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Organo-Clay-Free Non-Aqueous Fluid Provided Better Solution Creation and Problem Resolution

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Abstract

Stuck pipe incidents in the study selected areas provide the greatest contribution to non-productive time while drilling/tripping through unstable shale formations in buildup sections and permeable sandstone lateral reservoir sections. A standard non-aqueous fluid (NAF) has traditionally been used to drill through these sections. This paper describes the performance of Organo-Clay-Free NAF, as compared to standard NAF.

Organo-Clay-Free NAF was introduced to replace conventional NAF. The low solids content and excellent fluid loss control properties made by the polymeric package creates a slick filter-cake that is more resistant to differential sticking. Meanwhile, the fluid provides a fragile gel structure which assists in reducing wellbore cycling pressure while allowing for faster trip times. A performance comparison of the Organo-Clay-Free NAF and a standard NAF was performed using data from 55 intervals in three Areas where standard NAF was used, and data from 44 intervals drilled using Organo-Clay-Free NAF.

The Organo-Clay-Free NAF helped to provide better performance, as compared to the standard NAF; stuck pipe incidents and wellbore stability issues were reduced by 38%. In addition, capability to resist contamination helped to provide better performance with high water content while still providing the required inhibition, especially while tripping or running casing through sensitive formations; the average tripping time was reduced by 32%. The Organo-Clay-Free NAF helped to reduce base oil consumption by 20%. Because the Organo-Clay-Free NAF consists of fewer products, the required chemicals recorded as 61% less than that required for a standard NAF, reducing logistics in offshore operations.

Introduction

During drilling operations in three challenging Areas, a standard nonaqueous fluid (NAF) system was used to drill through the buildup section and long lateral sections. After reviewing the data from these areas, several issues were identified, including differential sticking and unstable shale. Stuck pipe incidents significantly contribute to nonproductive time (NPT) incurred while drilling/tripping in buildup and lateral reservoir sections. To help address these issues, an organoclay-free NAF system was proposed. This paper discusses the use of the organoclay-free NAF system during drilling operations in the three areas and compares its performance with the standard NAF system.

The standard NAF system was used to ensure good inhibition across sensitive shale formations and to help mitigate stuck pipe incidents, particularly while drilling a buildup section and long lateral sections in the minimum stress direction. Despite the use of NAF, the areas proved challenging and the following issues were observed after reviewing the data in the Areas and comparing offset wells:

- Unstable shale formations
- Hole cleaning issues in the buildup section with high doglegs
- Differential sticking incidents while running lower completion screens

In view of the above issues, the mud system was changed from standard NAF to high performance organo-clay-free NAF. Organo-clay-free NAF key differentiators from standard NAF include formulation with strong emulisifier package, synthetic polymeric fluid loss agents and organic rheology modifiers that replace the traditional organophilic clays and natural product fluid loss agents. This specific fluid was engineered fit-for-purpose with a 20% lower OWR and reduced solids percentage without a higher rheology profile thereby providing a lower ECD during drilling operations as compared to the standard NAF. In addition, the fluid allowed for smooth trips in and out of the hole giving better performance in key areas of concern for the customer.

After using the organo-clay-free NAF technology during drilling operations, a great success was achieved by reducing logistics, mixing time, and minimizing NPT related to stuck pipe and lost circulation incidents, In addition the achievements associated with the increase in recycled volumes helped optimize the cost per barrel and cost per foot. A comprehensive study of the performance, volume, and chemical consumption in 97 intervals was completed to demonstrate the benefits of using the organo-clay-free NAF system during such operations.

Standard NAF fluids in the subject operations area are built using a combination of traditional primary and secondary emulsifier products available from a wide range of suppliers. These have been used successfully for over 60 years in the industry. Although primary emulsifiers bring benefits such as

reduced filtrate and high-temperature tolerance, they can also limit the yield of organoclay viscosifiers and increase the PV of the system.

The Organo-Clay-Free NAF fluid utilizes a strong emulsifier package at lower concentrations than standard NAF with very strict control of manufacturing and quality. It has been formulated to provide optimum performance in systems without organophilic clays. This allows for the other system components to reach full yield and provide fragile gels and flat rheology characteristics. The secondary emulsifier is a highly concentrated tall oil derivative which adds supplemental filtration control and high-temperature stability. Although it can cause slight thinning in fluid systems at higher temperatures, it is typically used at less than ¼ the total amount of emulsifier package to limit these effects and maximize the benefits.

