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REPRESENTATIVE WELL DESCRIPTIONS FOR COMPARATIVE ANALYSIS OF DUAL DENSITY DEEPWATER DRILLING SYSTEMS

TASK #2 REPORT

(July 2003 – September 2004)

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13. ABSTRACT (Maximum 200 words)

The objective of this research was to describe the design of representative, deepwater Gulf of Mexico wells to provide a logical basis for subsequent economic comparisons between conventional and dual density drilling methods. Data from multiple operators and service companies was acquired on ten representative deepwater Gulf of Mexico wells. The data generally included hole sizes, casing sizes and setting depths, and mud weights. In some cases, more detailed data was available including pore and fracture pressures, drilling costs, and in one case, daily drilling reports. This data was then combined with historical data available at LSU and with published reports on expected future trends in deepwater exploration and development. These descriptions of past, current, and future deepwater Gulf of Mexico activities were then used to define the water depth, well depth, and general geology of three hypothetical wells representative of wells where dual density systems might be applied. The data collected was used as a basis for generic deepwater pore pressure and fracture pressure models. Those models were the basis for selecting the mud weights, casing sizes and setting depths, and hole sizes for the three representative well designs.

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SUMMARY

Development of our nation's deepwater gas resources is currently limited by the high capital costs involved in developing these resources. Dual gradient drilling methods have been proposed as a means to provide simpler, safer, more economic well designs and therefore increase the ultimate development and utilization of deepwater gas resources. Two dual density drilling concepts, riser dilution with a low density liquid and riser gas lift, are being investigated in this project as potential means to implement a dual gradient system. The overall objective of the project is to establish whether there is justification for further research on dual density drilling systems that rely on using low density fluids, either liquid or gas.

This research is intended to begin answering four critical questions about the practical feasibility and commerciality of these two dual density drilling methods. The first is the probable cost benefit relationship for each. The second is whether effective well control methods can be defined. The third question is the practicality of separating the low density and high density components of the mixed fluid that returns to the surface in the riser for reuse. The fourth question is whether a riser gas lift or liquid injection system can be controlled to allow all of the major drilling operations to be conducted safely and predictably.

This report describes the work performed and the results of Task 2, which was to acquire and summarize the design specifications and anticipated costs for conventional drilling of up to four representative, Gulf of Mexico deepwater development and exploratory wells. The objective is to provide a logical basis for comparison between conventional and dual density drilling methods.

Three major achievements have resulted from this work. First, data from multiple operators and service companies was acquired to give what they consider to be ten reasonably representative descriptions of deepwater Gulf of Mexico wells. Second, metrics describing current and future deepwater Gulf of Mexico activities were accumulated, analyzed, and used to define three hypothetical wells that are considered to be representative of future wells where dual density systems might be applied. Lastly, mud weight and fracture pressure information for a large number of wells was collated and used as a basis for deepwater pore pressure and fracture pressure models representative of typical Gulf of Mexico conditions.

INTRODUCTION

The overall objective of this project is to establish whether more comprehensive research concerning dual density drilling systems based on use of low density fluids, either liquid or gas, is justified. The project is intended to continue the research initiated by LSU and Petrobras on the riser gas lift method and to begin assessing injection of unweighted liquid into the riser as another alternative. These methods are intended to offer alternative methods of achieving a dual gradient deepwater drilling system that utilize more standard equipment than the separate industry projects focused on the use of sea floor pumps to achieve the advantages of a dual gradient method.

The focus of the project is to evaluate and develop the operational concepts for two dual density methods that can be applied using current riser-supported subsea drilling systems: riser gas lift and injection of unweighted liquid into the riser. It is intended to provide a first step in beginning to answer four critical questions about the practical feasibility and commerciality of these systems. The first is the probable cost benefit relationship for each of the two alternative concepts if applied to representative deepwater Gulf of Mexico development and exploratory wells. The second is whether an effective well control method can be defined for a system containing so many different density fluids and different flow paths. In particular, we will compare the conventional approach of circulating against a surface choke to the more dynamic approach of using the dense fluids already in the well to regain an overbalance and to the potential use of a seafloor choke. The third question is the practicality of separating the low density and high density components of the mixed fluid that returns to the surface for reuse. The fourth question is whether a riser gas lift or liquid injection system can be controlled to allow all of the major drilling operations to be conducted safely and predictably.

The rationale for investigating these dual density drilling methods is based on the expectation that development of deepwater natural gas reserves will contribute significantly to new gas reserves in the lower 48 states over the next fifteen years according to recent GTI baseline projections. However, the current economic significance of deepwater gas production is constrained by the substantial capital costs of deepwater development. Although a great deal of effort has been expended on new technologies to reduce the cost of deepwater production facilities and on building new deepwater drilling rigs, no major new technologies have been commercialized to reduce drilling costs by improving the drilling and well design concepts. Even though wells have been drilled in water as deep as 10,000 feet, the riser inside diameter can severely limit the number of casing strings that can be used and consequently the maximum practical well depth when conventional well designs are used. These limits become more severe with increasing water depth. Specific geologic conditions, such as long salt intervals or a lack of significant overpressures, or more costly rig and well equipment, such as a larger riser or use of expandable tubulars, can offset these limitations. Nevertheless, some deepwater resources will be left unexplored or undeveloped because the current well design technology is too limited or too costly to be used.

A simpler, potentially more cost effective, well design would use a moderate density fluid in the annulus of the riser and a higher density fluid in the wellbore to provide a more favorable pressure profile in the well, specifically a pressure profile closer to what naturally exists in the subsurface formations. The drilling system that would allow these two different fluid gradients in the well has been called the dual density system. An example of how the fluid gradients and casing points in this kind of well design would match up with formation pressure gradients is provided in Figure 1.

