Riserless drilling with casing: GOM well design model requires change for deepwater drilling

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AS DEEPWATER GULF of Mexico (GOM) drilling operations move into deeper water and well depths, there has been a lack of consistent and sustained performance improvement in exploration and appraisal drilling. The following metrics illustrate the facts: There has been arguably poor to no learning, especially as the wells become more complex, with most of the wells to be drilled being of a complexity of mechanical risk index (MRI) of 10,000 or greater. Furthermore, these metrics do not indicate the well failures of not attaining well objectives.

A paradigm shift in well design philosophy is critical to the future success and economic viability of deepwater drilling. It involves managing drilling risks in the shallow hole sections, where the well costs are minimum, rather than the current practice of incurring risks subsalt after significant investment has been made.

With these wells' daily operating cost often approaching USD$1 million and requiring 100 days or more to drill, it is critical to the economic success of deepwater field development to reduce well costs and improve attainment of well objectives.

Current operations have focused on a myriad of changes in an attempt to improve performance and sustain learnings by changing fluids, holes sizes, underreaming, hole opening, casing sizes, improving drilling execution and team building. Singularly or collectively, none of these changes has resulted in the overall improvement of drilling time. Many wells fail to achieve objectives, and some wells are simply "lost" – failing to meet any objectives. The conclusion must be that the prevalent common denominator in all these wells is the well design itself.

The complex deepwater drilling environment has pushed the typical offshore well construction design model to its limits. The current well design philosophy is an evolution of the benign shelf model trying to survive in an earth model with complex uncertainties. A step-change in well design philosophy and the understanding and acceptance of the associated risks of implementing new practices and technologies is required. The acceptance of change has been a monumental driver in our industry but can also induce philosophical friction. The proposed changes discussed have as their underlying principle the discipline of applied engineering, not merely opinion. The goal of this proposed design change is to ensure that exploration and development of oil and gas continues to be feasible in this industry, which is subject to volatile commodity prices and increasing costs.

The proposed well design model uses the shallow and rapid growth of the pore pressure/fracture gradient (PP/FG) environment to optimize casing seats. Drilling with casing can be an enabling technology that mitigates shallow hazards, safer and more effectively

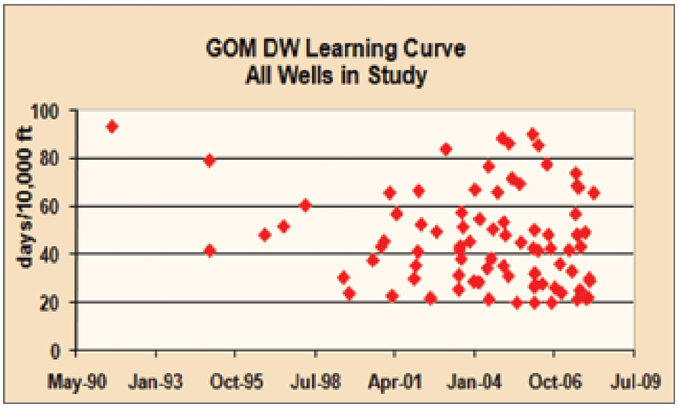

Figure 1: All wells studied, no learning across all complexities.

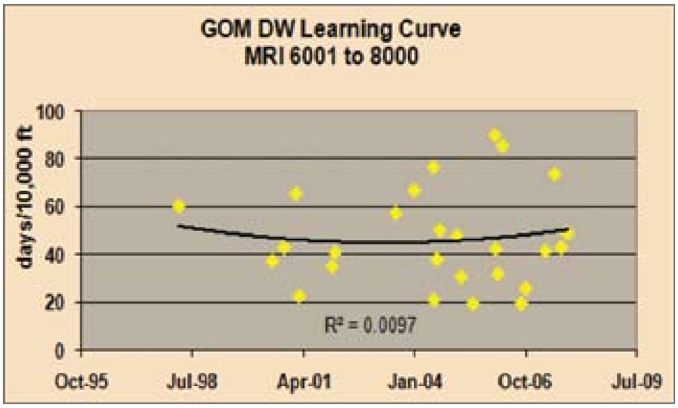

Figure 2: Mechanical risk index (MRI) 6001 < 8000 wells, no apparent learning.

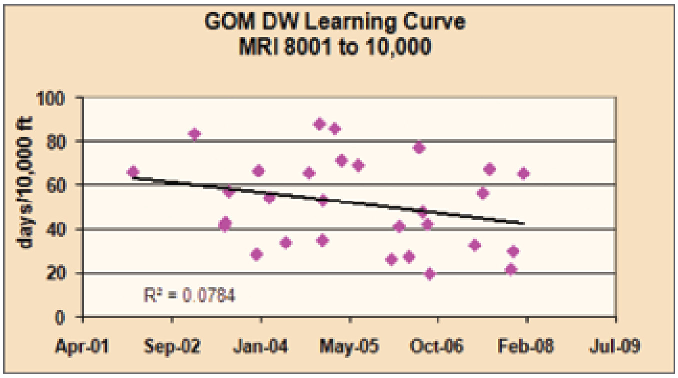

Figure 3: Mechanical risk index (MRI) 8001 < 10,000 wells, poor to no learning.

