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Selecting Seal Materials for Deepwater Completions

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Abstract

A variety of seal materials have been used in downhole completions since the first cement plug was invented circa 1924. That first plug had a canvas wrap over a natural rubber "element." Since that time, proper selection of materials that have been developed or adapted for application in specific downhole environments has had a significant impact on helping our industry attain today's high level of production. Although individual seal costs used in a well completion are a fraction of total completion costs, they are critical to performance.

As producible wells become more complex, so must the tools we use to develop them. Proper seal material selection becomes even more critical when production costs increase with more complex environments such as high-pressure/high-temperature (HP/HT), subsea and deepwater completions. But is seal material selection any different for deepwater completions versus land-based completions? After all, one downhole environment is the same as another, isn't it?

This paper will explore seal material selection criteria as well as when those criteria should be amended for deepwater completions. The presentation will also review the concept of "durability" as a deepwater selection criterion.

Introduction

Wells have been drilled offshore for many years, so it seems that a short review is in order of how progression to the current day offshore drilling operations has transpired. According to a recent publication (PennWell, 2007) that reviewed the book, "Pioneeing Offshore: The Early Years" by Schempf, drilling over water started as early as the 1890s. Drilling equipment was placed on wooden piers extending from the shore and drilling into very shallow reservoirs of the Southern Carlifornia coast. Similar methods were used around the world into the 1930s—typically at water depths of less than 10 ft (3 m). In 1937, Pure Oil and Superior Oil, now Chevron and Exxon Mobil respectively, drilled a well 1 mile offshore, in 14 ft (4.3 m) of water from a wooden deck, 14 ft (4.3 m) above water clearance—perhaps the first free-standing, pile-driven offshore drilling platform. According to the book, however, Kerr-McGee Industries (now Anadarko Petroleum), Phillips Petroleum (now Conoco Phillips) and Stanolind Oil & Gas (now BP) completed the first well from a barge-assisted, steel-girderd, wood-deck drilling platform out of sight of land in 1947.

We are now drilling from many different sizes and types of platforms with tremendous differences in complexity. We long ago passed that 14-ft water depth criteria and are now drilling in depths up to 5,000 ft (1524 m) with increasing frequency and moving into ultradeep drilling. At deepwater (over 1,000 ft, or 304.8 m) or ultra-deepwater (5,000 to 7,500 ft, or 1524 to 2286 m) depths, engineering a stable and safe enough platform, however, is expensive; between 2008 and 2012, the bill for deepwater drilling could be in the $108 billion range (John and MacFarlan, 2007). Other significant expenditures will exist as well, such as completion equipment and pipelines to move the oil into upstream processing. With an estimated $38 billion expenditure on just deepwater drilling and completion in the next five years, what considerations need to be made for selecting completion equipment and, more specifically, sealing materials for those completion schemes?

Deepwater completion equipment is outside the scope of this presentation. While equipment is being designed specifically for deepwater completions, basic "shallow" well completion equipment will be similar, differing only in design criteria such as tensile load ratings, pressure ratings and general size range. For example, deepwater wells tend to have a greater total vertical depth (TVD) than other wells and higher hydrostatic loads versus required differentials must be accommodated for deepwater applications.

As we seek more efficient and cost-effective ways to complete deepwater wells, applications and designs will be developed that are narrower in focus. However, in an article in *Offshore*, Hanrahan and Chitwood (2005) identified several areas of interest from the DeepStar project subsea well workovers: 1) repair of completion equipment failures, 2)