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One-Sack HPWBM System Improves Drilling Efficiency

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Abstract

Drilling costs can be substantially reduced by increasing efficiency. A novel and more efficient approach to drilling fluids design and management has been achieved by utilizing a highly inhibitive, high-performance water-based mud system (HPWBM), built and maintained with a One-Sack additive as the mud system's backbone. Mud chemistry balance becomes easier to achieve, while fewer demands are placed upon mud engineers, logistics personnel, drilling contractor personnel, deck space, deck loading, and mechanical equipment. Rates of penetration, shale washout, and down hole friction values are more in line with oil-based muds than with conventional water-based muds. Increased drilling fluid performance drives up efficiency, which drives down drilling time, which in turn drives down drilling costs.

The new system consists of a combination of dry additives blended together in a prescribed ratio. Included in the blend are thinners, viscosifiers, fluid loss control additives, shale inhibitors, sealants, and alkalinity modifiers. Flexibility is inherent within the design, allowing modifications for a variety of drilling conditions.

Introduction

Our industry is faced with the challenge of getting wells drilled with an aging fleet of drilling rigs and an increasingly inexperienced work force. Any tool that can be used as leverage to help reduce the risks associated with these handicaps must be employed. This new approach is also more compatible with the drilling industry's emphasis on creating a safer, healthier, less litigious, and more environmentally friendly work place.

Oil-based and synthetic-based muds (OBM & SBM) have been the drilling fluids of choice by operators and mud companies alike in recent years. This is due not only to their inhibitive and lubricious characteristics, but also because they are easy for mud engineers to run. Young engineers without much experience as well as older engineers who do not get around like they used to find them easily manageable. However, concerns about regulatory, health, safety and environmental issues are driving the industry back to water based muds (WBM), specifically, high performance versions (HPWBM).

A more user friendly HPWBM that drives efficiency while pushing the upper end of the performance envelope by emulating an OBM/SBM has been called the holy grail of mud. We call it a common sense approach whose time has come.

Objectives

- Reduces drilling costs
- Decreases drilling time
- Prevents hole problems
- Simplifies mud system maintenance
- Mixes easily
- Easier to engineer
- Safer and easier for rig personnel
- Removes risk of mixing error
- Forces balanced mud chemistry
- Optimizes inventory management
- Requires less deck space
- Increases productivity
- Provides HSE benefits
- Lowers liability exposure
- Fewer lifts with crane or forklift
- Contains 100% active ingredients
- No liquid carriers needed
- No tanks or hoses needed
- Removes operational bottle necks
- Reduces rig clean-up costs
- Eliminates haul-off and disposal costs

Drilling Cost Reduction

The bottom line is cost savings. Time is money. Daily operating costs range from an estimated $30,000 on land, to $50,000 in inland waters, to $100,000 on the shelf, to over $400,000 in deep water with a drill ship.

The biggest contributors to cost overruns are the ones that add days to a project. Flat lines occur on drilling curves when troubles arise due to stuck pipe, lost circulation, shale instability, problems making trips, and problems while logging. A concerted effort must be made not only to prevent flat lines from being added to the budgeted drilling curve, but to take days off of it. This can be accomplished with a One-Sack HPWBM system in a number of ways.

Ease of Use

Less cost is incurred, fewer mistakes are made, and safety is enhanced when the volume of materials being loaded, stored, moved, mixed, and otherwise handled is decreased. A One-Sack blend of dry active ingredients vastly decreases the need for tanks, tank stands, tank racks, hoses, valves, slings, and numerous lifts that accompany most HPWBM systems. Additionally, fewer damages result in lower overall costs.

Whether stacking pallets of drilling chemicals inside a sack room on a small jack-up rig or on a roomier land location, many lifts are required to access a particular sequence of products when needed. The more movement required by fork lifts, cranes, and personnel, the longer it takes to get the products into position and to get them into the mud system.

Safety is also an issue when there is a higher demand placed upon equipment and personnel to make numerous lifts.

Mixing hoppers are generally in congested areas. When mixing chemical treatments, personnel are usually faced with the task of positioning numerous pallets, bulk bags, or containers of varying types of additives in a prioritized mozaic. This often creates a bottleneck and results in component omissions or over treatments. Additionally, mud system integrity can be compromised due to delays in chemical additions when access is hindered.

