The accelerated growth of the world population and their living standard also includes the growth of energy needs. New developments in knowledge and technology change the prediction of Hubbert’s oil peak curve philosophy in the direction of much higher hydrocarbon reserves that can be exploited. These reserves are spread all over the world, but the largest reserves are concentrated in several areas that correspond with the known spacing of the source rocks (Middle East, Northern and Central Africa, Siberia-Russia, North Sea, Alaska, Central USA, Gulf of Mexico, South America, Indonesia, China, etc.). The estimated quantity of oil which engineering and economic data demonstrate that is recoverable with reasonable certainty, under existing economic and operating conditions, has been estimated about 1.27·10^{12} barrels (202·10^{9} m^3) in 2003, and 1.39·10^{12} barrels (216·10^{9} m^3) in 2011, but the different estimations are going up to 3.9·10^{12} barrels (620·10^{9} m^3). At the same time, the gas reserves are estimated to be 6.4·10^{15} ft^3 (1.8·10^{14} m^3).

Such growing demands demand new paths for supply from the layer/deposit to the users. The supply path starts with the well (that exists or must be drilled) and continues with completion, production, gathering, and transportation to the storage systems. All of that can be a potential source of hazard for people and the environment.

The Macondo disaster, the last known worldwide oil spill, is only the fourth of the world’s largest oil spills. The first, the Gulf War oil spill in Kuwait (11·10^6 barrels; 1.75·10^6 m^3), was the result of the destruction of thousands of wellheads that prevented blowout and controlled production from the well when functioning correctly. Several others on the list were the result of blowouts, starting with the first one, Shaw Gusher (Canada, 1862), and the Lucas Gusher (USA, 1901). Qom Wildcat Gusher (Iran, 1956) was the largest one with a spill of about 10.8·10^6 barrels (1.71·10^6 m^3) of oil.

The second largest oil spills are the result of tanker disasters. The biggest was the Atlantic Empress (West Indies, 1979), with 2.1·10^6 bbl (0.33·10^6 m^3) of oil spilled. Several other large tanker disasters are known, but the most publicity was given to Exxon Valdez (Alaska, 1989) with “only” 260,000 barrels (41,340 m^3) of oil spilled.

When talking about petroleum transport, it is mainly through the pipelines. The leakages of such systems are usually not visible because they are buried in the ground. In some areas (Africa), human greediness or poverty can result in tragedies, when the stealing of oil from the pipeline finishes with explosion or fire.
As the last point of the pathway is the storage system, which can differ in volume. They have to store all the produced hydrocarbons before the final use. Statistically, it is possible that some or many of them could catch fire, but much more of them can leak.

All of that shows that the path of the oil or gas from the layer/deposit to the user can seriously endanger people and the environment.

The essential part of the book will be the engineering analysis of potential hazards and risk assessment in three areas: (1) drilling, (2) completion, production, workover, and formation treatments, and (3) gathering, transportation, and storage of hydrocarbons. In addition, the sources and triggers of the hazards are determined, and remedial or controlling actions elaborated.

The aim of the book is to point out the potential risk of any of those three segments of petroleum engineering activities. The risk assessment and the designing and working approach in direction of avoiding accidents are elaborated.

The book gives a short introduction to the problem with the approach to risk analysis in chapter 1. Explanation of basic terms, their interdependence, dilemmas, and methods of risk analysis are introduced. Each method is shortly described with main anteriority and shortcomings. The impact, occurrence, and the consequences are at the end compared to the risk acceptance criteria concept. The ALARP (As Low as Reasonably Practicable) framework is explained with some observation on the quality and acceptance in petroleum industry. Finally, the human impact on the risk and consequences is analyzed.

Wellbore instability problems are usually related to drilling operation, but they can also appear during completion, workover, or the production stage of certain wells. Chapter 2 gives one general overview of wellbore instability problems and their causes as well as an overview of actual approaches and methods in wellbore stability and risk assessment.

A stuck pipe is a common worldwide drilling problem in terms of time and financial cost. It causes significant increases in non-productive time and losses of millions of dollars each year in the petroleum industry. Stuck pipe risk could be minimized by using available methodologies for stuck pipe prediction and avoiding based on available drilling parameters as is stated in chapter 3.

In chapter 4, lost circulation is defined as the uncontrolled flow of mud into a thief zone and presents one of the major risks associated with drilling. Successful management of lost circulation should include identification of potential loss zones, optimization of drilling hydraulics, and remedial measures when lost circulation occurs.

