Health, Safety and Environmental Risk Management in Ghana's Upstream Oil and Gas Industry

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***Abstract*- This paper examine the major health, safety and environmental risk management in Ghana's upstream oil and gas industry. There were four main specific objectives of the study which included examining the main occupational health hazards; the level of employees' awareness and attitudes to HSE risk issues; the extent of management commitment to managing HSE and finally, the challenges confronting the management in addressing HSE risk issues. The study was based on the views of 105 staff from the study area. A self-administered questionnaire was the main research instrument. The results from the survey were analyzed and the first major findings were following. Considering the first objective, the study found that there are five main health hazards namely: physical, chemical, biological, ergonomic and psychological hazards. In the case of the second objective, it was found that the management attitudes toward occupational hazards and safety practices were positive. When it comes to the objective three, it was found that the level of management commitment to managing HSE risks in Ghana was very high. Finally, on the issue of challenges, it was discovered that there were various challenges of which the two most important ones were overlapping authorities and responsibilities among ministries and lack of employee and community involvement in policy making process. Based on these it was recommended that authorities and responsibilities among ministries should be well spelt out. Additionally, there should be both employees and the community involvement in policy making process.**

***Index Terms*- Hazard, Health, Safety and Environment (HSE), Oil and Gas, Risk Management, Upstream**

I. BACKGROUND TO THE STUDY

Health and safety is relevant to all branches of industry, it is particularly important for the construction industry. It has always been a major issue as it is considered as among the most exposed sectors when it comes to occupational accidents. Although tremendous improvements have been made in health and safety performance in some countries, the construction industry continues to lag behind most other industries. This has been the experience within most countries. The reality is that the construction industry continually has injury and fatality statistics that make it one of the most dangerous industries in which to work predominantly in developing countries. As a result of the increasing number of accidents, the development and publication of standards and good engineering practices based on experience and codes started.

Occupational hazards of the oil and gas workforce are of interest because oilfield occupations present high risks, and little is known regarding chronic exposures and health effects faced by this workforce. Public health officials and media alike, centering attention around the general population, have overlooked a population likely to have higher exposure rates over longer durations than the general population. Moreover, dialogue and trust between exploration and production companies, governmental organizations, and the public is strained. In part, trust has been undermined by media sensationalism, pushing public health professionals to investigate the effects on the general population, while the workforce remains underserved.

On the other side, as the world has become smaller through technology and through cooperative arrangements that cross many borders; the issue of the construction worker 's health and safety has become a well-recognised problem and represents a concern that is shared worldwide. Even though the mechanization of the construction industry is not uniform throughout the world especially in the developing countries, which use labour intensive construction methods, high accidents and fatalities rates are vastly different to developed regions. This is due, in part to the minimum use of equipment, shortages of adequately craftsmen (skilled workers), difficulty in acquiring needed materials, and lack of adequate infrastructure and other facilities. Furthermore, there are many other obstacles to the achievement of good standards such as pressure of production or performance targets, and the complexity of the organization are typical examples of such obstacles including the most crucial factor of cultural and behavioral aspects. The workforce may be drawn from many different countries, use many languages and have a variety of cultural backgrounds. Culture frames the ways in which we express ourselves [1] and how we interpret the actions of others. People from different nationalities and ethnic groups express themselves and understand the behaviors of others in different ways, which are informed by specific sets of cultural knowledge and conventions. Thus, cross-cultural misunderstandings occur which can lead to health, safety and environmental problems.

Therefore, a new approach to the management of health, safety and environment is required. Thus, it can be considered that the HSE problems that exist in construction are rarely unique to a single country and as the global community

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continues to shrink, it will benefit to share ideas and to learn from the lessons already experienced by others. Since, in the global market, construction problems are very similar from country to country and this is quite evident when attending international health, safety and environment conferences where the themes of primary interest have general appeal to all participants, construction health and safety problems appear to be everywhere. Consequently, health and safety can be improved by addressing construction problems in many different ways as it reflects the common threat that binds the global research efforts in construction safety. A variety of studies, for example [2] have investigated the construction health and safety within developed countries. In the majority of these studies, researchers have either developed a new framework model or replicated an already tested one with a view to improving its adequacy. However, there is a lack of research in this area in the context of developing countries with specific requirements.