A One-Sack product provides a more homogeneous chemical inventory, creating less demand upon people and equipment, freeing up those resources to work on other tasks which contribute to project efficiency.

Inexperienced personnel have directly caused mud problems and drilling delays due to mixing the wrong additives or an incorrect sequence of additives into a mud system while drilling. A One-Sack mud system is easier for them to build and maintain and lowers the risk of a mishap due to wrong chemical additions.

Performance

- Replacement for OBM or SBM
- Can be discharged into federal waters
- Outperforms conventional WBM
- Inhibits hydration and swelling of clays and shales due to physio-chemical interaction
- Allows more days in open hole where water sensitive shales are encountered
- Minimizes hole washout
- Encapsulates cuttings
- Drives up solids control efficiency
- Extends shaker screen life and lowers cuttings by-pass into the active mud system
- Reduces dilution requirements
- Keeps MBT values low
- Eliminates cuttings containment and disposal costs
- Reduces trip time
- Extends time between short trips
- Reduces circulating and conditioning time
- Lessens key-seating tendency
- Lubricious
- Reduces fluid and mechanical friction, allowing the drill bit to perform at its optimum, achieving more actual (WOB) while generating more horsepower to the bit
- Coats and seals exposed formations
- Produces a thin, tough, high-quality filter cake across permeable formations
- Lowers risk of differential sticking
- Reduces cuttings bed development
- Reduces lost circulation tendency by providing early tip screen-out of hydraulically induced tensile fractures
- Compatible with PDC bits
- Enhances ROP
- Reduces productive formation damage
- Fresh water, sea water, and saturated salt water compatible
- Effective in broad pH range
- Stable in high mud weight range
- Provides good hole cleaning
- Temperature stable

Ease of use is important, but a new tool must pass muster when it comes to performance. There are a myriad of functions that HPWBM are expected to address.

The main advantage that a One-Sack mud system offers is the ability to maintain a chemical balance at all times, especially when treating large volumes of fluid. Each sack that is added to the mud system contains virtually all of the needed chemicals in their proper proportions.

By avoiding over treatment or under treatment with one or more mud system components, the likelihood of encountering unstable mud properties, an unstable well bore, and drilling delays are greatly diminished.

Because shale problems are so common, costing the industry about $1.3 billion per year[1], shale inhibition is at the core of the One-Sack HPWBM concept. Multiple redundancy is intentionally built into the blend of components.

Included are low molecular weight polymers that provide encapsulation, without producing excessive viscosity. These polymers coat drilled cuttings, along with the clay and shale formations as they are exposed by the drilling process.

An alkali metal salt contributes ample ionic inhibition while lowering the activity of the water phase of the drilling fluid. Polymeric thinners provide rhelological and temperature stability, as well as contaminant resistance.

Fluid loss control is provided by a combination of polymers and sulfonated resins. Multiple micronized sealants are incorporated into the blend in order to enhance the mud's PSD and to provide rapid sealing of sands and micro-fractured shales, as well as to impart lubricity.

The One-Sack HPWBM ensures the wellbore is stabilized by preventing the near-wellbore pore pressure of shales from increasing due to hydration and by preventing the propagation of natural micro-fractures in shales that are weak in compressive strength.

Flexibility

The One-Sack mud system idea was developed by envisioning a HPWBM in finished liquid form, identifying all of the desired components and their respective concentrations, then sourcing and blending only the highest quality dry powdered version of each active ingredient into a homogenous mixture.

There are currently twelve components within the standard One-Sack HPWBM blend. This standard formulation includes every additive necessary to build a HPWBM system, excluding gel, barite, and KOH.

Substitutions and component percentage changes are optional. For example, to formulate a saturated salt mud, small additions or substitutions with a more chloride tolerant fluid loss control additive would be appropriate. Optional liquid additives, such as glycols, esters and oils can be added to the mud system to achieve enhanced lubricity, inhibition, and anti-accretion characteristics.

The One-Sack HPWBM can be used as an add-on for conventional WBM systems where additional inhibition or performance is needed. Concentrations range from 4 to 8 ppb as an add-on to as much as 30 ppb to formulate an entire unweighted HPWBM system. Pills for logging and running casing can be formulated by adding the One-Sack HPWBM dry blend to an existing WBM and then spotting the pill across a troublesome shale or a depleted sand.

