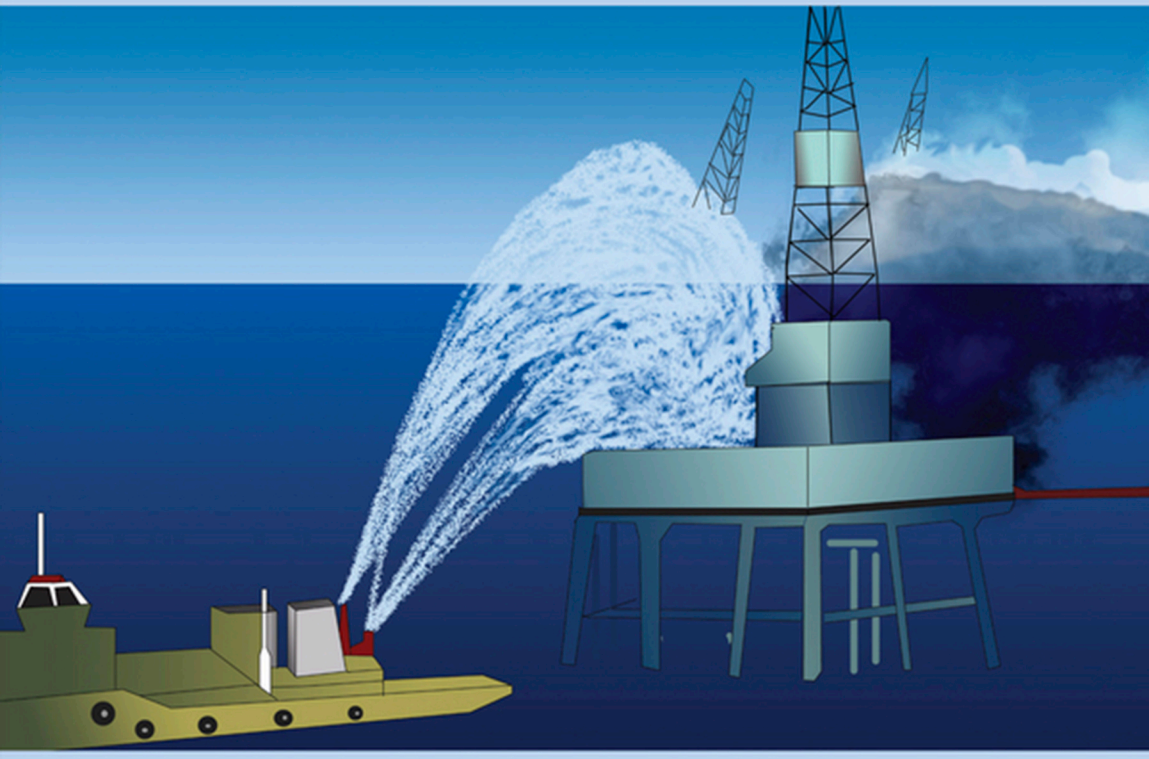

HEALTH, SAFETY, AND ENVIRONMENTAL MANAGEMENT IN OFFSHORE AND PETROLEUM ENGINEERING

Srinivasan Chandrasekaran

with website

WILEY

Health, Safety, and Environmental Management in Offshore and Petroleum Engineering

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India

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Preface

The regulations of risks to health, safety, and environmental management that arise from the exploration and production works in the oil and gas industries are gaining more attention in the recent past. There is a growing necessity to maintain good and healthy work-space for people on board and also to protect the fragile ecosystem. The unregulated use of chemicals or other hazardous substances in oil and gas industries can challenge the technical workforce by putting their health at risk, causing various levels of discomfort in addition to causing catastrophic damage to the offshore assets. Accidents reported in the recent past in oil and gas sector also demonstrate the seriousness of Health, Safety, and Environmental Management in this domain of workspace. The objective of the book is to share the technical know-how in the field of health, safety, and environmental management, applicable to oil and gas industries. Contents of the book are spread across four chapters, addressing the vital areas of interest in HSE, as applicable to offshore and petroleum engineering. The first chapter highlights safety assurance and assessment, emphasizing the need for safety. The second chapter focuses on the environmental issues and management that arise from oil and gas exploration. The third chapter deals with the accident modeling, risk assessment, and management, while the fourth chapter is focused on safety measures in design and operations. The book explains the concepts in HSE through a simple and straightforward approach, which makes it comfortable for practicing engineers as well. The focus however is capacity building in safety and risk assessment, which is achieved through a variety of example problems and case studies. The author's experiences in both the academia and leading oil and gas industries are shared through the illustrated case studies. The book is an important milestone in the capacity building of young engineers and preparing them for a safe exploration process. Sincere thanks are due to Centre for Continuing Education, IIT Madras for assisting in writing this book.

