**11.5**	**3.8**	**3.8**	**3.8**	**3.8**	**0**
2	Proper /Adaptable work environment	**88.5**	**11.5**	**40.9**	**40.9**	**9.1**	**4.5**	**-**	**-**	**-**	**4.5**
3	Manageable personnel workload	**88.5**	**11.5**	**25**	**33.3**	**12.5**	**16.7**		**-**	**-**	**12.5**

		AVAILABILITY		HOW OFTEN DO COMPANY REVIEW				
	ORGANIZATIONAL	**A (%)**	**N/A (%)**	**Quarterly (%)**	**Yearly (%)**	**Every two years (%)**	**On need basis (%)**	**Never (%)**
1	Presence of relatable policies	**96.2**	**3.8**	**13**	**56.6**	**13**	**13**	**4.3**
2	Presence of standard operating procedure	**100**	**-**	**11.5**	**19.2**	**38.5**	**30.8**	**-**
3	Presence of management of change procedure	**96.2**	**3.8**	**16**	**24**	**28**	**32**	**-**

Table 3: Analysis of organizational barriers being used at oil and gas facilities in Niger Delta

4. Conclusion

The findings underscore a diverse implementation of safety barriers in the Niger-Delta oil and gas sector, emphasizing the varying maintenance schedules, review frequencies, and strategies among facilities. Given that certain components exhibit consistent availability, disparities in maintenance practices and review intervals across technical, operational, and organizational barriers, the potential areas for improvement and standardization are thus indicated.

5. Recommendations

1. Companies that own oil and gas facilities in the Niger Delta should as a matter of urgency increase the components of their respective risk reduction strategies as it has been found that some globally recognized technical components are not available in some of the facilities.
2. Companies that own oil and gas facilities in the Niger Delta should perform periodic training and re-training of their technical personnel in order to keep their technical skills and cognitive abilities abreast with global practices.
3. Continued research and regular assessments are important to adapt to evolving risks and enhance safety measures in the dynamic oil and gas landscape of the Niger-Delta region. This study serves as a foundation for further investigations and interventions aimed at fostering a safer and more resilient operational environment within the oil and gas industry.

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