Field Applications and Case Histories

- Apache Corporation, Magnet Whithers Field, Wharton County, Texas
- Apache Corporation, Matagorda Island Block 686, Offshore Texas
- Apache Corporation, Southeast Pass Field, Plaquemines Parish, Louisiana
- Badger Oil Corporation, Bayou Postillion Field (4 wells), Iberia Parish, Louisiana
- Badger Oil Corporation, Four Isle Dome Field, Terrebonne Parish, Louisiana
- Badger Oil Corporation, South Lake Bouef Field, Lafourche Parish, Louisiana
- Badger Oil Corporation, South Pecan Lake Field, Cameron Parish, Louisiana
- Badger Oil Corporation, Grand Lake Field, Cameron Parish, Louisiana
- Continental Resources, Jefferson Island Salt Dome Field, Vermilion Parish, Louisiana
- Novus Louisiana, Sorrento Field, Ascension Parish, Louisiana
- Spinnaker Exploration, High Island Block 47 (2 wells), Offshore Texas
- St. Mary Energy, Erath Field, Vermilion Parish, Louisiana

High Island Block 47 (An Operator's Perspective)

In 2003, Spinnaker Exploration drilled two wells in High Island Block 47 and used for the first time a One-Sack HPWBM. The #1 well was a commercial discovery and a follow-on #2 well was drilled immediately afterward. The One-Sack HPWBM was utilized on the second well due to its good performance on the first. The second well was deviated and longer than the first, and again the mud system performed admirably, providing very good value-for-money.

The first well was planned and executed as a straight hole to 11,000 feet, using a casing program of 16" x 10-3/4" to allow a 9-7/8" diameter hole to be drilled to Total Depth (TD). To Spinnaker's knowledge, this was the first well ever to be drilled in Block 47. The depth, expected pore pressure, and vertical nature of the well steered the planning towards a cost-efficient water-based mud (WBM). The One-Sack HPWBM was presented as such a cost-efficient mud, with a majority of the system's components already dry-blended in a bag.

The One-Sack HPWBM was introduced for the drilling of the production hole with PDC bits from under surface. This interval was drilled from 4,000 ft to 10,595 feet in 178 rotating hours over the course of ten days, which included a planned trip to pick up logging-while-drilling (LWD) tools and a new bit. The gross interval average ROP was 37 fph, including times spent drilling with only one mud pump while the other was under repair, and control-drilling through the productive interval. The ROP was consistent with the slope of the planned drilling curve, although the well was actually drilled 'under the curve' due to the trouble-free, thus faster-than-expected flat spots.

Following are some remarks taken directly from the well summary: (6850 ft) 9.5 ppg. Wiper trip, hole OK. (*36 hrs before first wiper trip*); (8484 ft) 10.0 ppg. POH, 10-15 Klbs drag. RIH, no fill. (*72 hrs since previous wiper trip*); (10115 ft) 11.0 ppg. POH wiper trip, hole OK, no fill. (*41 hrs since previous trip*); (10595 ft) 11.2 ppg. Drilled to TD, CBU, wiper trip, no overpull, no drag, no fill; (10595 ft) 11.2 ppg. Ran 7 5/8" casing to TD, no fill. 7-5/8" production casing was run to TD with no problems after wireline logging (2 logging runs and 1 SWC run). A caliper log showed an average hole washout of about 12.5%.

Success at #1 led to the planning of #2 as a follow-on well to test a remote target. In order to simplify the surface equipment, it was planned to keep the rig very near the existing #1 location and drill directionally to the #2 target. The target depth and desired hole size were the same as for the first well. The One-Sack HPWBM was selected due to its performance on the #1 well.

The One-Sack HPWBM was again used to drill the production hole, which this time involved 30° of inclination and ultimately, a displacement of some 3,500 feet from the surface location. All of the issues that normally accompany such a wellpath became 'non-issues' because there were no problems with cuttings beds, hole instability, sliding the directional assembly, or tripping. Minimal hole washout, i.e. successful shale inhibition by the One-Sack HPWBM, was probably the main factor in avoiding these potential problems. 193 drilling hours were required to drill from 4,000 ft to 11,729 ft, for a gross average ROP of 40 fph. This represented an 8% increase in ROP over the first well.

