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Offshore Production Systems for Ultra-Deep Water in the Gulf of Mexico — Part I: Well Systems

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ABSTRACT

Over the past decade, we have seen significant progress in deep-water production technology development. The advancement of technology in this area has allowed offshore operators to develop petroleum prospects in water depths in the range of 1,000 m. If the pace of research and development work is maintained in the industry and research institutions, the technology for producing oil and gas in water depths around 2,000 m can reach maturity by the turn of the century. Part I of this article provides a general review of the basic considerations for selecting a deep-water production concept. Of primary concern are the functional, design, and operation requirements of the well system in deep water and the associated impact on the overall production system selection. In particular, technical issues involved in the design, analysis, and installation of various riser concepts are addressed. Part II of this article addresses the design aspects of a deep-water production platform and its mooring/stationkeeping system. Due to the scope of this paper, our discussion will be restricted to the following three production concepts: namely, a tension leg platform, a semisubmersible platform, and a tanker-based production system. For each concept being considered, the dynamic characteristics, structural integrity, and operation issues are the main topics. Topics requiring further research and development are identified.

INTRODUCTION

The Gulf of Mexico (GOM) has been a test bed of offshore technology in the past 40 years. In view of the historical development, the advancement of offshore technology has allowed us to redefine the frontier of deep-water production in every decade. In the 1950s and 1960s, when offshore development work was focused on coastal and shallow water, applicable technologies were developed for oil and gas production in water depths up to 100 m. In the era of the 1970s, due to the rapid change of the global market condition and the demand for petroleum products, the pace of offshore technology development was at a high level unprecedented in history. In the early 1980s, the frontier of deep-water production reached 300 m in the GOM. The introduction of the dynamic positioning drillships was a major technological breakthrough to overcome the water-depth barrier. Vessels capable of drilling exploratory wells in water depths up to 2,000 m were available. The fast pace in offshore development work was maintained until 1986 when the oil prices collapsed. Despite the downturn of the industry after 1986, the overall progress in offshore technology in the 1980s remained very fruitful and significant. Today, mature technology for offshore production is available for application in water depths up to 1,000 m. Drilling an exploratory well in 3,000 m of water is technically feasible.

With the progress of field development activities, the list of deep-water leases has grown steadily in recent years.

Water-Depth Range	Net Blocks	Net Acres	Companies with Working Interest
1,000 to 1,500 m	528	3,034,454	32
1,500 to 2,000 m	281	1,618,557	21
2,000 to 3,000 m	234	1,343,244	23

For those of us who are engaged in the planning of offshore development, we frequently encounter the following question: As one can drill an exploratory well in 3,000 m of water, can one also produce in the same water depth? The answer to this question can be simple if there is only one single well to be produced for a short period of time. A system for well testing or early production belongs to this category. On the other hand, the solution could be quite complicated if a cluster of wells are involved in a full field development program. The problems we have to resolve are twofold: First, we have to deal with the operation problems of developmental drilling, which are not encountered in exploratory drilling. For example, the re-entry of an exploratory well is normally conducted with guidelineless operation. However, such operation may not be feasible at this moment for developmental drilling on a production platform if multiple production risers are installed in the vicinity of the drilling riser. Running a BOP stack without guidelines among the production risers is too risky and unacceptable from the safety standpoint and the issue of interference between the drilling and production equipment must be resolved. We shall examine this issue in more detail later in the discussion. Secondly, the risk due to long-term exposure of the production system is substantially higher than that for a mobile drilling unit. The time exposure for an exploratory well is on the order of 2 to 4 months; whereas a typical deep-water production platform is designed to have an operating life of 15 to 30 years. In this regard, the risk of encountering a major environmental event during the lifetime of a production unit can not be ignored. In order to address the issues of deep-water production, the author proposes a comprehensive review of the operation issues as well as the technology base.

The purpose of this paper is to provide a general discussion on what needs to be done in order to extend the frontier of deep-water production to around 2,000-m water depth. The discussion is focused on two fundamental areas, namely, the operation aspects of the well system and technical uncertainty for quantifying the riser response and integrity in this water depth. The first problem area is operation-oriented and is concerned with the safety and efficiency of the well operation, including developmental drilling, well maintenance and workover. Topics to be addressed or resolved in this area form the technology base for concept

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KEY WORDS: Gulf of Mexico, well systems, ultra-deep water, production systems.
UNIT CONVERSION: 1 in = 2.54E-02m; 1 ft = 3.048E-01 m; 1 knot = 1.689 ft/s.