

**Optimization of Mud Hammer Drilling Performance –
A Program to Benchmark the Viability of
Advanced Mud Hammer Drilling**

Quarterly Progress Report

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ABSTRACT

This document details the progress to date on the OPTIMIZATION OF MUD HAMMER DRILLING PERFORMANCE – A PROGRAM TO BENCHMARK THE VIABILITY OF ADVANCED MUD HAMMER DRILLING contract for the quarter starting July 2002 through September 2002.

Even though we are awaiting the optimization portion of the testing program, accomplishments include the following:

- Smith International agreed to participate in the DOE Mud Hammer program.
- Smith International chromed collars for upcoming benchmark tests at TerraTek, now scheduled for 4Q 2002.
- ConocoPhillips had a field trial of the Smith fluid hammer offshore Vietnam. The hammer functioned properly, though the well encountered hole conditions and reaming problems. ConocoPhillips plan another field trial as a result.
- DOE/NETL extended the contract for the fluid hammer program to allow Novatek to ‘optimize’ their much delayed tool to 2003 and to allow Smith International to add ‘benchmarking’ tests in light of SDS Digger Tools’ current financial inability to participate.
- ConocoPhillips joined the Industry Advisors for the mud hammer program.
- TerraTek acknowledges Smith International, BP America, PDVSA, and ConocoPhillips for cost-sharing the Smith benchmarking tests allowing extension of the contract to complete the optimizations tests.

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INTRODUCTION

The focus of the Introduction for this quarter will be on the recently announced participation by Smith International to test their fluid hammer under ‘benchmarking’ conditions established by the program last year and to participate in the optimization phase now awaiting Novatek’s progress likely in 2003.

Chroming of collar during late summer was done to accommodate testing in TerraTek’s Wellbore Simulator. The smooth finish allows the tool to stroke through the seal pack and maintain downhole conditions within the sample.



EXECUTIVE SUMMARY

Background

On January 9th of 2001, details of the Mud Hammer Drilling Performance Testing Project were presented at a “kick off” meeting held in Morgantown. Industry support is high and the importance to the drilling industry, as the business challenge of “hard rock drilling”, was presented by John Shaughnessy of BP Amoco. The Industry Partners for this program are SDS Digger Tools, Novatek, BP Amoco, and ExxonMobil. A test program was formulated and prepared for presentation at a meeting of the Industry Advisory Board in Houston on the 8th of February. The meeting was held and the DOE approved a test program was after thorough discussion.

DOE’s National Energy Technology Laboratory highlighted the Mud Hammer Project at an exhibit at the Offshore Technology Conference April 30 through May 3, 2001. TerraTek assisted NETL personnel with presentation materials appropriate for the project and a demonstration sample of ‘hard rock’ drilled in TerraTek’s wellbore simulator.

TerraTek completed 13 drilling tests by beginning July in Carthage Marble and hard Crab Orchard Sandstone with the SDS Digger Tool, Novatek tool, and a conventional rock bit. Overall the hammers are functioned properly at ‘borehole’ pressures up to 3,000 psi with weighted water based mud. Clearly the Department of Energy goals to determine hammer ***benchmark rates of penetration*** and ***ability to function at depth*** are being met. Additionally data on drilling intervals and rates of penetration specific to flow rates, pressure drops, rotary speed, and weights-on-bit have been given to the Industry Partners for detailed analysis. SDS and Novatek have gained considerable experience on the operation of their tools at simulated depth conditions. Some optimization has already started and has been identified as a result of these first tests.

TerraTek has completed analysis of drilling performance (rates of penetration, hydraulics, etc.) for the Phase One testing which was completed at the beginning of July. TerraTek also convened jointly with the Industry Advisory Board for this project and DOE/NETL a ‘lessons learned meeting’ to transfer technology vital for the next series of performance tests. Both hammer suppliers benefited from the testing program and are committed to pursue equipment improvements and ‘optimization’ in accordance with the scope of work.

PDVSA joined the advisory board to this DOE mud hammer project end 2001 and has formally committed funds (cost sharing) for the upcoming effort in testing at TerraTek. Additionally, TerraTek, DOE, and BP America (one of the industry contributing partners) has completed a publication entitled “World’s First Benchmarking of Drilling Mud Hammer Performance at Depth Conditions”.