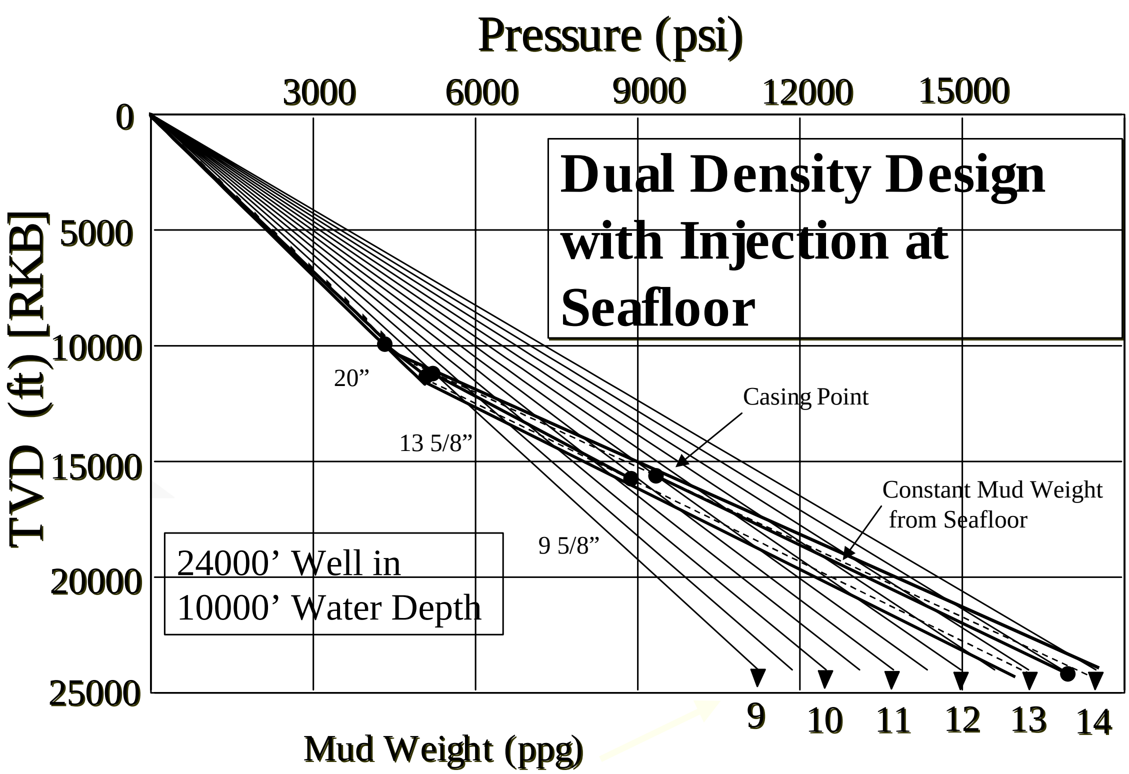

Figure 1 - Well Design for 24,000' Gulf of Mexico Well in 10,000' of Water Using the Dual Density Concept

This example assumes that the fluid gradient from the surface to the mudline is a seawater gradient and that the mud gradient below the mudline is adequate to provide overbalance for a trip margin. The dual density well design has the advantages of fewer casing strings for lower well cost, larger mud weight margins for improved safety, a larger production casing size for increased production and revenue rates, and reduced riser tension requirements which would allow longer risers to be used with existing tensioning systems. Ultimately, the benefit to gas consumers of implementing dual density deepwater drilling methods should be an increased supply of domestic natural gas providing reliable, cost effective energy and chemical feedstock to the U.S. economy.

METHODS, ASSUMPTIONS, AND PROCEDURES

WORK PLAN

The plan for this task, Task 2, was primarily to seek information from major deepwater operators on wells that they considered to be representative of wells that could be drilled using a dual gradient drilling system. This kind of information is necessary to begin addressing the first key question regarding the commercial viability of dual density systems, the cost benefit analysis relative to conventional deepwater drilling for representative, deepwater, Gulf of Mexico development and exploratory wells.

The information sought was an overall well plan summary including both well design and well cost for representative wells. We specifically sought the following information:

1. Total depth, measured and true vertical
2. Approximate depth of production interval
3. Casing sizes, setting depths, hole sizes, and anticipated shoe tests
4. Mud density and type versus depth
5. Water depth
6. Is well exploratory or development?
7. Is production likely to be oil, gas, or both?
8. How many wells are expected to be drilled to develop this prospect?
9. What is the approximate total well cost?

This information was to be acquired by contacting four major operators active in drilling wells in water depths greater than 5,000 feet and which had provided technical cooperation on past projects at LSU. The requested information would be supplemented with information from the researchers' historical files, service company records, and published sources. The goal was to assemble a collection of actual well data with enough detail and scope to provide a reasonable basis for developing the descriptions for representative wells.

Selection of the specific conditions to be used in the "representative" well descriptions was to be based on several factors. These include the well specifications presented by the operators as representative, specifications selected in published studies, the circumstances where major deepwater reserves are currently being developed, prospective deepwater areas yet to be developed, and emphasis on conditions where dual gradient systems are potentially most beneficial.

The representative well descriptions will be used as examples for cost comparisons to be performed in a subsequent phase of the study. These descriptions were to be developed based on the geologic conditions selected as representative and the composite of the corresponding conditions from the well data. The descriptions were to include water depth, total depth, pressure profile, casing points, drilling time, and costs. These example descriptions representative of future Gulf of Mexico wells are the primary deliverables for this task and are the focus of this report.