Srinivasan Chandrasekaran

About the Author

Professor Srinivasan Chandrasekaran is a Professor in the Department of Ocean Engineering, Indian Institute of Technology, Madras, India. He has teaching, research, and industrial experience of about 24 years during which he has supervised many sponsored research projects and offshore consultancy assignments both in India and abroad. His active areas of research include dynamic analysis and design of offshore platforms, development of geometric forms of compliant offshore structures for ultra-deep water oil exploration and production, structural health monitoring of ocean structures, seismic analysis, and design of structures and risk analyses and reliability studies of offshore and petroleum engineering plants. He was a visiting fellow under the invitation of Ministry of Italian University Research to University of Naples Federico II, Italy, for a period of 2 years during which he conducted research on advanced nonlinear modeling and analysis of structures under different environmental loads with experimental verifications. He has published about 140 research papers in international journals and refereed conferences organized by professional societies around the world. He has authored five textbooks, which are quite popular among the graduate students of civil and ocean engineering: *Seismic Design Aids for Nonlinear Analysis of Reinforced Concrete Structures* (ISBN: 978-1-4398-0914-3); *Analysis and Design of Offshore Structures with Illustrated Examples* (ISBN: 978-89-963915-5-5); *Advanced Theory on Offshore Plant FEED Engineering* (ISBN: 978-89-969792-8-9); *Dynamic Analysis and Design of Offshore Structures* (ISBN: 978-81-322-2276-7); *Advanced Marine Structures* (ISBN: 978-14-987-3968-9). His books are also recommended as reference material in many universities in India and abroad.

He also conducted two online courses under Mass Open Online Courses (MOOC) under NPTEL, GoI titled Dynamic analysis of offshore structures and HSE in oil offshore and petroleum industries. He is a member of many national and international professional bodies and has delivered many invited lectures and keynote addresses in the international conferences, workshops, and seminars organized in India and abroad. He has also delivered four web-based courses:

- Dynamic Analysis of Ocean Structures (http://nptel.ac.in/courses/114106036/)
- Ocean Structures and Materials (http://nptel.ac.in/courses/114106035/)
- Advanced Marine Structures (http://nptel.ac.in/courses/114106037/)
- Health, Safety and Management in Offshore and Petroleum Engineering (http://nptel.ac.in/courses/114106017/)

under the auspices of National Program on Technology Enhancement Learning (NPTEL), Government of India.

1

Safety Assurance and Assessment

Introduction to Safety, Health, and Environment Management

Health, Safety, and Environmental (HSE) management is an integral part of any business and is considered to be extremely essential when it comes to managing business in oil and gas sectors. HSE requirements are generally laid out considering the expectations of the divisional compliance with that of the standard policies. This is the most important part of HSE through legislation in the recent decades and thus forms the basis of HSE regulations in the present era. Apart from setting out the general duties and responsibilities of the employers and others, it also lays the foundation for subsequent legislation, regulations, and enforcement regimes. HSE standards are circumscribed around activities that are "reasonably practicable" to assure safety of the employees and assets as well. HSE regulations impose general duties on employers for facilitating the employees with minimum health and safety norms and members of the public; general duties on employees for their own health and safety and that of other employees, which are insisted as regulations.

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1.1 Importance of Safety

There are risks associated with every kind of work and workplace in day-to-day life. Levels of risk involved in some industries may be higher or lower due to the consequences involved. These consequences affect the industry as well as the society, which may create a negative impact on the market depending upon the level of risk involved (Ale, 2002). It is therefore very important to prevent death or injury to workers, general public, prevent physical and financial loss to the plant, prevent damage to the third party, and to the environment. Hence, rules and regulations for assuring safety are framed and strictly enforced in offshore and petroleum industries, which is considered to be one of the most hazardous industries (Arshad Ayub, 2011). The prime goal is to protect the public, property, and environment in which they work and live. It is a commitment for all industries and other stakeholders toward the interests of customers, employees, and others. One of the major objectives of the oil and gas industries is to carry out the intended operations without injuries or damage to equipment or the environment. Industries need to form rules, which will include all applicable laws and relevant industry standards of practice. Industries need to continuously evaluate the HSE aspects of equipment and services. It is important for oil and gas industries to believe that effective HSE management will ensure a good business. Continuous improvement in HSE management practices will yield good return in the business apart from ensuring goodness of the employees (Bottelberghs, 2000). From the top management through the entry level, every employee should feel responsible and accountable for HSE. Industries need to be committed to the integration of HSE objectives into management systems at all levels. This will not only enhance the business, but also increase the success rate by reducing risk and adding value to the customer services.

