ISSN 3049-317X (Online)

Overview of Impact of Organizational, Human, and Workplace Factors on Safety Performance in the Oil and Gas Industry

L. R. Gabhane
Research Scholar
Sri Balaji University Pune
lalitgabhane@yahoo.co.in

Dr. G. Gopalakrishnan
Director, BIMHRD
Sri Balaji University Pune
g.gopalakrishnan@bimhrdpune,edu.in

Abstract

The oil and gas industry, due to the nature of its volatile products is highly prone to be at the receiving end of major fires, explosions and other industrial disasters. In addition, this industry has also been marked as a major 'offender', in case of crimes against the environment along with concerns about the volatile nature of its products in the society and the risks associated with workplace accidents and injuries causing suffering for the workers, working in this industry.

This paper highlights the factors influencing accidents in the oil and gas sector. It integrates findings from scholarly articles, industry publications, and case studies to highlight the role of organizational factors, human factors, workplace environmental conditions such as workplace layout and ergonomics etc. This research paper has sought to provide a comprehensive understanding of the factors responsible for the accidents which have occurred in the oil and gas industry, through a review of the relevant research literature pertaining to the topic, so that the levels of industrial safety can be increased, reducing the chances for accidents to occur in the oil and gas industry, which can benefit the stakeholders in-charge in the industry for the development of industrial disaster and accident prevention and safety programs.

It emphasises on the importance of effective safety programs, management commitment, human factors like behaviour and fatigue, and workplace ergonomics in preventing accidents and promoting a culture of safety. The paper also discusses the significance of effective safety leadership, recognizing good safety practices to protect individuals, the environment, and support economic development in the industry.

Key Words: Oil, Gas, Safety, Accident, Human Factors, Workplace Environment, Organisational factors.

1. INTRODUCTION

The oil and gas industry plays an extremely crucial role in the countries in the world. One might state that it also performs a role similar to blood in our body and several wars have been fought for the control of this crucial industry in several regions in the world. India has considered this industry with a high level of seriousness and this has been evidenced in form of major infrastructure investments for this industry which includes 23 refineries, 15 gas processing plants, 4 LNG terminals, 680 oil and LPG installations, and a network of over 39,000 KM cross-country pipelines, as per data released by the Ministry of Petroleum and Natural Gas, Govt of India (Standing Committee on Petroleum & Natural Gas, Lok Sabha, 2019). Regarding the personnel strength, around 4 lakh 80 thousand employees are working in this crucial industry which contributes 15% to India's GDP.

Despite this significant role played by the sector, India, classified as a developing nation, unfortunately stands out for a notable number of Major Industrial

Accidents in the Oil & Gas sector. Among 319 major global accidents during 1917 to 2011, 195 were within the Oil & Gas Industries, placing India as the third highest in such occurrences even when compared with developed countries (Mihailidou et al., 2008). The data has revealed that in the three-year period between 2014 and 2017, more than 300 industrial accidents were reported in the Oil and Gas PSUs (Public Sector Undertakings) in India, causing 81 fatalities, and injuring 193 individuals. This underscores the sector's elevated risk, encompassing fire, explosion, environmental concerns, and crucially, human safety. Although advancements in technology and automation aim to enhance control and productivity, the activities like exploration, production, transportation, distribution, and use, present a very high safety risk. Accidents in oil and gas industry operations are not very frequent but they have serious consequences for employees, society, the environment, and property causing significant losses. Most accidents result from human errors, such as unsafe practices and hazardous conditions (Gordon, 1998).

Amongst the several industrial accidents in this industry, the Piper Alpha Disaster of 1988 and the ONGC BHN Disaster of 2005 stand out amidst the rest and regarding the other disasters, the repercussions of the Deepwater Horizon incident, the Pipeline explosion in Andhra Pradesh, Jaipur Oil terminal fire, and Hazira terminal fire, serve as a clear indication for the analysis of the accident patterns for the establishment of effective control mechanisms(Wang et al., 2020).

While the industry responds to major disasters, it often fails to learn from them and prevent future occurrences. The lack of recognition of hazards, root causes, safety controls, at-risk behaviours, contributes to this failure

Levovnik (2019) has described two key factor verticles which play a role in the designing and management of the industrial safety infrastructure in factories, establishments and other locations which are recognized as establishments following 'hazardous' manufacturing processes operations. These key factors are 1) Internal – Managerial commitment, Managerial communication, Integration & Involvement of employees in industrial safety, Industrial safety training, Rewards for vigilance and Establishment of a culture of safety. 2) External – Enforcement of the safety legislations, rules and regulations as enacted by the State by the Industrial safety authorities of the State, to conduct industrial safety audits with the assistance of the authorities and to offer external incentives for encouraging safe industrial work practices.