The well was determined to be non-commercial and was plugged with cement, after reaching TD four (4) days under the planned drilling curve.

Imagine a three-month period of time that contains the following: well planning and bid analysis, a discovery well, and a non-commercial follow-on well. During three months of 2003, Spinnaker was able to try a novel mud system and watch it succeed in both a vertical and a deviated wellbore. The two wells were drilled a total of 7 days (3 + 4) under the budgeted time, with a commensurate amount of drilling budget saved. The cost of the One-Sack HPWBM ultimately accounted for only 7% of the total money spent.

The pre-blended One-Sack HPWBM doesn't pretend to be either high technology or new technology, however it does present an innovative and more efficient way to build and maintain a mud system. Feedback from the rig crews and drilling supervisors was positive, commenting that the mud was easy to mix and easy to maintain. Spinnaker's office-based personnel had two reasons to be positive about the mud system; the first was because it worked well, and the second was because the costs were reasonable.

In a world of unknowns, Spinnaker was able to hit .500 for commercial hydrocarbons and to positively identify a cost-efficient HPWBM system for future use.

<u>Erath Field, Vermilion Parish, Louisiana</u>

St. Mary Energy planned to drill a deviated hole through five potentially depleted sands in a field where operators had encountered lost circulation and stuck pipe since the 1950's. Enlisting participation was difficult, as potential partners were skeptical about the prospects of being able to achieve the mechanical task of drilling and casing this well. Turnkey contractors declined to bid on this project because of its high risk nature.

In an effort to mitigate the dangers associated with drilling this well, management decided to use the One-Sack HPWBM and to follow a thoroughly detailed plan for preventing stuck pipe and minimizing mud loss. Contingency plans were carefully detailed for responding to massive lost circulation. Plans called for top setting 9-5/8 inch intermediate casing above the depleted interval, then setting a 7 5/8 inch drilling liner below the depleted sands. Maximum anticipated mud weight was 14.5 ppg.

Drilling proceeded as planned, kicking off at 7,487 feet and building angle to 19°. Multiple depleted sands were encountered, resulting in a maximum differential (Δp) pressure of 5,800 psi. The only problems that caused delays were a motor failure, lost cones from a milled tooth bit, and total mud losses of 99 barrels. Even so, the well was drilled five days ahead schedule, below AFE, with a 16.5 ppg maximum mud weight.

<u>Jefferson Island Salt Dome Field, Vermilion Parish, LA</u>

Continental Resources drilled a directional well with a saturated salt mud through the overhang of the Jefferson Island Salt Dome. After intermediate casing was run through the salt, drilling proceeded through the rubble below the salt overhang. A host of hole problems developed, including torque, drag, differential sticking, sloughing shale, and packing off.

The One-Sack HPWBM was used as an add-on to the existing 13.0 ppg mud system, which then contained 126,000 ppm chlorides. A series of 15 ppb pills were mixed and pumped until a system concentration of 7.5 ppb was attained. The well bore was stabilized, logged and cased with no further problems.

The drilling foreman commented, *""In over 40 years of drilling, I have never seen a mud product work that good and that quick. If we had used this product earlier, Continental could have saved more than $500,000 on this hole."* [2]

<u>Bayou Postillion Field, Iberia Parish, LA</u>

Badger Oil Corporation planned to drill a 42° angle, build-and-hold, well path through three severely depleted sands. Plans called for setting intermediate casing through the depleted sands, then drilling the lower target.

The well was logged once the depleted interval was drilled. Instead of running intermediate casing, Badger management decided to drill ahead to TD (13,300 feet MD) due to the absence of trouble signs such as torque, drag, and mud loss. The well was again logged and deemed to be non-commercial. The well was plugged back with cement and sidetracked from 7,500 feet.

In both the original and the sidetrack holes, differential pressures in excess of 5,000 psi were encountered. The probability of incurring differentially stuck pipe in a 42° angle hole reaches 50% when the Δp reaches approximately 1,530 psi.[3]

With the assistance provided by the One-Sack HPWBM, both wells were drilled ahead of the curve, eliminating two strings of intermediate casing, and without encountering any stuck pipe incidents. As a result, Badger was able to realize a cost savings of about $650,000.