The upstream oil and gas industry face risks ranging from volatile commodity prices, which are less linked to basic supply and demand but more to global socio-economic factors, to increased health, safety, and environmental pressures resulting from past and recent major accidents negatively impacting the environment, industry image and its social charter. However, risks related to asset damage, business interruption, pollution, injuries to people, and damage to properties are intrinsic in normal oil and gas activities. There are also additional risks of non-compliance and major cost overruns to the industry. Also, the stuxnet virus and the more recent cyber threat targeting oil and gas companies in the Middle East are just a few examples of the serious risk and threat that can impact the upstream oil and gas industry.

Operational risk is experienced at the cooperate level, but this study mainly focuses on what impacts everyday well, pipeline, and plant operations. The oil and gas industry is operating in increasingly remote geographical locations and harsher environmental conditions, with unconventional processes to extract hydrocarbons. In Ghana for instance, we have Tullow Oil, Kosmos Energy, Interoll, Lukoil, Hess and ENI, Arker Energy all operating in the Jubilee field.

Oil and gas industry operations occur in every corner of the globe, in a diverse range of habitats and ecosystems. These operations often place large pressures on the local environment and inhabitants, and as global population growth continues to rise, so too does the demand for useable energy and resources. Meeting the rising global energy demand comes with high risks and costs to both society and the environment. Oil and gas companies are thus faced with the challenge of meeting the world's expanding energy demands while minimizing the negative externalities associated with these operations. While there are both international and national regulations regarding best practices, many of the risks these corporations face are site specific, requiring detailed background research and precautionary measures that cannot be solved using a generalized framework. To address these concerns, there is an urgent need for Ghana to have a comprehensive HSE risk management policy for the operators of the Jubilee field to minimize harmful environmental impacts and incidents. By embedding environmental concerns into all aspects of daily operations, these multinational oil companies (MNOCs) can achieve socially beneficial outcomes, while avoiding potential disasters and more stringent legislation.

Including environmental proactivity is crucial because unsustainable business practices pose serious threats to the environment at both local and global levels. Oil production and the lack of adequate regulations on multinational companies have left indigenous communities further compromised due to environmental degradation [3]. There is devastation of the local economy as a result of the socio-economic and environmental disturbances from the oil industry. The social and environmental costs of oil production have been extensive. Wildlife and biodiversity have been destroyed, there has been loss of fertile soil and of clean air, and drinking water has been polluted. Furthermore, degradation of farmland and damage to aquatic ecosystems have occurred [4]. Risks are always present in oil and gas exploration because of the continuous exposure to both internal risk (exploration, production, contractual, financial, personal, stakeholders and operational risks) and external risks (environmental, social, political, economical, logistical, public and legal risks).

The paper is formulated in five sections. Section I details the background to the study. Section II covers the statement of the problem. In Section III review of related work is presented. Section IV describes the methodological approach used in the study. Section VI gives the conclusion.

II. STATEMENT OF THE PROBLEM

The recent discovery of oil and gas in commercial quantities in Ghana has resulted in high anticipation among Ghanaians of the prospects of massive makeover of the economy and a remarkable rise in the living standards particularly the people of the Western region of Ghana. However, there is very little discussion about the health, human safety and environmental risk management of the industry and how prepared Ghana is to manage these likely occurrences.

Accidents, disasters and occupational ill-health are global phenomena and occur at any time. Nonetheless, accidents in general and especially those with catastrophic impacts are not unpredictable or an 'Act of God'. Occupational hazards of the oil and gas workforce are of interest because oilfield occupations present high risks and little is known regarding chronic exposures and health effects faced by this workforce. Accidents occur principally from interaction between human, technological and organizational arrangement [5]. The identification of and preparedness for these accidents would either prevent their occurrence or mitigate the impact in the case that they do occur. The major stakeholders in Health, Safety and Environment (HSE) could be identified as (a) the state (b) the business/organization (c) employee(s) and (d) environment/society. So therefore, there are moral, legal and business implications to health, safety and environment practice. Consequently, a number of studies [6], [7], the UK's [8] have been conducted on health and safety in the oil and gas industrial sector.

Globally, several research studies have been conducted in different parts of the world prior to the year 2000 with respect to the economics of natural resource in developing countries.

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Some of the early authors include: [9] relative to Dutch disease; [10] in regard to paradox of plenty, and [11] in resource curse. Others such as the Movement for the Survival of Ogoni People (1992), Human Right Watch (1995), [12], [13], [14], [15]. [16] [17], and [18], have conducted studies on the politics of crude oil exploration and its impact on the environment and human rights.

