# Drill-Sure™ OBM Additive Decreases HTHP Fluid Loss and Enhances Stability

Drill-Sure™ OBM Additive significantly reduces High Temperature High Pressure (HTHP) fluid loss and enhances emulsion stability. Laboratory tests using diesel and mineral oil invert emulsion drilling fluids have shown significant reductions in HTHP fluid loss. In field trials product concentrations of 1.5-2.5 $lb_m$/bbl resulted in HTHP fluid losses of 2-10 mL/ 30 min. The product also enhanced invert emulsion fluid stability as evidenced by an increase in electrical stability (ES). Laboratory and field results are discussed.

## Introduction

Drilling operations are continually searching for improved methods and products for their operations. Performance, cost effectiveness, and supply availability are all important criteria in product selection. A novel additive for use in invert emulsion drilling fluids, Drill-Sure™ OBM Additive (the HTHP additive), has been developed and successfully used in multiple field trials. The HTHP additive was developed to provide superior HTHP fluid loss control as well as providing an available alternative to uintaite, commonly referred to by its trademark name, Gilsonite®[1]. Drill-Sure™ OBM Additive has shown effectiveness in diesel, and mineral oil, based invert emulsion systems.

High fluid loss can lead to increased cost, excessively thick filter cakes, increased torque and drag, increased equivalent circulating density (ECD), difficulties tripping pipe and running casing, substandard cement jobs, and even differential sticking. HTHP fluid loss control is a special area of concern and an area for constant improvement in both aqueous based and non-aqueous based drilling fluids. HTHP fluid loss in invert emulsion drilling fluids can be difficult and costly to control due to the nature of the system and the fact that there are limited product types available to effectively reduce HTHP. Asphalt, Gilsonite®, polyamide resins, and styrene copolymers are commonly used to supplement the inherent fluid loss control of the invert emulsion.

It was determined that a product that provided improved HTHP fluid loss control without significantly affecting rheology or detrimentally impacting electrical stability ES, was needed by the industry. The result was the Drill-Sure™ OBM Additive discussed in this paper.

## Laboratory Development

Potential candidates were evaluated in laboratory diesel based and mineral oil based drilling fluids. The initial base fluid used for screening was a 14 $lb_m$/gallon (1.68 kg/L) diesel oil invert field mud employing organophillic clay, lime, emulsifiers, and wetting agents. The OWR was 75:25 with the brine phase containing 29 weight % $CaCl_2$. The fluid formulation is presented in Table [I] and a summary of the test results in Table [II].

Gilsonite® was used as a reference control HTHP fluid loss additive. Drill-Sure™ OBM Additive and the control both increased the rheology of the base fluid, initially and after hot rolling. The initial PV increase was approximately 25% by both products. The PV of the base fluid and the control exhibited a normal decrease after hot rolling. However, the fluid containing the Drill-Sure™ OBM Additive actually showed a modest PV increase after hot rolling 16 hours at 300 °F (149 °C). A similar effect was observed in YP. Both the Drill-Sure™ OBM Additive and the control exhibited approximately 10% higher initial YP than the base fluid. After hot rolling, the YP decreased in all cases with the Drill-Sure™ OBM Additive maintaining a slightly higher YP than the base fluid or Gilsonite® control. Gel strengths did increase with the addition of the Drill-Sure™ OBM Additive exhibiting slightly higher gel strengths. The gel strengths were essentially flat between 10 minutes and 30 minutes. HTHP fluid loss was low for all the fluids, including the base mud. The HTHP of the fluid containing Gilsonite® was reduced by 46% compared to the base fluid. The HTHP of the fluid containing the Drill-Sure™ OBM Additive was reduced by 65% compared to the base fluid.

The Drill-Sure™ OBM Additive was tested at 6 $lb_m$/bbl in a 14 $lb_m$/gallon laboratory mineral oil based mud. Results were similar to those of the diesel oil base mud with minor effects on rheology and gel strength. HTHP fluid loss using both filter paper and 20 um rated ceramic filter disks decreased to less than 3 mL/30 minutes. The fluid formulation is presented in Table [III]. Although testing in the lab was conducted at 6 $lb_m$/bbl, usage in the field indicates the product provides significant fluid loss at 1/3 this concentration which is what is seen in much of field vs. laboratory testing of products.