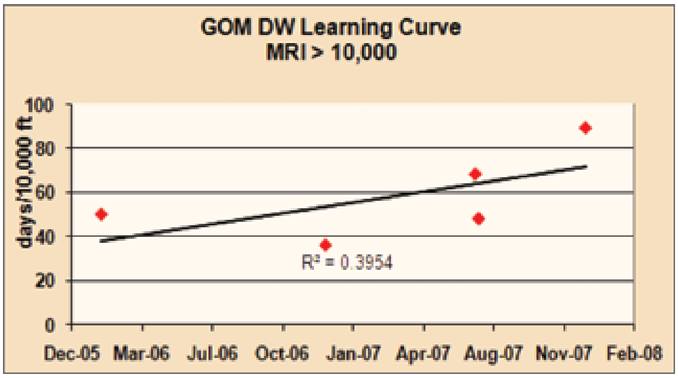

Figure 4: Mechanical risk index (MRI) > 10,000 wells, reverse learning and does not include failed wells.

than the existing model. The fundamental premise is to use this technology to set the first – and possibly the second – casing strings, across the shallow hazards, significantly deeper than the current practice.

The proven ability of drilling with casing to mitigate many similar drilling hazards as those encountered in deepwater drilling would allow the casing seats to be based on the prevailing PP/FG environments, rather than being influenced by shallow hazards. This could allow for the following improvements:

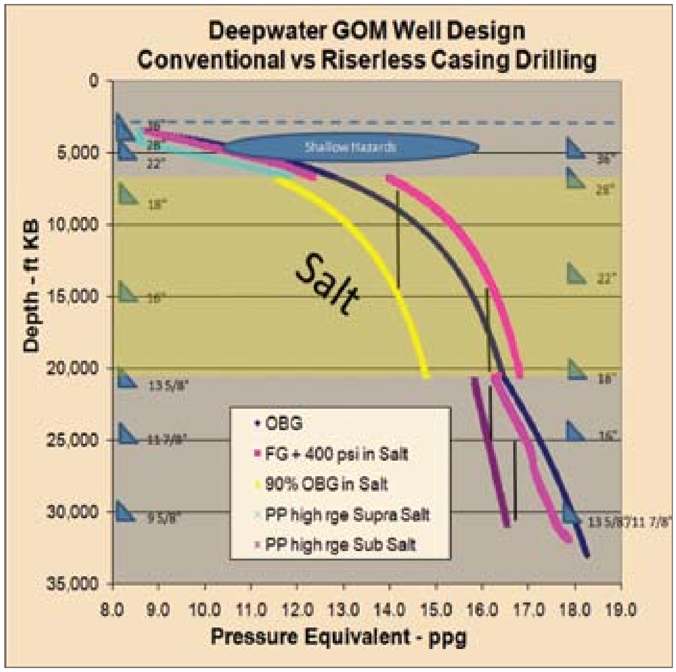

Figure 5: A comparative model of conventional (left) vs the proposed new design (right).

• Fewer casing strings required to meet the well objectives. This reduction of hole sections would reduce the time required to construct the well. Flat time activities in deepwater typically are very time-consuming, making a reduction of hole sections significant.

• Larger annuli below salt for improved operating margin management. This is the most important aspect in an improved well design. The larger annuli in the narrow operating margin well sections will improve equivalent circulating density (ECD) where tenths of ppg of mud density is the difference between managing an influx, "ballooning," or avoiding fluid losses. There have been a number of exploration wells that have failed to meet well objectives because of this engineering dynamic.

• Use of conventional casing string sizes for contingencies in the subsalt narrow operating margin sections. Using conventional sizes of casing as contingencies in subsalt well sections will improve costs and efficiencies and offer improved deeper choices for emergency contingencies, such as expandable tubulars.

• Decreasing the risk of not obtaining at least an 8 ½-in. ID completion; essential for economic success in deepwater environments. In current deepwater drilling design, there is significant risk and high likelihood that this desired production string working diameter may be expended before total depth is reached. Due to the high cost of deepwater wells, it would therefore be more appropriate to maintain a discovery well as a "keeper" if it had the appropriate hole size across the targets.

• Possible batch drilling into salt, which optimizes horsepower, as well as cost. It may be more effective to use a smaller-capacity drilling vessel to drill the riserless sections; larger vessels could be used for drilling and handling deeper hole sections requiring heavier hook loads. This could be a huge benefit to the industry, where saving concessions are important and optimizing horsepower is critical to effective rig scheduling.