Thus, from the beginning of early 2000, concerted efforts were made by social scientists and researchers all over the globe to proffer solutions to the oil crisis, which engulfed countries like Nigeria from the early 1990s. The majority of the researchers [19]; [20]; [21]; [22]; [23], etc., focused their studies on the political, economic and socio-cultural perspectives of the crisis. These researchers, however, tended to overlook the environmental impact aspect of the subject matter. To date, there is paucity of information on HSE risk management that focus on the subject matter holistically. It is this gap in literature that the present study seeks to fill.

III. REVIEW OF RELATED WORK

The purpose of this section is to review the related literature on health, safety and environmental (HSE) risk management in Ghana's upstream oil and gas industry. Generally, it has been noted that the literature on HSE risk management is extensive and a focused search was therefore necessary. In view of this, there are four issues that have been given attention in this section. The first part will concentrate on the conceptual background of the study which includes discussions on the concepts of hazard and risks and explanation of key terms in the topic. The main occupational health hazards confronting employees in upstream oil and gas industry is also discussed. The second section focuses on environmental risk management. The third section concentrates on the extent to which risks are managed in upstream oil and gas industry. The final section focuses mainly on the challenges confronting the management in the upstream oil and gas industry.

i. The Concepts of Hazard and risk in upstream oil and gas industry

Many experts have realized the need to distinguish between a hazard and a risk as the two terms are often confusing and certain activities such as oil exploration are often called high risk when they are high hazard. According to [25] hazard is the potential of a substance, activity or process to cause harm and it can take many forms including, for example, chemicals, electricity and poor working condition. 'Ref'[26] believed that poor working conditions can affect the environment workers live in, since the working and living environments are the same for many workers. This means that occupational hazards can have harmful effects on workers, their families, and other people in the community, as well as on the physical environment around the workplace. A classic example is the use of heavy machines in construction work. Workers can be exposed to dust and chemicals in a number of ways when spraying, clearing and applying bitumen, they can inhale the chemicals during and after spraying, the chemicals can be absorbed through the skin, and the workers can ingest the chemicals if they eat, drink, or smoke without first washing their hands, or if drinking water that has become contaminated with the chemicals. Reference [27] noted that workers' families can also be exposed in a number of ways: they can be exposed to residues which may be on the workers' clothes. Other people in the community can all be exposed in the same ways as well.

Explanation of key terms in HSE risk management

Accident: This is defined as occurrence of single or sequence of events that produce unintended loss.

Safety or Loss prevention: Prevention of hazards occurrence (accidents) through proper hazards identification and elimination.

Hazards: Chemical or physical condition that has potential to cause damage to people, property or environment.

Incident: Loss of contamination of material or energy. All incidents do not promulgate to accidents.

Consequence: It is a measure of expected effects of the results of an incident

Risk: Is the potential for realization of unwanted, negative consequences of an event [28]

Risk Analysis: This is quantitative estimate of risk using engineering evaluation and mathematical techniques. It involves estimation of hazards, their probability of occurrence and combination of both.

Hazards Analysis: This is the identification of undesired events that lead materialization of a hazard, analysis of the mechanism by which these undesired events could occur and the estimation of the extent, magnitude and likelihood of any harmful effects.

Environment: "The physical or natural surroundings made up of the land, water and air, as well as natural resources including plants, animals and minerals that make development possible." [29].

Health: The protection of the bodies and minds of people from illness resulting from the materials, processes or procedures used in the workplace [30].

Safety: The protection of people from physical injury. The borderline between health and safety is ill-defined and the two words are normally used together to indicate concern for the physical and mental well-being of the individual at the place of work [30].

ii. The main occupational health hazards confronting employees in upstream oil and gas industry

This section discusses the occupational health hazards confronting upstream oil and gas industry. The discussion draws on the extant literature to explain the common occupational hazards which include: physical, chemical, biological, ergonomic and psychological hazards [31]. These are discussed below.

Physical hazards

These are the occupational injuries often sustained by the employees and they are definitely a common occurrence among workers on oil rigs. Reference [32] classified the injuries according to the part of the body involved in the injuries. They recorded hand and finger and leg injuries.