**Table I** Diesel OBM Formulation

| Base Fluid (Components mixed in order as listed) | Units | Quantity |
|---|---|---|
| Diesel | bbl | 0.537 |
| Organophillic Clay | $lb_m$/bbl | 6.0 |
| Lime | $lb_m$/bbl | 5.0 |
| Emulsifier | $lb_m$/bbl | 8.0 |
| Oil wetting agent | $lb_m$/bbl | 4.0 |
| Tap water | bbl | 0.178 |
| CaCl2 | $lb_m$/bbl | 25.3 |
| Barite | $lb_m$/bbl | 312.9 |
| Density | $lb_m$/gallon | 14.0 |
| OWR | | 75 : 25 |
| $CaCl_2$ Brine Concentration | | 29% |

**Table II** Results of Laboratory Diesel based OBM

| Sample | Base Fluid | | Base Fluid + 6 $lb_m$/bbl Gilsonite® | |
|---|---|---|---|---|
| | Initial | AHR[1] | Initial | AHR[1] |
| 600/300 (RPM)[2] | 105/76 | 77/50 | 124/88 | 90/57 |
| 200/100 (RPM)[2] | 63/49 | 40/29 | 73/56 | 45/32 |
| 6/3 (RPM)[2] | 28/26 | 14/12 | 31/29 | 14/13 |
| Gel Strengths, (10s/10m/30m) ($lb_f$/100 $ft^2$) | 26/30/30 | 13/17/17 | 29/33/33 | 16/21/21 |
| Apparent Viscosity (cPs) | 52.5 | 38.5 | 62 | 45 |
| Plastic Viscosity (cPs) | 29 | 27 | 36 | 33 |
| Yield Point ($lb_f$/100 $ft^2$) | 47 | 23 | 52 | 24 |
| Electrical Stability @ 150° F (volts) | 992 | 788 | 1074 | 854 |
| API HTHP F.L. (mL/30 minutes) | - | 11.9 | - | 6.4 |
| Filter cake Thickness (mm) | - | 2.0 | - | 1.6 |

**Table II** Results of Laboratory Diesel based OBM (continued)

| Sample | Base Fluid + 6 $lb_m$/bbl Lab Batch [A] | | Base Fluid + 6 $lb_m$/bbl Lab Batch [B] | |
|---|---|---|---|---|
| | Initial | AHR[1] | Initial | AHR[1] |
| 600/300 (RPM)[2] | 129/92 | 108/67 | 122/86 | 118/77 |
| 200/100 (RPM)[2] | 76/59 | 52/36 | 72/56 | 61/44 |
| 6/3 (RPM)[2] | 35/34 | 17/16 | 33/32 | 22/20 |
| Gel Strengths, (10s/10m/30m) ($lb_f$/100 $ft^2$) | 38/50/51 | 27/46/47 | 36/44/47 | 32/50/51 |
| Apparent Viscosity (cPs) | 64.5 | 54 | 61 | 59 |
| Plastic Viscosity (cPs) | 37 | 41 | 36 | 41 |
| Yield Point ($lb_f$/100 $ft^2$) | 55 | 26 | 50 | 36 |
| Electrical Stability @ 150° F (volts) | 1204 | 700 | 1040 | 948 |
| API HTHP F.L. (mL/30 minutes) | - | 4.3 | - | 4.1 |
| Filter cake Thickness (mm) | - | 1.5 | - | 1.7 |

1: AHR After Hot Rolling for 16 hours @ 300 °F (148.9 °C)
2: Rheology measured @ 150 °F (65.6 °C)
3: API HTHP fluid loss @ 500 psi (3450 kPa) differential pressure, 300 °F (148.9 °C)

**Table III** Results with Mineral Oil based Mud (MOBM)

| Properties | Base Fluid | Base Drilling Fluid + 6.0 $lb_m$/bbl Drill-Sure™ OBM Additive |
|---|---|---|
| HTHP Filtrate °F | 300 | 300 |
| HTHP Filtrate ml x 2 | 2.7 | 2.0 |
| % < Base HTHP Fluid loss | - | 25.9 |
| Filter cake thickness mm | 2.51 | 1.81 |
| Electrical Stability @ 120 °F | 793 | 842 (+6.18%) |
| Dynamic Rheology @ °F | 120 | 120 |
| Plastic Viscosity | 37 | 49 |
| Yield Point | 11 | 15 |
| 6 rpm | 6 | 4 |
| 3 rpm | 5 | 3 |
| Gel Strengths, (10s/10m/30m) | 10/27/34 | 5/24/35 |

14.0 ppg 80/20 OWR mineral oil based mud (MOBM) ~ Individual Additive at 6.0 ppb concentration HTHP Fluid Loss with/Filter paper@ 300 °F /Electrical Stability @ 120 °F. 120 °F Rheology results comparison post 16 hr. Hot Roll @ 300 °F