Figure 5 represents a comparison of the current deepwater well design on the left side of the graph and the proposed new design on the right side. The drilling margin represents the boundary between the lowest ECD necessary to ensure safe operations and wellbore integrity, and the highest ECD that can be tolerated to avoid fracturing the shoe of the prior casing string.

In the proposed design, the 36-in. is set at a much deeper depth, thus leveraging the growth of the fracture gradient more effectively. This telescopic improvement is evident as each casing seat is set deeper. For example, at approximately 27,000 ft MD there is a net gain of two casing sizes for the proposed model.

In order to achieve deeper depths for these first two strings, drilling with casing would be utilized to drill in the first casing string to a suitable depth, 1,000 to 1,500 ft BML, to act as both a structural and surface casing. This would be possible by mitigating shallow hazards with the unique characteristics of casing drilling of improved dynamic ECD control and its wellbore smearing effect. This string would be drilled with the low-pressure wellhead housing (LPWHH) in place and would be cemented once at section depth. Subsequently, the next casing string would be drilled into place in the same manner to obtain depth determined by the PP/FG environment, then landed inside the LPWHH.

The challenge of GOM well designs is that increases in water depth have the net effect of decreasing the margin between pore pressures and fracture gradient. This effect, combined with the current approach to managing shallow hazards, results in a high number of casing strings, as illustrated in Figure 5.

Furthermore, this exacerbates the management of the narrow operating window for wellbore pressures during drilling operations, specifically the ECD, where the window is often only 0.5 ppg near the well targets.

In summary, the relationship between the pore pressures and fracture pressures in deepwater environments should be the major factor that drives the well design and drilling practices, as opposed to the arbitrary structural setting depths currently being utilized.

In general, the fracture pressure at a given depth increases as the cumulative weight of overburden above it increases. As water depth increases, the hydrostatic pressure exerted by the seawater column, in effect, replaces the pressure that would be exerted by overburden in shallower waters. This reduction in overburden pressure dramatically decreases the fracture gradient, especially in ultra-deepwater locations. As water depths increase and more casing strings are required, it becomes more critical to use effective design and drilling practices to maintain wellbore pressures within the operating window, while achieving well objectives.

A key challenge to successful deepwater drilling is effective management of wellbore pressures to enable maneuvering through these narrow operating windows, of which the casing design setting depth is the predominant factor.

From an engineering and physics perspective, the deeper placement of each casing string, the higher the probability of successfully executing the next hole section. Understanding the engineering dynamics required to optimize pore pressure/fracture gradient dynamics is imperative for efficient and safe operations. The better the prior string shoe tolerance, the better the ability to ensure safe and efficient drilling operations in the next hole section.

There are some obvious technical challenges to this well design, and each can be overcome. Some of the key issues are summarized:

1. Setting each casing string deeper is limited by the mechanical properties of the casing: Vendors of OCTG have confirmed that large-OD casing in 22 in. and 18 in. can be manufactured in P110 and Q125 with appropriate connections.

2. No one has ever drilled the first hole section to depths below typical "jetting" depths. This is not correct. In 2005, an industry JIP in conjunction with the US Department of Energy was conducted in the Gulf of Mexico specially to analyze the shallow hazard of methane hydrates. The holes were successfully permitted and safely cored to depths greater than 1,500 ft BML through known methane hydrate deposits using conventional coring techniques.

3. Current offshore rigs limit the hook load available for deeper-set bigger casing strings: The higher mechanical specification of the casing makes the casing lighter, and many newer rigs have the required capacity to run two million lb landing and casing string loads, and additional torque for the casing drilling operation.

4. No one has ever drilled with casing of this OD: To date, the largest has been 22 in., and the premise of this concept is to take the risk when the well costs are millions, not hundreds of million.

5. No one has ever attempted to drill 36-in. or 28-in. casing as a liner, and can it be done? Conceptual design of the required tools are with a couple of vendors, and, again, the premise of this concept is to take the risk when the well costs are millions and not hundreds of millions.

6. Current wellhead design is not compatible: This concept does not change the wellhead design from the current 18 ¾-in. HPWWH concept, but it eliminates the requirement of a "CADA" tool.

Setting the first casing string significantly deeper than is the current deepwater practice would have a major positive impact on the entire well design and will result in billions of dollars in cost savings for the deepwater industry. That is only the initial cost: Successfully achieving well objectives will result in increased production and long-term reserves. Our industry is looking for a leader to step up to take deepwater drilling to the next technological level.

Article references are online at www.drillingcontractor.org.

David Pritchard is a petroleum engineer with extensive experience worldwide. His skills include well design and planning, drilling and completion engineering, permitting, gathering systems, artificial lift, production optimization and facilities design. He has been involved in management culture and development for well planning processes, hazards, risk and management of change. Kenneth Kotow is a professional engineer registered with APEGGA in Alberta and has more than 25 years of petroleum and drilling engineering experience. His focus for the last 15 years has been on drilling project management and engineering for HPHT, MPD and complex wells and in deepwater.