

RPSEA-0004-04

GRI-04/0176

**FEASIBILITY STUDY OF
DILUTING A WEIGHTED DRILLING FLUID WITH
A LOW DENSITY LIQUID TO CREATE A RISER FLUID
FOR A DUAL DENSITY DRILLING SYSTEM**

TASK #4 REPORT

(July 2003 – April 2004)

Prepared by:

John Shelton and John Rogers Smith

Craft and Hawkins Department of Petroleum Engineering
Louisiana State University
Baton Rouge, LA 70803-6417

Prepared for:

RESEARCH PARTNERSHIP TO SECURE ENERGY FOR AMERICA
Subcontract No. R-506

RPSEA Project Manager
Robert W. Siegfried
Vice-President, Unconventional Gas Technology

August 2004

REPORT DOCUMENTATION PAGE			Form Approved OMB No. 0704-0188	
Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information, Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503.				
1. AGENCY USE ONLY (Leave blank)		2. REPORT DATE August 2004		3. REPORT TYPE AND DATES COVERED Task 4 July 2003 – April 2004
4. TITLE AND SUBTITLE Feasibility Study of Diluting a Weighted Drilling Fluid with a Low Density Liquid to Create a Riser Fluid for a Dual Density Drilling System			5. FUNDING NUMBERS RPSEA Subcontract R-506 GRI Contract 8693	
6. AUTHOR(S) John Shelton and John Rogers Smith				
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Craft and Hawkins Department of Petroleum Engineering Louisiana State University Baton Rouge, LA 70803-6417			8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING ORGANIZATION NAME AND ADDRESS Research Partnership to Secure Energy for America 1650 Highway 6 Suite 300 Sugar Land, TX 77478			10. SPONSORING/MONITORING AGENCY REPORT NUMBER RPSEA-0004-04 GRI-04/0176	
11. SUPPLEMENTARY NOTES The work documented in this RPSEA report was funded under GRI Contract 8693 with RPSEA, Technology Development for Unconventional and Ultra Deep Offshore Natural Gas Resources.				
12a. DISTRIBUTION/AVAILABILITY STATEMENT			12b. DISTRIBUTION CODE	
13. ABSTRACT (Maximum 200 words) Practical deepwater drilling fluid formulations and their required properties were determined based on input from three major drilling fluid companies. The maximum drilling fluid density required for applying the dual density concept to any of the actual deepwater wells studied in Task #2 was determined to be 17 lb/gal. Consequently, a number of lab samples of 17 lb/gal synthetic-based muds and a dilution fluid with similar fluid makeup but no weighting material were formulated and evaluated for suitable properties individually and when combined to form a riser fluid. Formulations were defined that provided good emulsion stability for all three subsystems. However, achieving a dilution fluid formulation that was both consistent with the weighted fluid and provided for appropriate rheology in both the weighted fluid and the riser fluid was not achieved. Earlier tests by de Boer gave much more favorable properties when using a lower density weighted fluid.				
14. SUBJECT TERMS dual gradient drilling, dual density, riser dilution, synthetic-based mud, mud compatibility, emulsion stability, barite settling, mud dilution			15. NUMBER OF PAGES 18	
			16. PRICE CODE	
17. SECURITY CLASSIFICATION OF REPORT Unclassified	18. SECURITY CLASSIFICATION OF THIS PAGE Unclassified	19. SECURITY CLASSIFICATION OF ABSTRACT Unclassified	20. LIMITATION OF ABSTRACT	

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 to 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 further research concerning dual density drilling systems based on use of low density fluids, either liquid or gas, is justified.

This research is intended to begin answering several critical questions about the practical feasibility and commerciality of these two dual density drilling methods. The specific concern researched herein is whether the riser fluid can retain sufficient solids suspension and cutting transport properties after heavy dilution with an unweighted liquid. This relates to the general question about 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.

This report summarizes the results of the experimental study of diluting representative, high density, deepwater drilling fluids with an unweighted dilution fluid. The goal of achieving a mud formulation that would allow dilution of a weighted wellbore mud with an unweighted dilution mud and still retain the properties necessary for suspending barite and transporting cuttings was not achieved. Nevertheless, emulsion stability within all three required mud streams was achieved and previous work by de Boer (2003) indicates that reasonable rheologies should be achievable, at least when using a lower density wellbore mud.

INTRODUCTION

Dual density drilling has the potential to reduce offshore drilling costs per Smith (2003-a). It can yield a more favorable pressure profile in the well that would lead to the setting of fewer casing strings, less time spent on a well, and a larger production casing size.