1. Base fluid = 14.0 ppg, 80/20 (OWR) MOBM
2. Base fluid + 6.0 ppb Drill-Sure™ OBM Additive

**Table III** Results with Mineral Oil based Mud (MOBM) continued

| Properties | Base Fluid | Base Drilling Fluid + 6.0 $lb_m$/bbl Drill-Sure™ OBM Additive |
|---|---|---|
| HTHP Filtrate °F | 300 | 300 |
| Disk Size μm | 20 | 20 |
| Spurt Loss ml | 0.2 | 0.05 |
| HTHP Filtrate ml x 2 | 2.9 | 0.90 |
| % < Base HTHP Fluid loss | - | 68.9 |
| Filter cake thickness mm | 1.25 | 1.30 |
| Electrical Stability @ 150 °F | 792 | 793 |
| Dynamic Rheology @ °F | 150 | 150 |
| Plastic Viscosity | 28 | 36 |
| Yield Point | 5 | 9 |
| 6 rpm | 6 | 3 |
| 3 rpm | 4 | 2 |
| Gel Strengths, (10s/10m/30m) | 7/18/21 | 4/19/26 |

14.0 ppg 80/20 OWR MOBM ~ Individual Additive at 6.0 ppb concentration HTHP Fluid Loss with/20 μm Disk @ 300 °F/Electrical Stability @ 150 °F/150 °F Rheology results comparison post 16 hr. Hot Roll @ 300 °F

1. Base fluid = 14.0 ppg, 80/20 (OWR) MOBM
2. Base fluid + 6.0 ppb Drill-Sure™ OBM Additive

## Field Trials

### *Well 1*

The first field trial for Drill-Sure™ OBM Additive was conducted in Karnes County, Texas in the Eagleford shale play. The diesel OBM used for the first trial had been used on three previous jobs and utilized Gilsonite® and styrene based polymer to control the HTHP fluid loss. As per the operator, the HTHP requirement was 12-14 mL in the vertical section, then 10-12 mL through the curve and lateral sections. The ES was to be maintained between 300-400 volts and the water phase salinity range between 225K-250K mg/L chlorides. For this field trial the Drill-Sure™ OBM Additive would be used exclusively to maintain the HTHP fluid loss. The surface interval was drilled with WBM and surface casing set at 5,220 feet. The temperature profile for this well was moderate with a temperature of 150 °F at the shoe, 215 °F at the top of the curve, 220 °F at the bottom of the curve, with the lateral reaching 260 °F.

Day 1: After setting surface casing, the diesel OBM from the previous job was transferred into the rig pits, and the WBM was displaced out of the hole. The OBM was centrifuged to remove solids, which reduced the density from 11.9 $lb_m$/gallon to 10.3 $lb_m$/gallon. A mud check was conducted after two complete circulations. The HTHP was 10 mL and no treatment was required. The evening mud check was conducted at 6,815 feet, and the HTHP had increased to 14 mls.

**Table IV** Well 1 Initial Mud Properties

| MW | PV | YP | ES | HTHP (250 °F) | OWR | LGS (wt. %) |
|---|---|---|---|---|---|---|
| 10.3 | 11 | 8 | 484 | 10 | 72/28 | 6.3 |

Day 2: Drilling resumed after 12 hours of mud pump repair and tripping time. One-half $lb_m$/bbl Drill-Sure™ OBM Additive was added to mud system. Three hundred bbls of used OBM were added into the active system to maintain pit volume. The evening mud check was done at 9,100 feet; the HTHP had decreased to 10 mls. The mud engineer increased the concentration of the Drill-Sure™ OBM Additive to 1 $lb_m$/bbl. Five hundred fifty bbls of virgin mud were delivered to location for makeup volume. The KOP, 10,287 feet, was reached, and a trip was made to pick up new directional tools.

Day 3: The trip for directional tools occurred without incident. Drilling resumed, and the mud was checked after 2 circulations. The HTHP fluid loss had decreased to 9 mls. While building the curve, 100 bbls of fresh mud was transferred in, and the Drill-Sure™ OBM Additive concentration was maintained at 1 $lb_m$/bbl.

Day 4: Hole volume was maintained with diesel oil while continuing to build the curve. One $lb_m$/bbl Drill-Sure™ OBM Additive was maintained in the system, and the HTHP fluid loss remained at 9 mls. The mud density was increased to 10.8 $lb_m$/gallon according to the weight up schedule. Once the hole angle reached 50 degrees, tandem low viscosity and weighted sweeps were pumped to aid with hole cleaning. The low viscosity sweeps were made by adding approximately 15 bbls of diesel to 35 bbls of mud from the active system. The evening HTHP fluid loss had increased to 12 mls the Drill-Sure™ OBM Additive to 1.5 $lb_m$/bbl. The mud density was increased during the night to 11.2 $lb_m$/gallon to control background gas.

Day 5: The morning mud check showed the HTHP fluid loss had decreased to 8 mL with a 1.5 $lb_m$/bbl concentration of the Drill-Sure™ OBM Additive. The mud motor failed. The rig tripped for a new bit and motor without incident.

Day 6: Drilling resumed, and the curve section was completed. The morning mud check reported the HTHP fluid loss had increased to 25 mls. It was determined the sample most likely included some unincorporated low viscosity sweep. To be on the safe side, the mud engineer increased Drill-Sure™ OBM Additive concentration to 2.0 $lb_m$/bbl. The evening mud check showed that the HTHP fluid loss had decreased to 8 mls. The mud density was increased during the night to 11.8 $lb_m$/gallon to control background gas.