The research focussing on understanding the most common and frequent reasons and root causes for industrial accidents in the oil and gas industry will benefit the stakeholders in the industry, the government and the general public as the research efforts in the analysis of the industrial accident patterns, the symptoms detected prior to the accidents along with understanding of the root factors responsible for the accidents which have occurred in the industry, etc. as the information generated through such research can enable the development of industrial safety practices, necessary for reducing the chances of accidents, loss and death in the future (Samia et al., 2018).

The researchers have performed an examination of the diverse set of factors responsible for industrial accidents in the petroleum oil and gas in this paper, with a focus on organizational, human, and workplace environmental factors. Drawing upon established literature and published reports, the organizational factors section in the paper will discuss the role played by managerial commitment, the culture of industrial safety, effective communication, training and competency, procedural compliance, resource allocation, risk management, regulatory compliance, organizational learning, and continuous improvement as the key factors which can reduce the chances of industrial accidents in the oil and gas industry.

The human factor analysis refers key studies and industry findings to explore operator errors, fatigue and stress, training and competency gaps, complacency, human-machine interface challenges, and behavioural aspects influencing safety outcomes. The workplace environment section integrates insights from scholarly articles, industry publications, and case studies to highlight the role of the physical, organizational, and cultural dimensions. Specific emphasis is placed on equipment design and maintenance, worksite layout, environmental conditions, organizational structure, emergency response preparedness, and workplace ergonomics (Eskandari et al., 2017).

2. LITERATURE REVIEW-ACCIDENT CAUSATION FACTORS:

The interplay of human actions, the surrounding work environment, and managerial decisions constitutes a complex web that contributes to the occurrence of industrial accidents (Tappura, 2017).

The human element has been identified as a major factor, responsible for industrial accidents and the elements of this factor such as the individual behaviour of the persons working in the industry, their cognitive aspects, the nature, frequency and the quality of the industrial safety training given, etc. play a crucial role in the determination of the likelihood of accidents as petroleum, being a volatile chemical can catch fire and explode easily which will happen if the industrial safety regulations, best practices, safe operations protocols, ergonomic considerations, etc. might be flouted or might not be followed as they should, increasing the number and

hazardousness of the industrial accidents (Mannan et al., 2015) Additionally, the decisions and practices adopted by management significantly impact the overall safety culture within an organization (Unnikrishnan et al., 2015).

Accidents have diverse failures and root causes, with safety management lapses being a common factor (Bakar et al., 2017). Effective safety programs with proper controls can prevent accidents and bring benefits. Employers and contractors must recognize good safety practices to protect people, the environment, and promote economic development, highlighting that every life is equally important (Bhawana Yadav, S C Kundu B & Jambheshwar, n.d.).

A. ORGANISATIONAL FACTORS:

Several organizational factors have been identified, which play a role in influencing the ways and means in which industrial safety related decisions are taken and behaviors are seen in organizations. These factors are crucial because they have a role to play in influencing the industrial safety performance of the organizations.

Eskandari et. al., (2017) in their investigation into the organizational factors which are related to the occurrence of industrial accidents have identified eleven organizational factors responsible for the above (for example: blame culture, education & training, employee involvement, etc.) stating that organizations need to consider these factors while designing their internal industrial safety processes and procedures to prevent the occurrence of industrial accidents and disasters on their watch. On a similar note, research by A.N. et al., (2024) reported that safety leadership quality is an essential attribute for every organisational leader to have, to drive a positive safety culture where personnel feel free to express their concerns about safety matters without fear.