Riser dilution may be an economical means of achieving a dual density drilling system for deepwater. This system would use an unweighted mud injected into the riser to dilute the weighted mud returning from the well annulus (See Figure 1). Smith et al (2003-b) provide a more comprehensive review of dual gradient drilling methods in the form of a literature review that was the final report for Task #1 of this project.

PROJECT OBJECTIVE

The overall objective of this project is to establish whether more comprehensive research is justified concerning dual density drilling systems based on use of low density fluids, either liquid or gas. 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 utilizes more standard equipment than the separate industry projects focused on the use of seafloor pumps to achieve the advantages of a dual gradient method.

Two key questions exist regarding the practicality of the riser dilution concept from a drilling fluids perspective. First, can dilution be made at the ratios required for dual density drilling without negative effects on cuttings transport, mud stability, and barite suspension? Second, can the diluted fluid be

separated back into useable weighted and unweighted components? This study addresses only the first question.

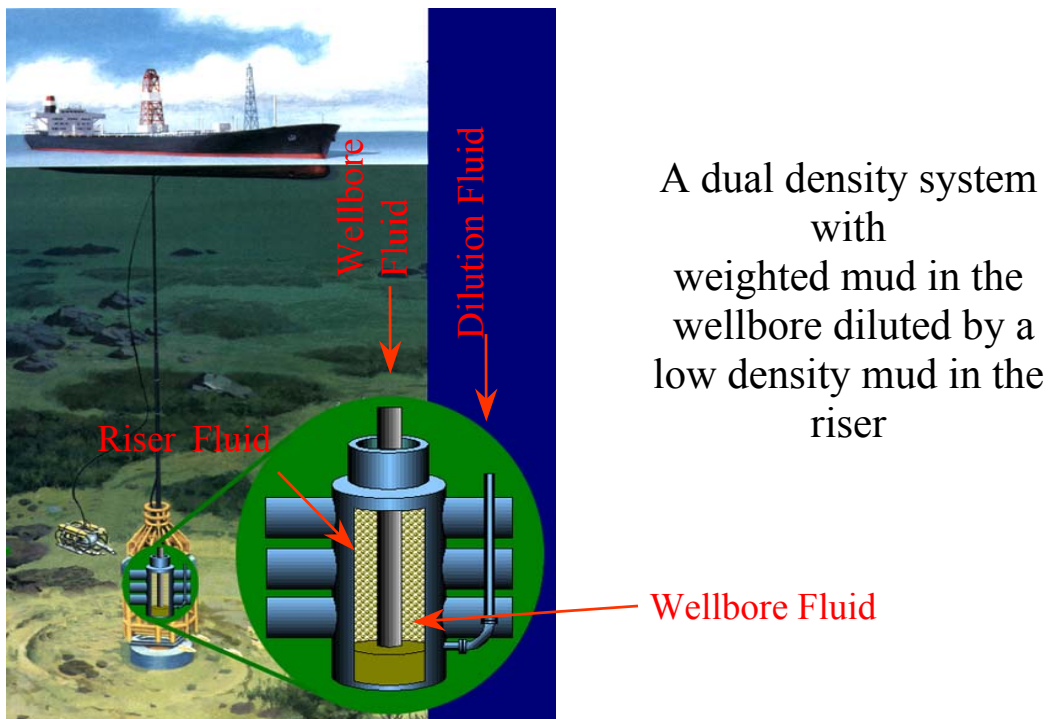


Figure 1 – Fluid Flow Paths for a Dual Density System Based on Riser Dilution

OVERVIEW OF STUDY

The work described in this report pertains to the formulation and testing of the drilling fluids for a dual density system based on riser dilution. The goal of this testing was to determine whether a mud system could be defined that would allow dilution to be made at the ratios required for dual density drilling without negative effects on cuttings transport, mud stability, and barite suspension in the riser.

A synthetic-based mud was selected as most representative of the muds currently being used in deepwater operations in the Gulf of Mexico. The weighted and unweighted mud densities were selected to give an average overall gradient equal to the highest mud weight utilized historically in conventional deepwater drilling. The riser mud was assumed to be the weighted mud diluted with a mud of the same base stock, but without weighting material, at dilution ratios from 2:1 to 4:1. Rheology, gel strength, and electrical stability were measured as a function of the mud densities, dilution ratios, and base fluid parameters. These properties were then compared to the desired properties for each portion of the system: the weighted mud in the well, the dilution fluid, and the diluted mud in the riser.

The key strategy employed in this study was that the dilution mud and the weighted mud should be formulated with the same proportions of materials in the fluid phase. Consequently, the only difference in the formulations would be the barite that is in the weighted mud. The intent in applying this strategy was to ensure that when the fluid streams are mixed and then subsequently separated at the surface there would be no dilution of additives in either fluid stream.