Day 7: The drilling of the lateral continued without incident. No additional Drill-Sure™ OBM Additive was added which allowed the HTHP fluid loss to increase into the desired range of 10-12 mls

Day 8: TD was reached at 16,210 feet. The final HTHP fluid loss was 12 mL at a concentration of 1.5 $lb_m$/bbl HTHP additive in the mud system. There were no reported problems while running casing.

The Drill-Sure™ OBM Additive performed very well with respect to HTHP fluid loss. Typically the mud company uses an average of 6,000 lb of Gilsonite® and 1,000 lb of a styrene based polymer per job. This well used only 4,700 lb of Drill-Sure™ OBM Additive. Table [V] shows the HTHP additive used in this field trial compared to fluid loss additives used previously. Typically, a single centrifuge is run continuously during drilling to help lower the low gravity solids in the mud. The mud engineer felt their setup stripped out a large portion of the Gilsonite®. Running the centrifuge had no effect on the HTHP for this system. The centrifuge was run during trips as well to help clean the mud, and there was not any increase in the HTHP after trips. It was impossible to notice any loss of Drill-Sure™ OBM Additive over the shaker screen. However, due to the performance of the product, it is unlikely any was lost over the 200 mesh screens. The operator's relatively high HTHP fluid loss requirement was achieved with low HTHP additive concentrations. With regards to torque and drag there was little room for improvement. The trips went without incident and the 5,000 foot laterals typically drilled in this area don't have many issues with torque. Beginning with a fresh untreated mud would allow for a greater concentration of Drill-Sure™ OBM Additive to be incorporated into the mud and allow for the possibility of benefits to ROP, torque and drag.

**Table V** Fluid Loss Additive Concentration Comparison vs. cost performance against a typical Eagleford well

| | Field Trial Well 1 | Previous Fluid Loss Systems | |
|---|---|---|---|
| Per Well | Drill-Sure™ OBM Additive | Gilsonite® | Styrene based polymer |
| Average Amount Used | 2.0-2.5 $lb_m$/bbl | 4-5 $lb_m$/bbl | 0.25-0.85 $lb_m$/bbl |
| Product usage | 96 sack | 120 sacks | 20 sacks |
| Percentage saved | 31.5 | | |

***Well 2***

Based on the results of the first trial, the operator and service-company elected to use Drill-Sure™ OBM Additive in a second well in Karnes County, Texas in the Eagleford shale play. After setting surface pipe at 5,227 feet, the water based fluid was displaced with a 10.5 $lb_m$/gallon new (unused) diesel OBM, so there were no residual fluid additives in contrast to the used mud in the first trial.

**Table VI** Well 2 Initial Mud Properties

| MW | PV | YP | ES | HTHP (250 °F) | OWR | LGS % |
|---|---|---|---|---|---|---|
| 10.5 | 22 | 11 | 361 | 18 | 74/26 | 5.1 |

Once the new diesel OBM was circulated, the Drill-Sure™ OBM Additive was added to an initial concentration of 0.9 $lb_m$/bbl. The concentration was increased in stages to achieve the recommended HTHP fluid loss of 10 mL/30 min. This was reached with a Drill-Sure™ OBM Additive concentration of 2.2 $lb_m$/bbl. The well was drilled to a total depth of 16,107 feet MD in 6 days with a final mud density of 11.8 $lb_m$/gallon. The mud recovered from the first trial was used to supplement mud volumes in the second trial. As in the first well, low viscosity, weighted sweeps were pumped every 500 feet in the horizontal section as a standard recommendation by the service company.

Rate of Penetration for the 2nd intermediate section (5,221 feet to 10,235 feet) of the well was 233 feet per hour which included connection times. *The company man and mud engineer both reported that this was the fastest they had ever drilled this interval. When pulling drill pipe wet, the Co. man, driller and mud engineer reported that they pulled about 40,000# less than they would normally pull off bottom and there were no problems pulling the first 10 stands when tripping out to lay down the drill string.* At TD the maximum hook load was 274 K $lb_f$ even though this well had a nasty 18 degree dog leg at the bottom of the well. The mud engineer reported that a normal hook load range for previous wells had been between 290-300 K $lb_f$.