a. MANAGEMENT COMMITTMENT AND PARTICIPATION: Management is generally defined as how businesses organize and direct workflow, operations, and employees for getting the work, done that is required for achieving the organisation's goals in an efficient and effective manner (Soyuti & Sabran, 2016). Creating an environment conducive to employees working efficiently, productively, and in a safe manner without causing a harm to themselves and others is the primary objective of management. The involvement and dedication of management are crucial in determining the safety environment in the oil and gas industry. Ahsan Waquar et. al., (2024) in their research on the Malaysian oil and gas industrial projects identified a number of critical industrial safety related factors, many of which have been identified as the significant factors, responsible for accidents such as – non adequate industrial safety training, insufficient industrial safety procedures and non-adequate supervision, particularly in high risk areas, etc. The findings are significant as majority of the cases of industrial accidents and disasters which were examined, the factors so discovered in the research were found to be responsible in a significant way for the accidents. The researchers emphasise that the risk of industrial accidents can be reduced by more active involvement of the management and the employers in the cultivation of a culture of industrial safety in the organization as such efforts, if actively emphasised by the leaders through their active participation will establish a commitment from the top that percolates down through the workforce. Such culture motivates employees to adopt safe work practices and view accident prevention as a collective duty. Conversely, a deficiency in management commitment may lead to reluctance in embracing new safety protocols and technologies (Sugiono et al., 2020). Such reluctance can obstruct advancements in accident prevention and limit the industry's capacity to address emerging risks.

Organizations who have created Occupational Health & Safety (OHS) Policies for their workplaces have a duty to uphold the terms and conditions of the policies in complete terms as the policy is a regulatory, moral and economic responsibility of the organization in doing its best for ensuring the general health and safety of its employees and workplaces (infrastructure, buildings, etc.) and successful implementation of such policies can contribute to the employees' wellbeing as the strict enforcement of such policies can create a feeling of security, which can cause the employees to feel safe, enabling them to focus more on their work, thereby increasing the performance of the organizations in the long run (Rezagholi Högskolan Gävle & Rezagholi, 2016, Tappura, 2017).

Anyim et al., (2013) has argued that organizations should involve the HR (Human Resources (the employees)) of the organization in the development and deployment of industrial safety and health policies as the employees, who have been in the system, know how the systems work in the organizations and can make the best use of the resources in the time of need, ensuring everyone's safety during emergencies. Due to this, HR remains relevant in spite of the changes brought by adoption of new technologies as it has the capability to adapt to changing situations and circumstances. Also, in realization of the strategic value of human resources, employers in many organizations essentially put into place a well-defined and communicated health and safety programme in a bid to improve organizational performance. By prioritizing management commitment, resource allocation, employee participation, risk assessment, and cost-benefit analysis, employers can increase the end value of their occupational health and safety programs in effective terms.

b. EFFECTIVE POLICY IMPLEMENTATION: When management's involvement is merely symbolic rather than genuinely committed, it can yield adverse consequences (Levovnik et al., 2019). Such a scenario might result in a disconnect between safety goals set by the organization and the actual safety practices implemented, thereby diminishing the efficacy of the safety programs. On the contrast, committed management guarantees the formulation and enforcement of rigorous safety protocols, encompassing routine safety audits, risk evaluations, and emergency preparedness strategies(Harm at Work Leadership Program, n.d.). Proactive engagement from management ensures that safety guidelines remain both thorough and adaptable, capable of addressing the ever-evolving risks inherent in the dynamic oil and gas sector.

c. RESOURCE ALLOCATION FOR SAFETY: Management's dedication translates into the provision of sufficient resources for safety endeavours, encompassing financial support for state-of-the-art safety technologies, continual employee training, and infrastructure upkeep(Manette & Tuyl, n.d.). However, despite management involvement, insufficient allocation of resources for safety initiatives can impede accident prevention endeavours. Inadequate funding, outdated safety equipment, and inadequate training schemes may undermine the overall efficacy of safety measures. Nevhageoch (n.d.) developed a preliminary model designed for explaining the impact of the economic pressure felt on the safety performance of profit oriented organizations in the face of market challenges. Unlike in the past, the modern socio-ethical context and the associated legal and regulatory frameworks leave a very limited room for management to initiate direct actions that could openly jeopardize safety. Above all, the most companies understand the gravity of such detrimental actions nowadays and would not consciously support any action that clearly leads to poor safety performance (Jiang et al., 2020).