Conclusions

There are direct and indirect costs incurred in the selection and application of drilling fluids. The direct costs are for the mud and chemicals used to build and maintain a mud system used to drill a well; the indirect costs accrue to the operator when a drilling fluid underperforms, causing time and cost overruns.

In the world of aviation, it is said that a flight is a success or a failure before you leave the ground. That's important because a failed flight often results in a deadly crash. Fortunately for us, a failed drilling operation usually just costs more time and money – hundreds of thousands and sometimes millions of dollars.

We should utilize all of the available leverage in the form of tools, technology, and expertise in order to get wells drilled as economically as possible, on the first try. This should be done by using the most efficient approach available, not by following those who do things because that's the way they've always been done.

Regulatory, health, safety, environmental, and legal issues are forcing all of us to reconsider our methods. When we find safer, cleaner, healthier, and less litigious ways to go about running our businesses, we are well served by using and refining those new approaches.

A One-Sack HPWBM can save time and money by allowing a mud system, as well as the personnel and equipment involved in a drilling operation to function more efficiently. This has been demonstrated on a number of real-world tests – on actual wells drilled by operators who were willing to find a better way to get the job done.

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Nomenclature

HPWBM = high-performance water based mud
OBM = oil-based mud
SBM = synthetic-based mud
PPG = pounds per gallon
PSI = pounds per square inch
KLBS = thousand pounds
FPH = feet per hour
ROP = drilling rate of penetration
MD = measured depth
TD = total depth
MBT = methylene blue test
PPM = parts per million
GMS = grams
Δp = differential pressure
WOB = weight on bit

References

1. Tare, U. A., and Mody, F. K.: "Managing Borehole Stability Problems: On the Learning, Unlearning, and Relearning Curve," AADE Technical Conference, Houston, Texas, April 2-3, 2002.
2. Conversation with Bob Stebbins, drilling foreman with Continental Resources, Inc., after successful application of the One-Sack HPWBM.
3. Weakley, R.R.: "Use of Stuck Pipe Statistics To Reduce the Occurrence of Stuck Pipe," Paper SPE 20410 presented at the SPE Technical Conference and Exhibition, New Orleans, LA, Sept. 23-26, 1990.

Shown below are compressed shale wafers, made from shale samples collected from a Unocal well drilled offshore Louisiana. Two 20.0 gram wafers were subjected to hot-rolling for 16 hours in each of a synthetic-based mud (SBM) and a One-Sack HPWBM, then dried and re-weighed. Both muds exhibited excellent shale inhibition as seen by the minimal weight loss of the recovered shale samples.

Control	Eco-Flow (SBM)	One-Sack HPWBM
20.0 gms	19.2 gms	19.3 gms

Fig. 1 - Shale inhibition (Hot Roll/Dispersion) test comparing an SBM with a One-Sack HPWBM

Figure 2

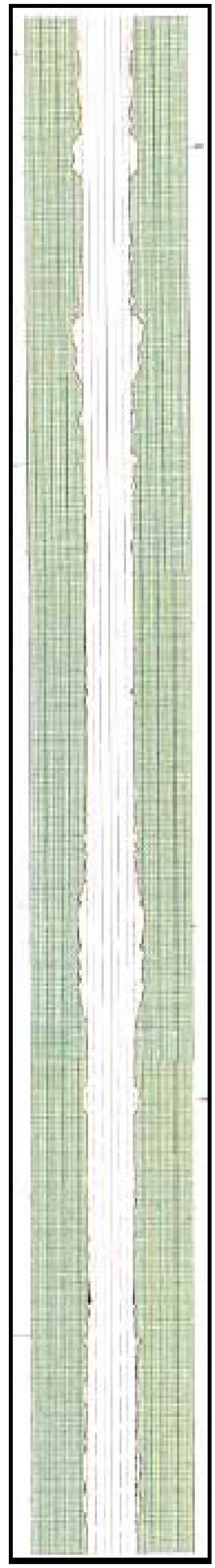

Figure 2: This is a copy of a caliper log from a 9 7/8 inch open hole section of the Spinnaker Exploration High Island 47#1 discovery well. Due to the confidential nature of well information, depths and SP curve have been omitted. Note that the hole is nearly gauge over most of the interval, with washout to about 11 inches in some sections. Overall, washout was slightly more than 12% for the entire interval, demonstrating the inhibitive nature of the drilling fluid used.