**Table VII** Fluid Loss Additive Concentration Comparison vs. cost performance against a typical Eagleford well

| | Field Trial Well 2 | Previous Fluid Loss Systems | |
|---|---|---|---|
| Per Well | Drill-Sure™ OBM Additive | Gilsonite® | Styrene based polymer |
| Average Amount Used | 2.0-2.5 $lb_m$/bbl | 4-5 $lb_m$/bbl | 0.25-0.85 $lb_m$/bbl |
| Product usage | 112 sack | 120 sacks | 20 sacks |
| Percentage saved | 20 | | |

***Well 3***

The third field trial was conducted in Roger Mills County, Oklahoma. Casing was set at 7,745 feet, and 600 barrels of new 7.7 $lb_m$/gallon 80:20 OWR diesel OBM was used to displace the WBM. The mud was checked after two circulations, and the initial HTHP fluid loss was 15 mL. There was water in the filtrate indicating the emulsion was not stable. The Drill-Sure™ OBM Additive was added for a concentration of 1.5 $lb_m$/bbl. The OBM began to stabilize with no water in the filtrate. The Drill-Sure™ OBM Additive concentration was increased to 2.0 $lb_m$/bbl resulting in an HTHP fluid loss of 6.6 mL. As the solids began to accumulate and the electrical stability increased, the fluid loss decreased to 4.2 mL. As requested by the operator, the HTHP fluid loss was maintained <5 mL which required a concentration of 2.2 to 2.3 $lb_m$/bbl of Drill-Sure™ OBM Additive. Over the duration of the well, the electrical stability decreased slightly, and subsequently a slight increase in the fluid loss was observed but remained less than 5 mL.

HTHP filter cake at 250 °F before and after washing well #3

***Well 4***

The candidate well for this case study was one of 5 Bakken wells located on the same pad in Williams County, ND. The vertical and curve sections of the directional wellbores were drilled in succession; the laterals were to be completed once all the curves were drilled on the pad. The two offset wells had been drilled prior to the test well and the mineral based OBM was reused on each. The two offset wells used a competing product to control HTHP and provide wellbore stability. The operator of these wells required an HTHP of 4.0 mL or less through the vertical and curve interval. The mud out of storage had a HTHP of 2.0 mL from previous treatments on the last offset; the offsets had an out of storage HTHP < 3.0 mL as well. A 1.5-2.0 pound per barrel (ppb) concentration of the Drill-Sure™ OBM Additive was the only additive used to maintain the fluid loss on the test well. Both offset wells consumed over 100 sacks of the product in contrast to the 80 sacks of the Drill-Sure™ OBM Additive used on the test well. This resulted in an average cost savings to the operator of $2,850 compared to the two offset wells. The average HTHP for the test well was 2.4 mL. Additionally, the test well had an average ROP higher than seen on the test wells in the vertical section of the hole. After KOP was reached, poor penetration was observed due to an incorrect bit and motor assembly; consequently an extra trip occurred on the test well. Once the proper curve assembly was run, the test well continued to drill at a higher penetration rate than both offsets, as depicted by Figure [1]: Days vs. Depth.

With respect to trips and the drag observed during each, the test well exhibited an average over pull in between that of the two offsets see Figure [2]: Avg. Trip Over pull per Trip with an overall trend of less over pull observed. This phenomenon can be attributed to the observable filtercake quality depicted in Figures [4-6]. Most noticeably, the filtercakes containing the Drill-Sure™ OBM Additive did not dehydrate nor crack and remained slicker in contrast to the first two filtercakes with no additive concentration. The improved filtercake likely facilitated the 7" intermediate casing run but is not conclusive due to the directional dog leg created by the improper bottom hole assembly that was responsible for the additional trip. This factor being a differentiating occurrence between the offsets and test well as its impact was observed during the casing run. The casing was washed & worked to bottom (~244 Klbs) and successfully cemented.

Other than the observed improvements in HTHP and filtercake quality on the test well, all other mud properties including rheology, gel strengths, and emulsion did not differ from the offsets. The downhole losses on the test well were in between the two offsets, totaling 345 bbls Figure [7]. The drilling conditions were improved on the test well as seen by the drilling time saved in Figure [1]. Improved mud properties arguably had a hand in better performing drilling conditions; to what extent can only be proven with more field trials and offsets. The efficacy of the Drill-Sure™ OBM Additive is demonstrated by achieving the same mud properties on all three wells, with a 32% reduction in product consumed on the test well, equating to 20% cost savings to the operator Figure [3]: Cost Savings of Less Product Usage. In this case, less does in fact become more with fewer products on location and less quantity used equals more dollars saved; not just on the mud bill but in the overall drilling operation! A detailed summary of this well is shown in Tables [VIII] and [IX].