1.2 Basic Terminologies in HSE

ALARP: To reduce a risk to a level 'as low as reasonably practical' (ALARP). It involves balancing reduction in risk against time, trouble, difficulty, and cost of achieving it. Cost of further reduction measures become unreasonably disproportionate to the additional risk reduction obtained.

Audit: A systematic, independent evaluation to determine whether or not the HSE-MS and its operations comply with planned arrangements. It also examines whether system is implemented effectively and is suitable to fulfill the company's HSE policies and objectives.

Client: A company that issues a contract to a contractor or subcontractor. In this document the client will generally be an oil and gas exploration company that will issue a contract to a contractor to carry out the work. The contractor may then take the role of a client by issuing contract(s) to subcontractor(s).

Contract(*s*): An agreement between two parties in which both are bound by law and which can therefore be enforced in a court or other equivalent forum.

Contractor(*s*): An individual or a company carrying out work under a written or verbally agreed contract for a client.

Hazard: An object, physical effect, or condition with the potential to harm people, the environment, or property.

HSE: Health, safety, and environment. This is a set of guidelines, in which security and social responsibilities are recognized as integral elements of HSE management system.

HSE capability assessment: A method of screening potential contractors to establish that they have the necessary experience and capability to undertake the assigned work in a responsible manner while knowing how to effectively deal with the associated risks.

HSE Plan: Is a definitive plan, including any interface topics, which sets out the complete system of HSE management for a particular contract.

Incident: An event or chain of events that has caused or could have caused injury or illness to people and/or damage (loss) to the environment, assets, or third parties. It includes near-miss events also.

Inspection: A system of checking that an operating system is in place and is working satisfactorily. Usually this is conducted by a manager and with the aid of a prepared checklists. It is important to note that this is not the same as an audit.

Interface: A documented identification of relevant gaps (including roles, responsibilities, and actions) in the different HSE-MS of the participating parties in a contract, which, when added to the HSE plan will combine to provide an operating system to manage all HSE aspects encountered in the contract with maximum efficiency and effectiveness.

Leading indicator: A measure that, if adopted, helps to improve performance.

Subcontractor(*s*): An individual or company performing some of the work within a contract, and under contract to either the original client or contractor.

Third party: Individuals, groups of people, or companies, other than the principal contracted parties, that may be affected by or involved with the contract.

Toolbox meeting: A meeting held by the workforce at the workplace to discuss HSE hazards that may be encountered during work and the procedures that are in place to successfully manage these hazards. Usually this is held at the start of the day's work; a process of continual awareness and improvement.

Accident: It refers to the occurrence of single or sequence of events that produce unintended loss. It refers to the occurrence of events only and not the magnitude of events.

Safety or loss Prevention: It is the prevention of hazard occurrence (accidents) through proper hazard identification, assessment, and elimination.

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

Risk: It is the measure of the magnitude of damage along with its probability of occurrence. In other words, it is the product of the chance that a specific undesired event will occur and the severity of the consequences of the event.

Risk analysis: It is the quantitative estimate of risk using engineering evaluation and mathematical techniques. It involves estimation of hazard, their probability of occurrence, and a combination of both.

Hazard analysis: It is the identification of undesired events that lead to materialization of a hazard. It includes analysis of the mechanisms by which these undesired events could occur and estimation of the extent, magnitude, and likelihood of any harmful effects.

Safety program: Good program identifies and eliminates existing safety hazards. Outstanding program prevents the existence of a hazard in the first place. Ingredients of a safety program are safety knowledge, safety experience, technical competence, safety management support, and commitment to safety.

Initial response from HSE: There are two sets of regimes namely: (i) goal- setting regimes; and (ii) rule- based regimes. *Goal-setting regimes* have a duty holder who assesses the risk. They should demonstrate its understanding and controls the management, technical, and systems issues. They should keep pace with new knowledge and should give an opportunity for workforce involvement. *Rule-based regimes* consist of a legislator who sets the rules. They emphasizes compliance rather than outcomes. The disadvantage is that they it are slow to respond. They gives less emphasis on continuous improvement and less work force involvement.