Simultaneous operations as given in chapter 5 are to be coordinated through joint planning efforts by production, workover/completion, drilling and construction supervisors, and/or engineers, who plan and direct activities. Typical chain-of-command as well as simultaneous operations decision making process flow diagrams are presented in this chapter. In general, they have an impact on the installation safety procedures and contingency planning program. Once the simultaneous operations have been identified, there are basic steps to be regarded: performing risk assessment, assess and control risks, monitor the simultaneous tasks, and communicate the control measures.
After the accident on the Deepwater Horizon platform, while drilling the Macondo 252 well in the Gulf of Mexico in 2010, several commissions, investigation groups, advisory committees, and company reports have been prepared. The author’s approach is presented in chapter 6.

Well completion is defined as the optimal path for the reservoir fluids to be produced. The reliability of system components is essential for long lasting production. In addition, the differences according to natural flowing well risk and artificial lift are given. Nowadays, so called “intelligent completions” appear to give more financial benefits, flexibility, and control, but also a new range of risks, as explained in chapter 7.

Irreducible casing pressure, also termed Sustained Casing Pressure (SCP), is hazardous for a safe operation, and the affected wells cannot be terminated without remedial operations. In chapter 8, physical mechanisms of irreducible casing pressure and qualification of the associated risk by showing statistical data from the Gulf of Mexico and discussing the regulatory approach are introduced, with new approach to evaluate the risk of casing pressure by computing a probable rate of atmospheric emissions from wells with failed casing heads resulting from excessive pressure.

Chapter 9 is focused on the risk to the environment from hydraulic fracturing operations. Although many well development problems are blamed on fracturing, there are only excluded problems that are real and worthy of the discussion to help define boundaries of the fracturing risk. The initial assumption for the fracturing risk analysis is that the well is new and was constructed correctly so that all producible formations are securely isolated behind the barriers of casing and competent cement.

Workover risk and anomalies may be caused by erosion, corrosion, mechanical errors, and temperature effects on electronics, wear and tear on the dynamic seals, or seizure of moving components. Obviously, the simpler the system and the fewer moving parts, the fewer components are available to fail. The right approach and operating system selection is essential, as shown in chapter 10.

Gathering system as defined in chapter 11, include one or more segments of pipeline, usually interconnected to form a network that transports oil and natural gas from the production wells to one or more production facilities as well as from production facility to the inlet of a gas processing plant, storage facility, or a shipping point. Complexity of the processing facility depends on the treated fluid composition. Environmental impact during the oil and gas transportation and processing phase will cause long-term habitat changes. Such impact would also occur when surface facilities are removed after their useful life in a process of decommissioning. To avoid or minimize the environmental impact of gathering systems and surface facilities, it is very important to implement appropriate activities across the various phases: designing phase, construction, operational, and decommissioning phase.

Formal risk assessments are necessary at various phases of the asset life cycle as they help personnel identify, evaluate, and control hazards that could result in loss of life, injury, pollution, property damage, or business disruption. Hazard evaluations of production development concepts or facility design are well-defined processes, for which much literature is available as guidance. Such evaluations are mandated in some jurisdictions for project regulatory approval. Chapter 12 provides guidance on activity implementation from the designing phase, construction phase, operational phase, and decommissioning phase of gathering and processing systems.
Petroleum and natural gas must be moved from the production site to refineries or to users. These movements are made by using a number of different modes of transportation. Petroleum is transported across the water in barges and tankers. On land, petroleum is moved using pipelines, trucks, and trains. Natural gas is moved, mainly, by pipelines. Most of the time petroleum and natural gas are transported quietly and safely. However, accidents do occur. Chapter 13 describes the causes of incidents during oil and gas transportation both on land and across water.

Chapter 14 illustrates different types of crude oil and oil product storage tanks as well as the risks regarding the storage itself. Considering that the natural gas, in its gaseous state, is stored in underground storages like oil and gas depleted reservoirs, aquifers or salt caverns, and there are numerous publications and books covering the subject in detail, this chapter will only illustrate the storage of liquefied natural gas and the risks posed by its storage.

Geologic storage as the component of Carbon Capture and Storage (CCS) is elaborated in chapter 15. For the purposes of risk assessment, a priority is to evaluate what would happen if CO$_2$ migrated unexpectedly through the confining unit(s), potentially resulting in undesirable impacts on a variety of potential receptors. One of the main risks identified in geological CO$_2$ storage is the potential for CO$_2$ leakage through or along wells. To avoid leakage from the injection wells, the integrity of the wells must be maintained during the injection period and for as long as free CO$_2$ exists in the injection zone.

In chapter 16, the petroleum industry’s environmental incident history and statistics are presented. In addition, the environmental impact of the petroleum industry’s activities, its extent, and trends is analyzed. The overview of pollution sources with associated environmental risk is given along with the analysis of the causes and consequences of incidents in the petroleum industry. The impact on live organisms, soil, water, and air are discussed in general.

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