**Figure 1: Drilling time days vs. depth**

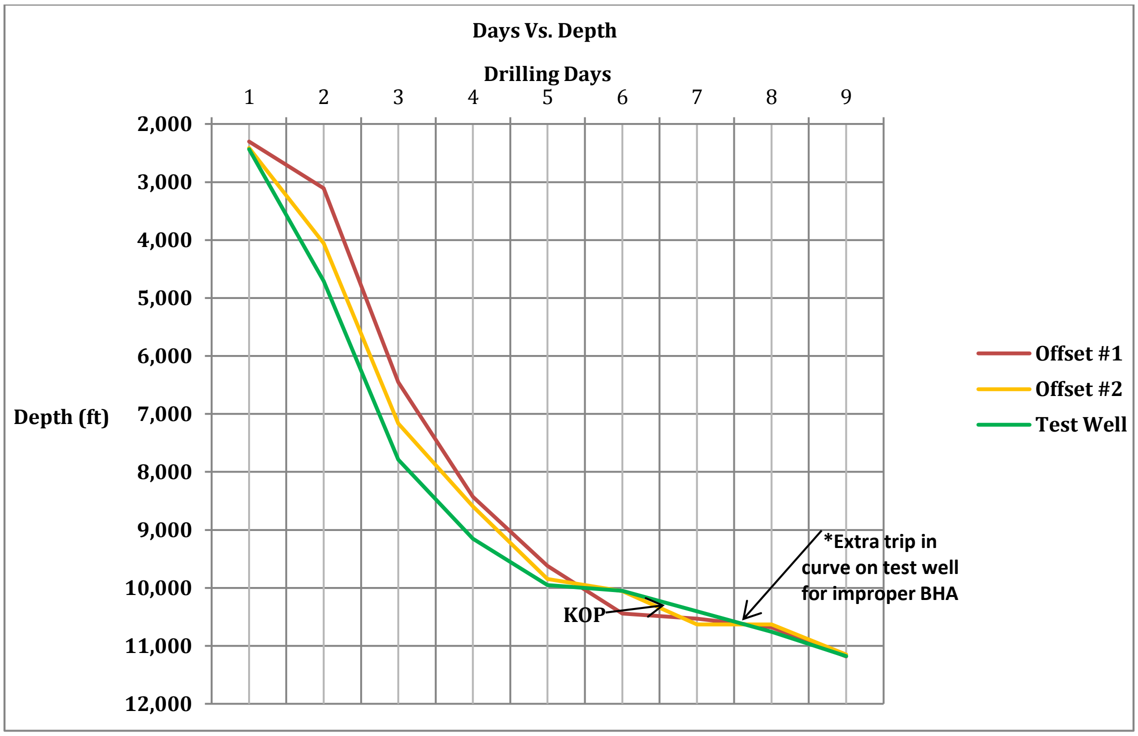


**Figure 2: Average Trip Overpull per Trip**

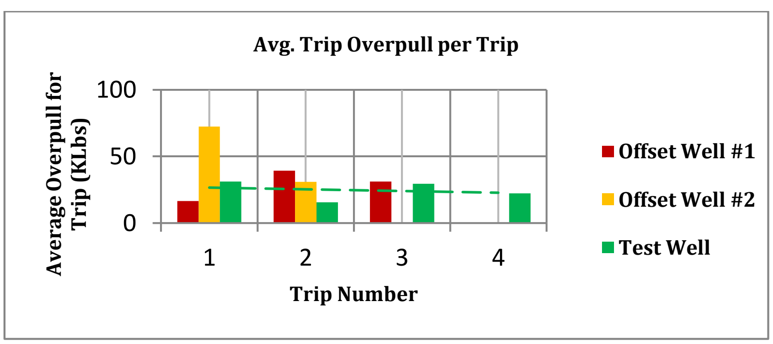

**Figure 3: Cost Savings of Less Product Usage**

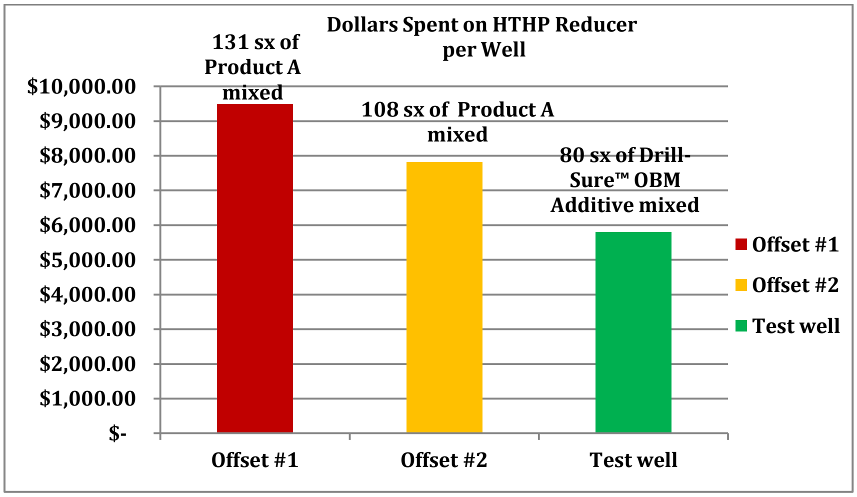


**Figure 4: First 3 filtercakes; HTHP additions were made on the 2nd day for a 1.5 ppb concentration. The thin, slick, & hydrated filtercake results are demonstrated on the 3rd day by the filtercake on the right.**