1.2.1 What Is Safety?

Safety is a healthy activity of prevention from being exposed to hazardous situation. By remaining safe, the disastrous consequences are avoided, thereby saving the life of human and plant in the industry.

1.2.2 Why Is Safety Important?

Any living creature around the world prefers to be safe rather than risk themselves to unfavorable conditions. The term safety is always associated with risk. When the chances of risks are higher then the situation is said to be highly unsafe. Therefore, risk has to be assessed and eliminated and safety has to be assured.

1.3 Importance of Safety in Offshore and Petroleum Industries

Safety assurance is important in offshore and petroleum industries as they are highly prone to hazardous situations. Two good reasons for practicing safety are: (i) investment in an offshore industry is several times higher than that of any other process/production industry across the world and (ii) offshore platform designs are very complex and innovative and hence it is not easy to reconstruct the design if any damage occurs (Bhattacharyya et al., 2010a, b). Prior to analyzing the importance of safety in offshore industries, one should understand the key issues in petroleum processing and production. Safety can be ensured by identifying and assessing the hazards in each and every stages of operation. Identification and assessment of hazard at every stages of operation are vital for monitoring safety, both in quantitative and qualitative terms. Prime importance of safety is to ensure prevention of death or injury to workers in the plant and also to the public located around. Safety should also be checked in terms of financial damage to the plant as investment is huge in oil and petroleum industries than any other industry. Safety must be ensured in such a way that the surrounding atmosphere is not contaminated (Brazier and Greenwood, 1998).

Piper Alpha suffered an explosion on July 1988, which is still regarded as one of the worst offshore oil disasters in the history of the United Kingdom (Figure 1.1). About 165 persons lost their lives along with 220 crew members. The accident is attributed mainly due to a human error and is a major eye-opener for the offshore industry to revisit safety issues. Estimation of property damage is about $1.4 billion. It is understood that the accident was

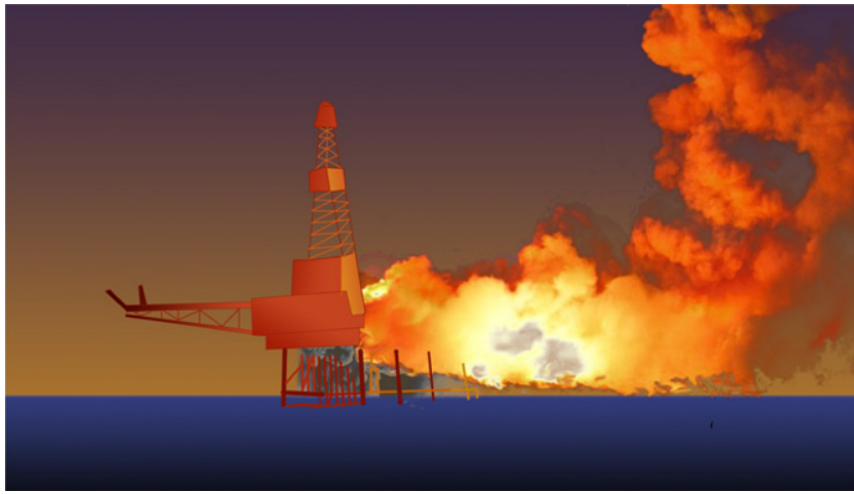

Figure 1.1 Piper Alpha disaster

mainly caused by negligence. Maintenance work was simultaneously carried out in one of the high-pressure condensate pumps' safety valve, which led to the leak of condensates and that resulted in the accident. After the removal of one of the gas condensate pumps' pressure safety valve for maintenance, the condensate pipe remained temporarily sealed with a blind flange as the work was not completed during the day shift. The night crew, who were unaware of the maintenance work being carried out in the last shift on one of the pumps, turned on the alternate pump. Following this, the blind flange, including firewalls, failed to handle the pressure, leading to several explosions. Intensified fire exploded due to the failure in closing the flow of gas from the Tartan Platform. Automatic fire fighting system remained inactive since divers worked underwater before the incident. One could therefore infer that the source of this devastating incident was due to a human error and lack of training in shift-handovers. Post this incident, significant (and stringent) changes were brought in the offshore industry with regard to safety management, regulation, and training (Kiran, 2014).