Deshai (2018) have presented a brief example of a schematic model (prelimnary development) designed for recognition of the mechanisms responsible for the apparent correlation between the variables of economic pressure and safety performance in case of profit oriented organizations. The researcher has theorized that economic stress felt by organizations who may not be performing well create several indirect pathways which can have a domino effect on the organizational health and safety management systems, leading to their deterioration. They noted that such pathways can be found even in case of organizations which have no intention to compromise on their health and safety for economic gain.

d. EMPLOYEE INVOLVEMENT AND EMPOWERMENT: Involvement empowers employees to actively participate in safety initiatives (James Reason, 2008). A culture where employees feel comfortable reporting hazards, suggesting improvements, and actively participating in safety drills is cultivated by committed management. Ghahramani (2016) in their research on industrial safety and management have identified the decisive factors in industrial safety management as – Commitment by the management, Communication of the policies, tactics and other operational decisions regarding industrial safety, Involvement of the employees in workplace safety and management, Integration of the industry best practices and S.O.Ps regarding industrial safety, Provision of training regarding Occupational Health & Safety (OHS), Creation and enforcement of a culture of safety along with internal incentives for the same, Creation and enforcement of OHS policies in the organization, ISO Standard audits related to industrial safety and external incentives approved by the employers for industrial safety, etc.

e. EDUCATION AND TRAINING:

Operations in the oil and gas industry usually involve the processing of crude oil and other oil and gas raw materials into valuable oils and gases for further processing, storage or object sale and usually involves several heat and pressure based processes such as petroleum cracking. These operations are listed as 'hazardous operations' in the labor legislations of several countries due to the volatile nature of the raw materials and the end products and establishments where such operations are run, have to involve additional layers and mechanisms for industrial safety both by official decree (Laws and legislations related to factories and labor) and by the industry themselves to ensure that the risk of industrial accidents can be reduced as can be and the researchers suggest that such mechanisms can become far more safer, if the workers and employees in the industry were given the OSH (Occupational Safety and Health) training designed to increase their awareness about the best practices for industrial safety and health so that the organizations will have many eyes roaming around on alert for potential risks, increasing the chances for safety in the industrial premises (Gilang Perdana & Sahroni, 2019).

Development of OSH skills within the workers and employees will be beneficial as it can ensure that they will take the right decisions and do the right actions, regarding industrial safety and health ensuring that the risk of workplace fatalities and industrial accidents can be brought down to a very low number. Such efforts can improve the necessary skill sets of the employees for detection of potential hazards and risks and to manage the

situation in times of emergencies to ensure that the number of casualties and property damage can be reduced in a greater way. Regarding the oil and gas industry, the end objective of the industrial safety and health training provided is to create a culture of safety and health with an emphasis on prevention than the cure and should include both the basic and the advanced aspects of plant operations, maintenance and S.O.Ps regarding industrial safety maintenance and emergency handling (Peter Okoh, 2013).

Analysis of several accidents has revealed that basic housekeeping plays a small but significant role in industrial safety and health. The individuals who perform the housekeeping tasks may not be as trained as the actual operators running the systems, but they too should be held responsible on an equal level in ensuring occupational health and safety so that they do not accidently press the wrong button which could lead to catastrophic results. Due to this, sensitization and familiarization of the consoles, panels and buttons should be done for the housekeeping staff so that the risk of accidents can be reduced. Also, having an extra pair of eyes and ears can be useful as they can alert the management about the symptoms, preventing the risk factor from becoming a disease (John Atherton and Frederic Gill, n.d.).

The risk of accidents is higher in specialized services providing companies than rather companies. This is due to the uniqueness of their products and services which might not have prior precedence, regarding best practices and S.O.Ps for industrial health and safety. A similar example can be seen in case of employees working on contract as they may be asked to perform hazardous or risky work, which may not be standard or commonplace in the industry. Due to these, Occupational Safety and Health training should be inclusive, covering all the employees in the organizations, in levels congruent with the actual nature of their work. The need for occupational safety and health was increased in the oil and gas industry in the wake of the Piper Alpha disaster and the Deepwater Horizon disaster in an attempt to reduce the chances for such accidents from occurring in the future (Safety Centre, 2013).

Safety training ensures that employees are well-informed about potential hazards, allowing them to identify and mitigate risks effectively. The importance of safety training was seen in case of the Texas City Refinery accident, where the absence of supervision by the senior personnel and lack of technically qualified personnel during the initial stages of the accident, created a domino effect upgrading it to a disaster it is known today (Process Safety Metrics Human Factors, 2007).

Industrial safety training is usually provided to ensure that the employees retain their presence of mind in time of accidents and emergencies so that they will be able to respond to the situation in a calm and collected way, necessary for ensuring their survival and the survival of their colleagues. Significant components in the training are devoted to prevention so that the symptoms of accidents can be identified immediately, preventing it from turning disastrous for ensuring the survival of all the personnel in the organization.