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However, based on the analysis of data from 518 [32] identified a number of occupational injuries and diseases among the workers. Of the 518 workers examined, occupational injuries were most frequent among the oil drillers (223), their assistants and manual workers at the drilling floor, rotating drill under the tower and around drilling tubes. Then followed injuries in deck hands and engineers (192) and auxiliary personnel, catering (36) and specialized services staff (26). However, no injuries were recorded among the management personnel. They also found that nearly 80% (414) of ill and injured workers were those engaged in the direct work process. This means that only those who will be directly involved in the extraction of the crude oil and gas will suffer most of the injuries.

Biological hazards

Another hazard faced by employees in oil and gas industry is biological one. It is known that food-poisoning outbreaks are typical manifestations of biological hazards in the offshore workplace. They tend to occur more commonly in less developed areas, often related to poor hygiene associated with water dispensers, ice makers and ice cream machines. Also, galley space can be limited, so cold storage can be deficient. Airborne diseases can spread rapidly through ventilation systems on offshore installations because accommodation is pressurized and living space is usually at a premium [34]. Thus, occupational diseases are some of the hazards faced by employees. Using the 10th revision of International Classification of Diseases and Related Health Problems (ICD), [32] classified the occupational diseases suffered by the offshore workers and found that many of the workers suffered the following diseases: accidental poisoning, musculoskeletal disorders, respiratory disorders, diseases of digestive system, mental disorders, diseases of nervous system, skin disorders (such as skin cancer), diseases of genitor-urinary system, and diseases of circulatory system. They found accidental poisoning, musculoskeletal disorders, respiratory disorders and diseases of the digestive system to be the most occurring health problems for the workers on the oil rig. However, they reported that diseases of the circulatory system hardly occurred among the workers. Reference [32] attributed the low occurrence of cardiovascular diseases among workers on the oil rig to the relatively young age of the workers who were examined; their age ranged mostly from 20-50 years, and the majority of them were 25-35 years old. Those in older age were not many, and they were mostly employed in the management and were assigned to easier work. Reference [35] reported that the frequently reported psychosomatic problems among Norwegian offshore workers include headaches, stomach problems, and muscular tensions.

Similarly, data collected by [36] show that in the manufacturing sector including petroleum and plastics, workers suffer diseases including noise-induced hearing loss, asthmatic attacks, skin diseases and irritation, cancers, musculoskeletal disorders (general body pains, back and joint pains), and respiratory diseases. Put together, this means that Ghanaians who are going to work on the oil rigs are more likely to suffer food poisoning due to handling of crude oil, musculoskeletal disorders, respiratory disorders (such as and digestive system disorders such as ulcers. The musculoskeletal disorders are known to be the result of awkward work posture, vibration, cold temperatures, repetitions, and quick motions which are all common occurrences in the work process of oil drilling.

Psychological hazard

Psychological hazards are different from other occupational hazards (e.g. noise and chemicals) because the level of stress within an organization from which employees go through varies both rapidly and significantly over time. The various stressors that are common to the offshore environment that require special attention include: work overload, lack of job clarity and frequent change. Also relevant are prolonged periods of limited interaction with people (phone, Internet, etc.), poor leisure activities, limited sleep quality and quantity (as a result of shift patterns and noise). The increased use of higher risk methods of transport (e.g. helicopters) can also increase perceived levels of stress [37]

Consequently, there have been lack of satisfaction with life as a whole and with different aspects of life (e.g., work, family, community, and health), the absence of positive affect (the experience of unpleasant emotions such as joy, contentment, happiness, pride and guilt, sadness, anxiety and depression, [38] cited in [39]. Though the absence of ill-health is not indicative of good psychological wellbeing, psychologists tend to use measures of stress, burnout, anxiety, and depression (mood swings), job satisfaction, and sleep as indicators of psychological wellbeing; [40] [41].