On March 23, 1989, Exxon Valdez, which was on its way from Valdez, Alaska, with a cargo of 180 000 tons of crude oil collided with an iceberg and 11 cargo tanks, got punctured. Within a few hours 19 000 tons of crude oil was lost. By the time the tanker was refloated on April 5, 1989, about 37 000 tons was lost. In addition, about 6600 km^2 of the country's greatest fishing grounds and the surrounding shoreline were sheathed in oil. The size of the

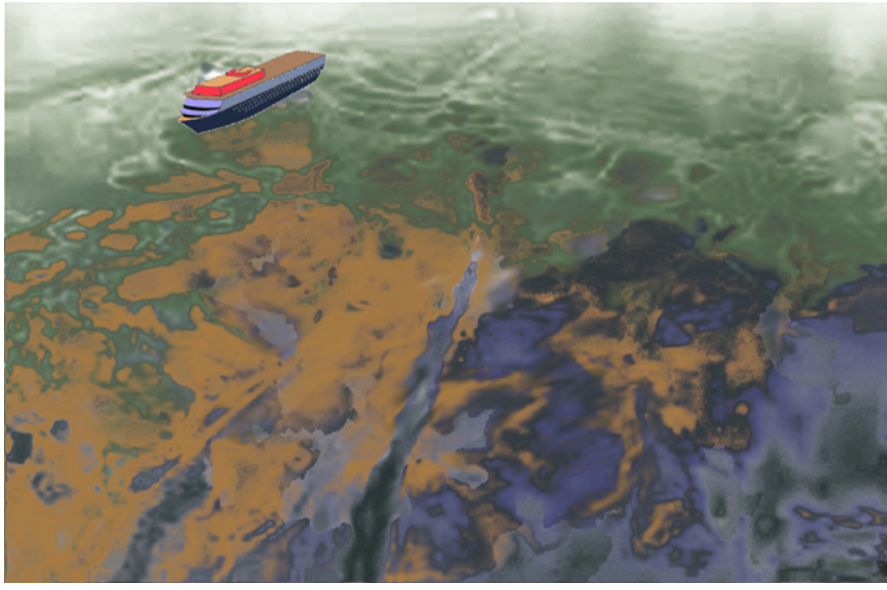

Figure 1.2 Exxon Valdez oil spill

spill and its remote location made it difficult for the government and industry to salvage the situation. This spill was about 20% of the 18 000 tons of crude oil, which the vessel was carrying when it struck the reef (Figure 1.2).

Safety plays a very important role in the offshore industry. Safety can be achieved by adopting and implementing control methods such as regular monitoring of temperature and pressure inside the plant, by means of well-equipped coolant system, proper functioning of check valves and vent outs, effective casing or shielding of the system and check for oil spillages into the water bodies, by thoroughly ensuring proper control facilities one can avoid or minimize the hazardous environment in the offshore industry (Chandrasekaran, 2011a, b).

1.4 Objectives of HSE

The overall objective is to describe a process by which clients can select suitable contractors and award contracts with a view to improving the client and contractor management on HSE performance in upstream activities. For brevity, security, and social responsibilities have not been included in the document title; however, they are recognized as integral elements of the

HSE-management systems. Active and ongoing participation by the client, contractor, and their subcontractors are essential to achieve the goal of effective HSE management. While each has a distinct role to play in ensuring the ongoing safety of all involved, there is an opportunity to further enhance the client–contractor relationship by clearly defining roles and responsibilities, establishing attainable objectives, and maintaining communication throughout the contract lifecycle. The aims of HSE practice are to improve performance by:

- Providing an effective management of HSE in a contract environment, so that both the client and the contractor can devote their resources to improve HSE performance.
- Facilitating the interface of the contractor's activities with those of the client, other contractors, and subcontractors so that HSE becomes an integrated activity of all facets of process.

These guidelines are generally formulated and provided to assist clients, contractors, and subcontractors to clarify the process of managing HSE in contract operations (Chandrasekaran, 2014a, b). This generated document does not replace the necessary professional judgment needed to recommend the specific contracting strategy to be followed. Each reader should analyze his or her particular situation and then modify the information provided in this document to meet their specific needs to obtain appropriate technical support wherever required. Oil and Gas Production Secretariat is the custodian of these guidelines and will initiate updates and modifications based upon review and feedback from users through periodic meetings. In general, these guidelines are not intended to take precedence over a host country's legal or other requirements (Chandrasekaran, 2011e).

1.5 Scope of HSE Guidelines

HSE guidelines provide a framework for developing and managing contracts in offshore industry. While HSE aspects are important in the development of a contract strategy, these guidelines do not cover many vital aspects of the contract process. They prescribe various phases of the contracting process and associated responsibilities of the client, contractors, and subcontractors. It begins with planning and ends with evaluation of the contract process.