In accordance to Task 7.0 (D. #2 Technical Publications) TerraTek, NETL, and the Industry Contributors successfully presented a paper detailing Phase 1 testing results at

the February 2002 IADC/SPE Drilling Conference, a prestigious venue for presenting DOE and private sector drilling technology advances. The full reference is as follows:

IADC/SPE 74540 "World's First Benchmarking of Drilling Mud Hammer Performance at Depth Conditions" authored by Gordon A. Tibbitts, TerraTek; Roy C. Long, US Department of Energy, Brian E. Miller, BP America, Inc.; Arnis Judzis, TerraTek; and Alan D. Black, TerraTek. Gordon Tibbitts, TerraTek, will presented the well-attended paper in February of 2002. The full text of the Mud Hammer paper was included in the last quarterly report.

The Phase 2 project planning meeting (Task 6) was held at ExxonMobil's Houston Greenspoint offices on February 22, 2002. In attendance were representatives from TerraTek, DOE, BP, ExxonMobil, PDVSA, Novatek, and SDS Digger Tools. PDVSA has joined the advisory board to this DOE mud hammer project. PDVSA's commitment of cash and in-kind contributions were reported during the last quarter. Strong Industry support remains for the DOE project. Both Andergauge and Smith Tools have expressed an interest in participating in the 'optimization' phase of the program. The potential for increased testing with additional Industry cash support was discussed at the planning meeting in February 2002.

Presentation material was provided to the DOE/NETL project manager (Dr. John Rogers) for the DOE exhibit at the 2002 Offshore Technology Conference. Two meeting at Smith International and one at Andergauge in Houston were held to investigate their interest in joining the Mud Hammer Performance study.

SDS Digger Tools (Task 3 Benchmarking participant) apparently has not negotiated a commercial deal with Halliburton on the supply of fluid hammers to the oil and gas business. TerraTek is awaiting progress by Novatek (a DOE contractor) on the redesign and development of their next hammer tool. Their delay will require an extension to TerraTek's contracted program. Smith International has sufficient interest in the program to start engineering and chroming of collars for testing at TerraTek.

Shell's Brian Tarr has agreed to join the Industry Advisory Group for the DOE project. The addition of Brian Tarr is welcomed as he has numerous years of experience with the Novatek tool and was involved in the early tests in Europe while with Mobil Oil. Finally, Conoco's field trial of the Smith fluid hammer for an application in Vietnam was organized and has contributed to the increased interest in their tool.

Current

Smith International agreed to participate in the DOE Mud Hammer program and chromed collars for upcoming benchmark tests at TerraTek, now scheduled for 4Q 2002. ConocoPhillips had a field trial of the Smith fluid hammer offshore Vietnam. The hammer functioned properly, though the well encountered hole conditions and reaming problems. ConocoPhillips plan another field trial as a result.

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‘benchmarking’ tests in light of SDS Digger Tools’ current financial inability to participate. ConocoPhillips joined the Industry Advisors for the mud hammer program and TerraTek acknowledges Smith International, BP America, PDVSA, and ConocoPhillips for cost-sharing the Smith benchmarking tests allowing extension of the contract to complete the optimizations tests.

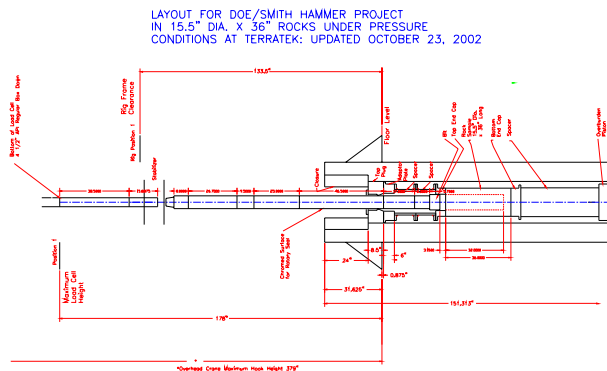
EXPERIMENTAL

Experimental work for ‘Benchmark’ testing has been completed and reported with the exception of the newly introduced Smith International hammer tests to be reported on 4Q 2002.