Unnikrishnan. S. et. al., (2015) had conducted a survey related to industrial safety practices in the SMEs and SMEs (Micro, Small and Medium Establishments) in and around Mumbai, Maharashtra with a sample size of 30 respondents. They reported that industrial safety is not taken much seriously as in many SMEs and MSMEs and the risk factors associated with safety differed from one SME/MSME to the other as in case of one SME/MSME the risk factor was very high and in case of another SME/MSME the risk factor was very low. The data revealed that financial conditions of the SMEs/MSMEs, resistance to change and lack of industrial safety training opportunities for the employees were found to have increased the risk factor for accidents in the SMEs and MSMEs. A similar finding was made by Verbitskaya & Alashoor (2022) in their research into the root causes for accidents in industrial establishments and the data reveals that in case of the establishments which were serious about industrial safety was due to the creation of a culture of safety, higher efficiency in their operations and the impact of the industrial and labor laws.

f. REWARD SYSTEM: Implementing a rewards system not only enhances employee satisfaction but also fosters the utilization of safety reporting systems, thereby facilitating the early identification and control of potential hazards. Organizations can introduce a system of rewards and incentives, which can encourage the employees to report possible risk factors and symptoms to reduce the chance of the former causing accidents in the future, in case no action was taken (Zhang et. al., (2016).

Oil and gas sector establishments have introduced industrial safety rewards and incentive schemes where employees who detect possible accident risk factors are rewarded for doing their part in ensuring the general safety and health of their establishment. Such practices are followed in this industry out of the assumption that rewards and incentives can motivate employees to prioritize safe behaviours for increasing the levels of safety in the oil and gas industry (Mannan et al., 2015).

Employee satisfaction has a multifaceted impact on workplace safety and accident causation. Satisfied employees are more likely to be engaged, motivated for safety compliance, communicate openly about concerns, collaborate effectively, and undergo necessary training. A positive work environment reduces stress and fatigue,

contributing to higher morale and well-being, ultimately enhancing the overall safety culture(Harm at Work Leadership Program, n.d.). The link between job satisfaction and accident prevention highlights the importance of fostering a workplace where the employees will feel that they matter, that they are valued as the chances of such employees developing real commitment towards ensuring the guidelines related occupational safety can increase as the information found by the researchers has indicated that the levels of job satisfaction felt by the employees can play an influential role in enabling occupational safety and prevention of industrial accidents (Mafini, C., & Dlodlo, N. (2014).

Researchers have identified a connection between industrial workplace safety and health and the job satisfaction of employees as organizations where the employees are highly satisfied, are extremely safe to work in and vice versa also rings true in this case. Ibrahim et. al., (2018) in their analysis on the relationship between occupational workplace safety and health with employee satisfaction, in case of the Kenyan Water Supply industry has reported that there is a strong connection between a positive work environment and occupational safety and health practices in the organizations in the constituent members of the industry covered by them in the survey as organizations which go the extra mile in ensuring the general happiness and wellbeing (employee satisfaction) of their employees were found to be organizations where the number of accidents were very low, proving that employees who are satisfied with their work play their part in making their workplaces more safer for themselves and their colleagues, and such feeling of satisfaction also plays a role in enhancing the quality of their work and end productivity in their jobs.

B. HUMAN FACTORS:

Factors specific to human being have been identified as one of the pivotal causes of accidents in the oil and gas industry, inspite of the improvements and advances in technology, safety protocols and other accident prevention mechanisms installed in the plants and units in the industry (Jiang et. al., 2020). A similar observation was made by Nwankwo et. al., (2022) who observed that in case of catastrophic accidents (Such as the Bhopal gas tragedy and the Chernobyl meltdown) human error can be held responsible as the most common cause for such serious accidents in the oil and gas industry. These observations are supported by the statistical data which has revealed that a very high number (80 to 90 percent) of workplace accidents ranging from serious to catastrophic could be blamed to human errors which is a true concern for worry on a global basis, increasing the need for the development of robust mechanisms on a national and international basis for finding solutions to such lacunae, as the human factors so identified as the most common factors in the accidents could lead to the development of a comprehensive mechanism for industrial safety and health, which could be then integrated in the overall design of the facilities, infrastructure and equipment in the oil and gas sector units so as to enable the operational maintenance of industrial safety in a smooth way (Bakar et. al., (2017). Amidst the various causes of accidents, human errors have been identified as one of the most prominent ones, increasing the need for the development of critical mechanisms for development of systems, resistant against human errors for possible reduction in accidents (Soyuti & Sabran 2016) as in almost all major industrial disasters and accidents such as Chernobyl in Pripyat, Ukraine and the Three Mile Island Pennsylvania nuclear power plant meltdown in the USA, this factor was identified, casting a light on human factors responsible such as the ways the decisions were taken, communication (and non/mis communication), technical/managerial competency and crucial skills match (and mismatch) which played a role in such accidents. By considering human factors, it is possible to mitigate the likelihood of errors and enhance overall safety standards. This entails designing systems that align with the capabilities and limitations of individuals, thereby reducing the potential for accidents (Shappell & Wiegmann, 2000).