In the review of literature on offshore workers published prior to 1996, Parkes (2002: 3–4) reported, among the key findings, that offshore workers tend to display higher levels of generalized anxiety disorders than comparable onshore employees. She reported that the offshore environment was associated with poorer psychological wellbeing. For instance, she found that installation characteristics (such as age, location, size, and type), physical environment (such as noise, ventilation, and illumination), and psychosocial factors (such as time pressures, workload, job insecurity, and perceived risks) all affected the psychological wellbeing of the offshore workers, with unfavorable conditions being associated with lower levels of psychological wellbeing. She also reported that circadian changes inherent in day/night shift rotation have adverse implications for sleep, performance and health. In short, [40] found that offshore workers tend to suffer stress, burnout, anxiety, depression, low job satisfaction, and sleep disorders. Similarly, [42] found in a study of 125 workers in a Croatian oil company that the workers find many aspects of their work stressful. For instance, compared with the laboratory workers and office workers, oil field workers found the work overload, overtime work, shift-work, night shifts, time on duty, working without co-workers, unpredictable conditions at sea, presence of fire and chemical hazards to be stressful. The conditions at sea represent a threat which is a common cause of stress, particularly the risk of harm caused by working in unsafe conditions.

The importance of psychological wellbeing in the oil and gas sector and in any other organization setting lies in its linkage with employee performance, accidents, and diseases. For instance, there is empirical evidence that many disorders and diseases are stress-related; these diseases and disorders

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range from musculoskeletal, cardiovascular, and endocrinological diseases, psychological and emotional disorders, a series of psychosomatic diseases, infectious diseases, and finally carcinoma (cancer affecting the tissue the lines the skin and the internal organs) [43]; [44]; [45]. Reference [46] have also documented evidence about the association between psychosocial stressors and musculoskeletal pains among Chinese offshore oil installation workers; they found that stress from safety, physical environment, and ergonomics were important predictors of musculoskeletal pains. In addition, [47] reported that stress at work can impact safety negatively and increase chances for occupational injury among workers working on oil platforms. This is because mood affects risk perceptions by workers. The link between risk perception and occupational injury and diseases is such that faulty risk perception leads to error which in turn leads to risk exposure. The risk exposure can lead to the accident or incident with or without unsafe acts. In a more recent review of the literature, Parkes (2010) reported that work-related stressors (including odd working hours) offshore are shown to be associated with physical and psychological health problems among offshore workers of operations in the upstream oil and gas sector (National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling, January 2011).

Chemical hazards

Chemical hazard has also been one of the hazards some years now. For example, the composition of drilling 'mud' had considerable toxicity for both the humans and the environment. Other potential toxic and suspected carcinogenic agents or mixtures exist, such as mineral oil mist and vapor, asbestos fibers, formaldehyde, tetrachloroethylene, welding/cutting fumes, acids, coatings, etc. [48]. Many epidemiological studies of workers in the oil and gas industry have been conducted to help address whether there is an excess of mortality from cancers. The vast majority of these have been limited to oil refinery workers (i.e. 'downstream'). Only four cohort studies [49]; [50]; [51], and one case–control study [50] have studied the oil and gas exploration and production segment of the industry (i.e. 'upstream'). The weight of the evidence, based on the results of these studies, is suggestive of an increased risk of mortality from leukemia among upstream petroleum workers, who started working before 1940 and who had a long duration of employment (over 30 years). Reference [31] came to a similar conclusion. An increased incidence of haematopoietic cancers, especially acute myeloid leukemia (AML) and multiple myeloma, has been found among Norwegian offshore operators. However, the possible causes are not clear at this time and require further study. It is possible that some nonoccupational factors, such as smoking or exposure to radiation arising from industrial or natural sources not associated with employment, could play a role. The conclusion drawn by the Norwegian investigators that the increased incidence of AML was most probably associated with benzene exposure was speculative and not substantiated by the evidence.

Upstream petroleum workers exposure levels to benzene, toluene, xylene and ethylbenzene, based on personal air monitoring data, are generally regarded as low during regular activities. Higher exposures, usually less than a full shift duration, may be encountered during maintenance tasks (e.g. when containment is broken or vessels need to be entered for cleaning). There has also been speculation that dermal exposures during early years of operations could be high, but such exposure has not been routinely assessed.

Ergonomic hazards

'Ergonomic hazards' generally refers to health problems due to the interaction between the following: (i) the postures people are forced to adopt to reach, act on or operate the objects and equipment they work with and (ii) the nature and time history of the application of force on those objects [49]. Ergonomic health issues are usually associated with the musculoskeletal system and principally the upper limbs, neck and lower back. They can also be associated with impaired visual function arising from working on visually demanding tasks over extended durations with inappropriate task lighting. The critical factor that identifies a health issue as being 'ergonomic' is that the injury arises because the way the environment and equipment are arranged requires people to adopt postures, movements, apply force and read material in conditions that are potentially damaging to health in order to complete what is expected of them in the normal course of their work.