**Figure 5: Filtercakes for 6 days of drilling**

**Figure 6: Final filtercake @ 2.0 ppb concentration**

**Figure 7: Losses for test well and two offsets**

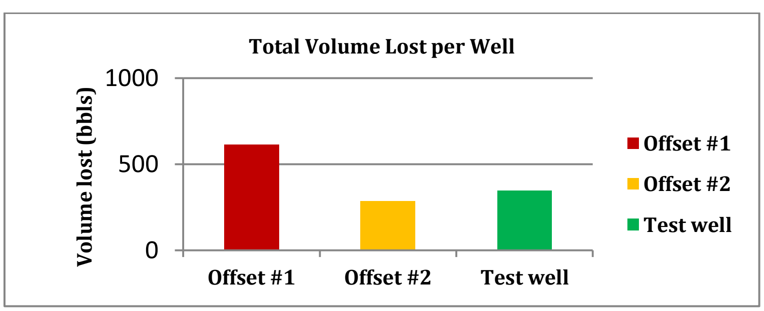

**Table VIII:** First 5 days of test well data

| Date | 4/22/2014 | 4/23/2014 | 4/24/2014 | 4/25/2014 | 4/26/2014 |
|---|---|---|---|---|---|
| Depth(MD)' | 4709 | 7790 | 9150 | 9951 | 10,050 |
| Drilling Activity & Comments | Crew drilled out surface at 18:00 on 4/21/14. Drilling ahead | Drilling ahead in vertical section | Pumped 25 bbls fresh water sweep to loosen up salt zones; thus a slight increase in VIS and HTHP. Drilling ahead. Built 150 bbls of volume w/ base oil & brine | Drilled 801' to 9,951' & tripped due to low ROP; P/U new motor/bit to drill additional ~400' to KOP of 10,400'; RIH at time of report. 100 bbls of volume built | Finished RIH w/ no problems. Down several hours for rig repairs. Resumed drilling w/ average ROP of 50 ft./hr. 200 bbls of volume built |
| Tourly Treatment | Mix: Organophilic clay 4 sx, Lime 10 sx, primary & secondary emulsifier | Mix: Organophilic clay 4 sx, Lime 10 sx, primary & secondary emulsifier & 20 sacks of the Drill-Sure™ OBM Additive | Mix: Organophilic clay 4 sx, Lime 10 sx, 172 sx barite, primary & secondary emulsifier & 20 sacks of the Drill-Sure™ OBM Additive | Mix: Organophilic clay 5 sx, Lime 15 sx, primary & secondary emulsifier, barite as needed to maintain weight | Mix: Organophilic clay 10 sx, Lime 15 sx, primary & secondary emulsifier, barite as needed to maintain wt. Mix 15 sx of the Drill-Sure™ OBM Additive |
| Observed Impact of HTHP additive, rheology, drilling conditions, hole stability, etc. | Filtercake is dehydrated and fluffy | Began HTHP additive Additions today. Starting concentration of .76 ppb is being added over 2 circulations | Filtercake has thinned and slickened up marginally. <u>Nutplug has been the only LCM addition to clean the bit;</u> this is an improvement over previous wells where there has been losses in the Dakota and Misson Canyon formations | 40 sx of the HTHP additive have been mixed. A 3.8 mL reduction in HTHP and improved filtercake quality observed. Filtercake is slick & compressed with an observed reduction in thickness of 1/32. Backing off Drill-Sure™ OBM Additive additions for next 24 hrs. until curve is reached | Continued to observe improvements in HTHP and filtercake. Filtercake is further compressed and the thinnest recorded of any offset. It has an excellent sheen and is quite slick. A total of 1,800 bbls has been treated thus far |