a. BEHAVIOURS AND WORK HABITS:

At-risk or unsafe behaviour such as wilful deviation from established safety protocols, reckless behaviour, unsafe acts etc, can significantly impact the overall safety culture and performance within an organization or community (Pasman et al., 2009). The investigation of the Buncefield fuel depot accident revealed that the explosion occurred from the overflow from one of the petrol storage tanks in the depot, which spilt over 300 tonnes of the volatile fluid, which rapidly turned into gas, caught fire and exploded, encompassing an area of 80 thousand square meters in a ball of fire and heat. The investigation further revealed instances of poor work habits and unsafe behaviour. Employees were found to engage in unsafe acts, such as ignoring safety protocols, improper storage practices, and inadequate reporting of near-misses (Elliott, 2017).

Investigations into several accidents which have occurred in the oil and gas industry has revealed that the accidents happen because of the intentional or unintentional ignorance of the safety systems and procedures by the workers or managers, either due to miscommunication, non-communication, procedural delays in case of repair or replacement of faulty equipment, etc. Chang & Lin (2006) in their fishbone diagram analysis of the causes behind 242 accidents involving chemical storage tank failures in factories and establishments 40 years ago found that in case of the

accidents, a significant number (30 percent) of the accidents could be traced to human errors such as poor operational competency, non-proper maintenance, etc.

b. IMPROPER COMMUNICATION: Errors and misunderstandings are common in human communication, but in safety-critical scenarios like shift handovers, reliable communication is essential (Beriha, 2012). Ensuring effective communication during a shift handover is a key factor in preventing major incidents as the risk factor for accidents can increase due to mis or non-communication about the systems running in the establishments as seen in case of the infamous Chernobyl disaster in Ukraine. Unreliable communication usually arises from accidental or intentional refusal to share information, inaccurate or incorrect information and issues related with the end quality and the usefulness of the information along with provision of information, not related to the tasks in hand.

Communication is a crucial element in management and administration and in many cases lack of communication or mis-communication can result in accidents as a cascading effects of poor or wrong decisions taken as the result of missing or non on-time information, poor quality of and non-accurate information along with provision of information which was not needed by the decision makers, etc. These factors can be identified in almost every accident, creating the need for a mechanism which can correct the above lacunae (Theophilius et. al., 2018). Communication plays a crucial role in change over operations in industrial establishments such as Shift Changes wherein responsibility for a particular area or a system is handed over to the next shift in-charge by the now concluded shift in-charge and the importance of this handover was highlighted in major accidents in the oil and gas industry such as the Piper Alpha, Texas Buncefield disaster. The enquiry report into this industrial accident clearly mentioned miscommunication in the shift handover as crucial information pertaining to the proper handling and management of the crucial control systems were not transmitted properly and was mentioned as one of the crucial factors, responsible for the accident. Another example can be cited in form of the Gulf of Mexico oil spill (Deepwater Horizon, 2010), where poor communication among the oil rig crew, contributed to the disaster. Misunderstandings about the well integrity and a lack of clear communication led to a delayed response to the blowout.

c. FATIGUE AND STRESS: H.T.A. Bakar (2017) has indicated the importance of adequate rest and sleep for the employees and has stated that employees who are forced to work long hours in arduous conditions run the risk of reduced performance, due to increased fatigue leading to poor level of alertness and concentration at work, reducing their end performance during the work. Such factors, particularly in case of high risk areas such as pressure vessel control stations, etc. are high risks for accidents and in many cases, have been identified as such as in case of the Exxon Valdez Crude oil spill in 1989, in the Accident report by the National Transportation Board of the USA which highlighted the human factors responsible for the oil spill as 1) Substance (alcohol, drugs, etc.) abuse, 2) Employee fatigue and 3) Excessive workload on the workers. The ship's captain had been working long hours, which likely contributed to poor decision-making and impaired judgment leading to the accident.