RESULTS AND DISCUSSION

This section of the report will expand upon some of the major issues progressed during the three month time period.

Plans were underway to add the Smith collar to the testing program. Various experimental programs and layouts to fit TerraTek’s Wellbore Simulator were discussed and drawn up.



Scope of Work Changes

Task 3.1.1 Addition

The following table will be inserted or added to the agreement in order to test Smith international mud hammer tool in Subtask 3.1.1 Test program under test sequence. All other testing specifications will remain as in the original agreement

Test	Hammer/Bit	Rock	Mud Density, ppg
13	Smith	Carthage	10
14	Smith	Crab Orchard	10
15	Smith	Carthage	15
16	Smith	Crab Orchard	15
17	Conventional	Carthage or Crab	*
18	Smith	*	*

* From previous testing, the comparison to ‘conventional drilling’ is available for 10 and 15 ppg fluids. Industry input at the February ’02 planning meeting (particularly BP, PDVSA) prompted plans to use a lighter weight brine as extra data points.

Task 5.1: Promoting Industry Development and Experience with Fluid Hammers

The task will seek out other hammer suppliers (e.g. Andergauge) and operators not currently in the program and determine if mud hammers could increase significantly hard rock drilling performance in their operations

Subtask 5.1.1: TerraTek and its Industry partners will implement the recommendations from the Industry Advisory Board planning meeting and reassess the capabilities of the early developers of Mud Hammers.

Subtask 5.1.2 TerraTek will evaluate information available from field trials available from its contacts within the industry (e.g. PDVSA in Venezuela, Conoco’s hard rock drilling program, and BP’s domestic hard rock drilling areas).

Subtask 6.3.1 The difficulties experience by both Novatek and SDS Digger are attributed in part to the challenge imposed by the DOE – that is ensure the satisfactory ‘performance of mud hammers at depth and with actual drilling fluids’. TerraTek’s tests under Task 4 provided the Industry partners with learnings perhaps exceeding what was originally expected – tools would require greater development times to optimize and could require different testing methods; e.g. SDS Digger is considering the use of a combination pressure balanced stroke sub – hammer system to deliver weights-on-bit independent of drill string extensions. Testing of these tools will require more extensive set-ups and time at TerraTek.

The Industry suppliers have already been working on Tasks 6.1, 6.2, and 6.4 as part of the preparation for Large-Scale testing.

Schedule and Milestones

Original portion of Task 3 has already been completed. The addendum to Task 3.1.1. (above) will be conducted during September and October 2002. Milestone will be the test results of the Smith tool benchmark performance

Original portion of Task 5.0 has already been completed. Proposed Tasks under 5.1 would commence immediately and continue through completion of Task 6.3 July 2003. An interim project meeting with Industry Advisors is now planned subsequent to benchmarking the Smith Tool (ca. November 2002).

Task 6.3 will commence end 2002 pending resources allocated by another DOE contractor Novatek. Testing is projected to commence November 2003 and end May 2003, assuming that SDS will continue to have prototype development deficiencies and scheduling problems identified in the completed 'benchmark' testing.

Task 7.0 Final Report will be completed by August 2003.

End of Scope of Work Changes section

CONCLUSIONS

- The optimization phase of the project is awaiting deployment of the Novatek tool.
- Industry interest in the project continues with interest by Andergauge and Smith Tools to contribute. Smith International joined the program.
- Tasks 1, 2, 3, 4, and 5 are completed in the original format, now with plans to expand Task 3 with the Smith tool during 4Q 2002.
- Task 6 started having concluded a Planning Meeting to determine the test matrix for the next phase of testing. The Industry Advisors will reconvene an additional time prior to formalizing the optimization test matrix.
- Task 7 D2 completed with formal presentation / paper as encouraged by DOE/NETL.

REFERENCES

Lagrec, A., De Santana, D., Suarez, G., Rodriguez, M. (PDVSA), McInnes, M. (SDS Digger Tools), "Fluid Percussion Hammer Filed Test in the Alothonous Cretaceous Block Eastern Venezuela", presented at the Petroleum Society's Canadian International Petroleum Conference 2002, Calagary, Alberta, Canada, June 11-13, 2002.