**Table IX:** Next 6 days of test well data

| Date | 4/27/2014 | 4/28/2014 | 4/29/2014 | 4/30/2014 | 5/1/2014 | 5/2/2014 |
|---|---|---|---|---|---|---|
| Depth(MD)' | 10,405 | 10,655 | 10,759 | 11,180 | 11,180 | 11,170 |
| Drilling Activity & Comments | Drilled 355' to KOP of 10,405', circulated bottoms up & POOH for curve assembly. RIH, light reaming & washing thru salts from 8564'-9402'. Continue to RIH at 9,586' at time of report. | Drilling/sliding ahead. 100 bbls of volume built since drilling resumed. Sliding ahead @ 8-15 ft./hr. | Drilled to 10,759' had difficulty holding directional tool face and ROP <15 ft. /hr. with 5 blade PDC. POOH to P/U tricone bit. Approx. 40 bbls of fresh water were added to system prior to trip. | Continuing to build curve; 85° inclination at time of report. Should reach TD within next 20' | Encountered some drag during casing run; packed off, & broke circulation w/ 1300 psi of standpipe pressure | Landed 7" casing @ 11,170' and cemented. |
| Tourly Treatment | Mix: Organophilic clay 10 sx, Lime 15 sx, primary & secondary emulsifier, barite as needed to maintain weight | Mix: Organophilic clay 4 sx, Lime 15 sx, primary & secondary emulsifier , barite as needed to maintain wt. Mix 5 sx Drill-Sure™ OBM Additive | Mix: Organophilic clay 4 sx, Lime 15 sx, primary & secondary emulsifier, barite as needed to maintain wt. Mix 10 sx Drill-Sure™ OBM Additive | Mix: Organophilic clay 4 sx, Lime 15 sx | No further treatment | No further treatment |
| Observed Impact of HTHP additive on, rheology, drilling conditions, hole stability, etc. | Less over pull observed on this trip than seen on prior trips for both this well and offsets (see trip conditions tab). The drying out and cracking of the filtercake has not been observed since the Drill-Sure™ OBM Additive additions. <u>Achieved a HTHP of less than 1.0</u> | Filtercake is marginally thicker with a 1.2 mL increase in HTHP. Making the HTHP additive additions to maintain at 1.5 ppb concentration. A total of 55 sacks of Drill-Sure™ OBM Additive have been mixed thus far | ~1950 bbls of active mud has been treated. Filtercake is not as consolidated and thin as previous cakes. Could be a result of making fresh water additions and not circulating for 14 hrs. Increasing concentration to 1.8 ppb once back on bottom | A total of 80 sacks of the Drill-Sure™ OBM Additive was been added to the system for a 2.0 ppb concentration. Filtercake has thinned again and appears slicker at the 2.0 ppb concentration | | |

**Conclusions**

- Although laboratory data had indicated adding large concentrations of Drill-Sure™ OBM Additive in a short amount of time would lower yield point and gel strengths it was not observed in the field trials.
- Additions of Drill-Sure™ OBM Additive resulted in an ES increase and stability.

- The HTHP filter cakes were thin (1-2/32 inch), tough and slick.
- Field usage showed that small concentrations of Drill-Sure™ OBM (1.5-2.0 ppb) were sufficient to control HTHP filtrate, reduce the thickness of filter cakes and reduce torque and drag.
- Company Man and Driller noted. "It seems to help on drag; we pulled 30-40K less off bottom than we normally do."
- The Company Man also said, "The excess drag seemed to be non-existent while pulling out the hole laying down drill pipe."
- The Drill-Sure™ OBM Additive worked well in the trials compared to the Gilsonite® and the styrene copolymer that is normally used.

It has been shown that Drill-Sure™ OBM additive, a novel oil based drilling fluid additive, significantly reduces HTHP fluid loss and enhances emulsion stability. Laboratory tests using both diesel and mineral oil invert emulsion drilling fluids have shown significant reductions in HTHP fluid loss at concentrations of 6 $lb_m$/bbl or less. Field trials had similar reductions in HTHP fluid loss at concentrations of 2-3 $lb_m$/bbl. Both lab tests and field trials confirmed increased emulsion stability. Field trials show decreased torque and drag when pulling off the bottom and tripping out of the hole.

**Nomenclature**

Define symbols used in the text here unless they are explained in the body of the text. Use units where appropriate.

*AHR* = *After Hot Roll*
*API* = *American Petroleum Institute*
*BHR* = *Before Hot Roll*
*bbl* = *barrel*
*cPs* = *centipoise*
*°C* = *degrees Centigrade*
*°F* = *degrees Fahrenheit*
*ECD* = *Equivalent Circulating Density*
*ES* = *Electrical Stability*
*HTHP* = *High Temperature High Pressure*
*K* = *Thousands*
*KOP* = *Kick Off Point*
*kpa* = *kilopascals*
*LGS* = *Low Gravity Solids*
*lb* = *pound*
$lb_f$ = *Pounds force*
$lb_m$ = *Pounds mass*
*m* = *minute*
*MD* = *Measured Depth*
*mL* = *Milliliters*
*MW* = *Mud Weight*
*OBM* = *Oil Based Mud*
*OWR* = *Oil Water Ratio*
*psi* = *Pounds force per square inch*
*PV* = *Plastic Viscosity*
*ROP* = *Rate of Penetration*
*RPM* = *Revolutions per minute*
*RIH* = *Running In Hole*
*s* = *seconds*
*TD* = *Total Depth*
*WBM* = *Water Based Mud*
*YP* = *Yield Point*

**References**

1. Registered trademark of American Gilsonite Company Corporation Oklahoma.

**Packaging:** Standard packaging is in 40 lb bags 50 bags to the pallet.

**For more information on Drilling Specialties Company products see our web site at [www.drillingspecialties.com](www.drillingspecialties.com)**