In summary, it can be said that Workers in Oil and Gas industry are generally susceptible to following agents which lead to various health and Illnesses hazards: chemical hazards (toxic, corrosive, carcinogens, asphyxiates, irritant and sensitizing substances); physical hazards (noise, vibration, radiations, extreme temperature); biological hazards (virus, parasites, bacteria); ergonomic hazards (manual handling activities, repetitive motions, awkward postures); and psychosocial hazards (overwork, odd working hours, isolated sites, violence).

iii. Environmental risk management

The management of HSE risks in oil and gas environment is not an easy task according to [52]. There are various challenges confronted in the path of implementation of safety culture in the working environment of oil and gas industry. It is an undeniable fact that exploration and exploitation of oil and gas resources does not only have economic implications for a country, but also comes with major challenges. This section presents some of these challenges with oil and gas discovery with regards to the environment. The exploration and production industry in any country is accompanied by many environmental challenges such as, seismic acquisition, drilling and occupational hazards, development, production, transportation and atmospheric emission are of great challenges to the environment.

iv. Key challenges to environmental risk management

Oil and gas companies must incorporate environmental concerns into daily operations because external sources have not proven to be effective in changing corporate environmental risk valuation procedures. Over the years, international frameworks, declarations, and treaties have been

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developed to combat the challenges associated with protecting the environment. Unfortunately, these international agreements have not proven to be an effective method to compel large oil and gas companies to manage their environmental impact. This is primarily due to the fact that the frameworks and treaties are not accepted and subsequently adopted by all countries. The Earth Summit UNCSD Conference held in Rio in 2012 brought together a large international audience to discuss green economies and the implementation of sustainable development [53]. Without a 100 percent participation rate, agreements made at these international meetings are not strong enough to combat these global environmental issues. Similar challenges arose with the Kyoto Protocol, which was intended to cap emissions through binding reduction targets [54]. Although many international players supported the protocol, several large countries, including the United States and Canada, were unwilling to accept and adopt it. The lack of unanimous voluntary participation for numerous international regulations has created gaps that minimize the effectiveness of the legislation. Discussions and revisions of programs such as the United Nations Environment Programme (UNEP) indicate there is an international agreement over the importance of addressing these environmental issues [53]. However, the lack of compliance and enforcement by all countries implies that international protocols and conferences are not sufficient enough in addressing these environmental challenges.

IV. RESEARCH METHOD

The study adopted the quantitative research method as its primary approach to collecting and analyzing data. This approach was used because according to [55], quantitative research approach is a type of research approach in which quantitative techniques in the form of descriptive and inferential statistics are used to describe issues study. Also, the approach was used based on the aim of having objective answers to the research questions and to help the researcher to remain unbiased and independent of what is being researched. In addition, such an approach helps the values of the researcher not to interfere with, or become part of, the research. Finally, such method can help measure variables with numbers, and analyze the issues using statistical techniques. In this way, the method can help minimize the problem associated with the generalizations of the study outcome since the views are more objective than being subjective. However, the use of this research approach requires a lot of scientific cautions and principles which when violated could distort findings [56].

V. CONCLUSION

Based on the study main research questions, it can be said that the main aim of the study has been achieved. The findings indicate that there are hazards in the oil and gas industry, the employees are aware of these health hazards, there is real commitment on the part of the management in solving the problem although there are a number of challenges involved. In view of some of these findings, it can be seen that while the oil and gas industry is very important, the risks that confront their authorities cannot be over-emphasized. Implicitly, these findings have significant health implications as they raise certain questions. One of such questions is whether the risk profile of exposure to health hazards in offshore oil and gas operations is likely to change in the future. In the absence of hard evidence to the contrary, from the point of view of the writer, perhaps the most credible assumption is that the move into an era of difficult oil will tend to increase the challenges facing health management for workers in the industry. The need to explore and produce oil and gas in increasingly remote and challenging geographical areas, to deal with ‘unconventionals’ such as the oil sands, to process raw products with high sulphide content, the need to be able to operate in increasingly deep waters and to drill to even greater depths, all potentially bring increases in the associated health risks.

Another question is whether technologies alone can help solve the problem. On this issue, there seems to be little reason to be confident that new technologies alone, or existing engineering design and production techniques, will be any more successful at reducing health risk per unit of time and money

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