C. WORKPLACE ENVIRONMENT:

The workplace environment significantly influences safety outcomes within the oil and gas industry (Cynthia Roth, 2006) The physical, organizational, and cultural aspects of the workplace environment can significantly influence the occurrence of accidents. According to Faith Eyayo (2014) the workers in the oil/gas refineries are forced to work in a variety of physical, chemical and mechanical or ergonomic risk factors, which can transform into accident hazards for the workers, if they are not alert or careful while at work. Following workplace environment factors have been identified and their role as accident causing factors in the oil and gas industry has been described as follows:

a. WORKPLACE ERGONOMICS:

While designing workplaces layouts and work areas, designers usually take into account the ergonomic considerations for enabling the employees and workers to have a workplace layout which is comfortable to work. The ergonomic factors in the employee work facility and accommodation layout and the ways in which the work activities have been organized has been systematically considered over the last decade or two on a short number of offshore facility design projects for – a) Increasing the occupational safety factors in the workplaces for the personnel. b) Assist in the performance of the maintenance tasks and work in an efficient way. c) play a role in improving the facilities for the general welfare and wellbeing of the employees in the offshore sites, etc. (Robb & Miller (n.d.).

Due to the volatile nature of the raw materials and refined products, the oil and gas industry has several industrial and operational health, safety and environmental risk mitigation features and systems designed and deployed within the numerous refineries, cracking units, storage and other related units so as to reduce the risk of accidents and injuries as much as possible (Oil refinery processes, n.d.).

The work environment in oil and gas sector is diverse, ranging from restricted spaces to open fields and offshore rigs(Storesund & Steen-Hansen, 2018). Within these settings, workers face various challenges such working in heated environments (near the cracker stacks), slippery surfaces (due to oil spills, in case of poor maintenance) and risks associated with handling and movement of raw materials, tanks and other heavy objects via overhead gantry cranes, truck cranes etc. In addition other risks associated with faulty or non-properly maintained electrical equipment, poor quality safety apparatus along with repetitive monotonous tasks such as valve turning and re-turning, etc. can pose a real threat to the lives and limbs of the employees in the oil and gas industry (Rademaeker et. al., (2012). If ergonomics is not considered throughout the different phases of operations, it can lead to negative consequences (Ahmadi et al., 2020). These consequences include a potential impact on production and an increased risk of injury for employees. Singh & Singh (2018) emphasized the importance of considering ergonomics and safety awareness across all stages of operations to prevent injuries and maintain optimal production levels. This implies that a proactive approach to ergonomic considerations and safety measures is essential for both the well-being of the workers and the efficiency of the processes.

b. EQUIPMENT DESIGN AND MAINTENANCE: Improper equipment design and maintenance pose significant risks, primarily increasing the likelihood of equipment failure. Critical components like valves, pipelines, pumps, and pressure vessels operate in harsh conditions. If not adequately designed or maintained, they can fail catastrophically, resulting in leaks, ruptures, or explosions(Bladon et al., 1992). As infrastructure ages, the equipment becomes more vulnerable to wear and tear, heightening the risk of accidents. Therefore, investment in infrastructure modernization and regular maintenance is vital to mitigate these risks.

In case of major industrial disasters such as the Bhopal Gas Tragedy and the BP Deepwater Horizon Oil Spill, maintenance reasons were identified as one of the significant causes of these serious industrial accidents in the accident investigation reports, revealing the crucial role played by proper maintenance as a preventive factor, ensuring employee health and safety (Tauseef et. al., (2017). Proper maintenance is a factor of utmost importance as organizations who give maintenance the proper respect it deserves in operational terms can reduce the risk of accidents and industrial hazards by 40%.

For instance, the 1984 Pemex LPG storage facility incident in Mexico resulted in the loss of 600 lives and injuries to thousands. Investigations revealed that many safety systems were either bypassed or non-operational, with the absence of a Safety Relief Valve (SRV) in the LPG manifold and inadequate gas detection systems being key factors (Rodante, n.d.). These incidents highlight the urgency of addressing and enhancing maintenance practices to improve safety in these industries. Poorly designed equipment may lack sufficient safety features or fail-safes, making it challenging for operators to respond effectively during emergencies.

c. ENVIRONMENTAL CONDITIONS: E. Ubaneri et. al., (2013) in their study on the environmental impact of gas flaring (burning of unusable natural gases and other volatile gases) have found that the noise, vibration and heat associated with gas flaring, particularly in locations where the flare stacks are not subjected to regular maintenance, create health and safety hazards for the employees, in case they are not provided the necessary safety & protection equipment and or have not undergone the necessary safety training associated with such operations in the oil and gas industry.

