

**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 April 2002 through June 2002.

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

- Presentation material was provided to the DOE/NETL project manager (Dr. John Rogers) for the DOE exhibit at the 2002 Offshore Technology Conference.
- Two meetings 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.
- 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.

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INTRODUCTION

The focus of the Introduction for this quarter will be on the presentation material provided to DOE/NETL's exhibit at the Offshore Technology Conference May 2002.

Learnings to date

Fluid Hammers have the ability to operate in 10 to 15 ppg muds

Fluid Hammers drilled medium to hard rock effectively in muds

Competitive ROPs demonstrated at moderate borehole pressures

Mud Hammer suppliers now in 'optimization' phase of testing

Hammer - bit *system* can also be optimized for hard rock drilling



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.

Current

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.

EXPERIMENTAL

All experimental work for 'Benchmark' testing has been completed and reported. Discussions and planning for Task 3 testing of the Smith tool and Task 6 are underway with after the February 22, 2002 planning meeting.

RESULTS AND DISCUSSION

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

Meetings with Smith International

Dimensions of Smith's Mud Hammer				
	Length (inches)			
	Start*	End	Diameter	Section
Top Sub	0.0	22.2	6.75	22.2
	22.2	26.2	6.50	4.0
	26.2	36.2	7.00	10.0
Casing	36.2	61.2	7.00	25.0
	61.2	107.7	7.13	46.5
	107.7	124.8	7.25	17.1
Retainer	124.8	133.1	7.63	8.3
Bit	133.1	136.8	8.75**	3.7
* Length is measured from the top of the tool (uphole side)				
** Bit diameter (range 7.875 to 8.75")				
*** The top sub and casing each are beveled .08x45 degrees				
Overall Length 136.8 inches				

Memo June, 2002 to "Mr. Swadi [Smith International],

It was a pleasure to meet you and discuss this project over the phone this morning.

After our discussion on the appropriate placement of the chrome on your tool, I took a more detailed look at the test scenario. I believe the optimum placement of the chrome on the 7.13" diameter x 46.5" would be the following:

Start the chrome 4" from the top of the sub and end the chrome 3 1/2" from the bottom of the sub. This will provide for a limited tong area on both the top and bottom just in case we have to break the tool down while it is here at the drilling laboratory. The top 4" should be undercut to allow burrs from "tonging" to not contact the seal surfaces during installation throughout the test program. The diameter might be the same as the adjacent sub.

This placement of the chrome will provide a total drilled depth of 28" into the test sample. The 28" will provide ample rock to gather the needed operational parameters for the tool. 8 1/2" diameter bits were used in the

previous testing programs and as such will most likely be the choice for these tests also. The chrome specification that we have used in the past is as follows:

.006" to .008" Hard chrome Mil spec. QQC-320A Type II Class 2A. Grind to a 16 finish. Diametrical tolerance is +000 -002".

Gordon Tibbitts, TerraTek”

Industry Partner (PDVSA) and SDS Digger Tools)

Mamo June 2002 to “Alejandro [PDVSA],

Gordon is on well deserved holiday, thus I will answer your questions.

First of all, I have attached the 1Q '02 progress report as delivered to the US Department of Energy. The second quarter report will be written end July '02.

Progress on the 'optimization' of the two tools has been slow, though here is my assessment of the situation. Novatek is building a completely new tool with a redesigned valve. The DOE is funding another project at Novatek (telemetry) thus they have put their resources on that project. The DOE and TerraTek expect a September schedule of tests at TerraTek.

SDS Digger has been difficult to reach. Gary Algate again informed me this week Malcolm in Australia needs money to ship the tool here plus personnel. I have not yet been contacted by him directly, though this indicates that their 'cost sharing' commitment is difficult to meet. If the amount is small, perhaps SDS can ask BP or ExxonMobil for some direct costs (?). TerraTek must certify Industry Cost sharing as we spend/invoice the DOE - that is mandatory per contract. I do not have a clear schedule for them, however Gary said that September is likely. SDS are also sending a tool to Vietnam for the Conoco application, thus that may be occupying their time. Have you contacted Malcolm since our planning meeting?

TerraTek has approached other suppliers with good success. Smith is willing to provide their hammer and test at TerraTek sometime in August. We are seriously considering this new opportunity given the fact that TerraTek's contract with the DOE will now need time extension and the DOE has approved the option of 'benchmarking' the Smith hammer "immediately". The DOE acknowledges that delays by Novatek (also a DOE contractor) and SDS Digger are commercially unacceptable to TerraTek.

Andergauge is also willing to test their 'hammer'(longer tool though) at TerraTek. They do not have funds to cover testing costs on their own.

Other operators are indeed interested too, though getting money has been difficult. Most prominent is Shell however there has been silence since May '02 from them. Any further operator interest and cost sharing could result in immediate testing of the Smith and possibly Andergauge tools, followed by a September re-test of the delayed Novatek and SDS tools.

I hope this helps. If you have better contacts with SDS or other operators, please let me know.

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CONCLUSIONS

- 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 is now willing to contribute funds.
- Tasks 1, 2, 3, 4, and 5 are completed pending plans to expand Task 3 with the Smith tool.
- Task 6 started having concluded a Planning Meeting to determine the test matrix for the next phase of testing. In this context, Novatek is working with the DOE to optimize their tool (summer schedule) and SDS's optimization will primarily focus on internal flow clearances to enhance strike frequency.
- Task 7 D2 completed with formal presentation / paper as encouraged by DOE/NETL.