The impact of noise on worker mental health cannot be overlooked. The Studies suggest a correlation between noise-induced stress and an increased likelihood of accidents in oil and gas fields. Proper noise control measures, including the use of sound barriers and personal protective equipment, are crucial (Alroomi & Mohamed, 2021). During night shifts on an oil rig, poor visibility due to inadequate lighting contributed to a series of near misses and accidents. Upgrading the lighting infrastructure by installing brighter lights and implementing a routine maintenance schedule significantly improved visibility. This initiative not only reduced the risk of accidents but also positively impacted the mental well-being of workers during night shifts.

Heat and ventilation has been observed as a catalysing factor in case of accidents and organization can benefit from taking the necessary steps in keeping the heat and temperature levels in their working environments under control so that the risk of accidents and injuries on the part of the employees can be reduced, enabling safe operations in the units run by the members of the oil and gas industry (Krista, n.d.).

Ventilation systems are essential for maintaining air quality by removing hazardous substances, fumes, dust, and gases, from the work environment. Poor air quality can result in respiratory issues, dizziness, and impaired decision-making, increasing the risk of accidents. Heating systems help maintain appropriate temperatures, preventing the risk of equipment malfunction or freezing, which can contribute to accidents.

3. DISCUSSION AND CONCLUSION:

As elucidated above, the history of major accidents

worldwide shows the significance of understanding the reasons for preventing the recurrence of such incidents. Key factors influencing accidents include how committed and involved senior management is in promoting safety, the quality of education and training provided to workers, the reward systems to recognise safe behaviours, and employee satisfaction. Human factors, such as workers' behaviour, communication issues, and the impact of tiredness and stress, continue to be major challenges. Real-life examples, like the Buncefield fuel depot explosion and the Exxon Valdez incident, demonstrated how these factors contribute to accidents. The workplace environment, work place designs and maintenance, emergency preparedness and the overall conditions in which people work, directly affects safety.

Oil and gas sector have well laid safety programs in place. Despite adopting a multi-layered protection approach, the oil and gas sector still experiences significant accidents, injuries, fires, explosions, etc. The researchers have identified 11 industrial accident risk factors in the oil and gas industry, in their literature review on the research literature on the topic. These factors are listed here as follows:

1. Regulatory safety compliances
2. Senior management commitment for safety
3. Quality of safety leadership
4. Investments and availability of finances
5. Identification and Assessment of site safety risks
6. Working conditions and environment at the workplace
7. Safety training and awareness levels of employees
8. Worker participation in safety activities
9. Human errors
10. Mechanical Integrity of the plant and equipment
11. Plant Operating procedures

The researchers state that there is a substantial scope for further study in this area, creating a research gap as existing studies reveal that only a limited scale investigation has been performed for identification of the most influential factors which are having significant level impacts on the industrial safety related performance factors in the oil and gas industry. They have also found a correlation between the various industrial accident related safety factors and the safety performance of the establishments working in the oil and gas industry, making this an area of significant interest for the researchers, and the findings can be useful for the organizational decision makers and the stakeholders as in congruence with the tenets of modern management, organisations need to know the aspects that have significant relationship with the organisational performance, to tailor their strategies and sustain the business in the competitive market.

There is a need to thoroughly study and examine the aforementioned factors, elucidating their influence on safety performance within the industry context and find out answers to the questions; Which factors have the most influence on the safety performance in the present days? Does the changing technology contribute for improving the safety performance? Is there a need to establish any new safety management technique or methodology? The answers to these questions can assist the various players in the oil and gas industry to design and deploy systems, mechanisms and other related ways and means for industrial health and safety, making the establishments in this industry, more safe than before benefiting the employees, the employers, the shareholders and the other external/internal stakeholders in the industry. Thus in conclusion, the researchers would like to state that there is scope for further research in a comprehensive and focussed way, to study the industry practices and S.O.Ps regarding industrial safety and health amidst the various organizations in the oil and gas industry, for identification of the influencing factors which play a role in enhancing the general levels of the industrial safety and health for the employees so that the members, organizations and the other players in the industry will be in a position to function and to work in a smooth, safe and sure way, which will benefit not only the employees and the employers but the economy of India in the long run.

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