This Organo-Clay-Free NAF specific fluid was engineered fit-for-purpose with a 20% lower OWR and reduced solids percentage without a higher rheology profile thereby providing a lower ECD during drilling operations as compared to the standard NAF. In addition, the fluid allowed for smooth trips in and out of the hole giving better performance in key areas of concern for the customer.

Key Performance Indicators (KPIs)

The following KPIs were set to recognize the benefits of using the organo-clay-free NAF system during drilling operations in Areas A, B, and C:

- Good hole stability: reducing or eliminating reaming trips before running casing
- Savings in time and logistics: minimizing dilution rates, obtaining less treatment, and minimizing mud conditioning time compared to the standard NAF system

The organo-clay-free NAF formulated at 60:40 oil/water ratio (OWR) to reduce the base oil consumption and increase the recycled volumes percentage. During this study, the KPIs tracked to help realize savings in operations NPT, logistics, and chemicals requirements.

Formulation of Organo-Clay-Free NAF

Products	Concentrations “ppb”
Primary Emulsifier	7 to 8
Viscosifier	2
Rheology Modifier	1 to 2
Fluid Loss Reducer	2
Fluid Loss Reducer	1 to 2

Formulation of Standard NAF

Products	Concentrations “ppb”
Primary Emulsifier	10 to 12
Secondary Emulsifier	5 to 6
Viscosifier	8 to 10
Rheology Modifier	2
Fluid Loss Reducer	10 to 12
Lignite	3 to 4

Performance Review

To obtain a reasonable comparison, this study initiated to compare the performance of the organo-clay-free NAF with the standard NAF system in three challenging areas (areas A, B, and C). Data from 53 different hole sections (12.25, 8.5, and 6 1/8 in.) drilled using the standard NAF system were compared to the 44 intervals drilled using the organo-clay-free NAF system in similar wells in the same area. This study included the operation performance and recorded incidents, such as stuck pipe, lost circulation, and hole instability. Tripping/reaming hours also recorded. The same parameters used to evaluate the two fluids during similar conditions on the same rigs. Additionally, the study included the used volumes and number of pallets of chemicals required, along with the recycled volumes percentage for each fluid type (Tables 1, 2 & 3).

Table 1—Standard NAF performance for Areas A, B, and C.

Area/Section (in.)	Average Recycled Volume (bbl)	Recycled Volume (%)	MT chemicals	Downhole Losses (%)	Hole Instability (%)	Stuck Pipe incidents	Tripping Hours
A/12.25	1,934.1	47	1.95	47	65	3	29.9
A/8.5	1,859.0	56	1.4	22	56	1	40.5
A/6 1/8	1,538.5	77	1.6	0	0	0	7.5
B/12.25	1,582.3	49	1.6	33	67	1	15.7
B/8.5	1,333.0	76	1	33	33	0	26.5
B/6 1/8	975.0	81	0.6	0	0	0	5.0
C/12.25	2,459.2	74	1.5	20	100	0	27.4
C/8.5	1,974.5	73	1	30	30	2	30.2
C/6 1/8	2,608.9	92	1.1	0	0	0	10.3
Average of All Areas for Standard NAF							
	1,807	**69**	**1.3**	**21**	**39**	**0.7**	**21.4**

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Table 2—Organo-Clay-Free NAF performance for Areas A, B, and C.

Area/Section (in.)	Average Recycled Volume (bbl)	Recycled Volume (%)	MT chemicals	Downhole Losses (%)	Hole Instability (%)	Stuck Pipe incidents	Tripping Hours
A/12.25	5,473.0	90	0.96	0	17	1	15.00
A/8.5	1,998.7	91	0.1	0	0	0	10.00
A/6 1/8	2,364.0	96	0.2	0	0	0	10.00
B/12.25	2,058.7	85	0.7	0	14	0	12.43
B/8.5	2,673.3	90	0.9	29	0	0	24.17
B/6 1/8	2,008.0	81	1.4	0	0	0	4.33
C/12.25	2,067.8	77	0.2	0	0	0	37.50
C/8.5	1,704.9	71	0.1	14	0	1	15.33
C/6 1/8	2,043.5	94	0.1	0	0	0	9.00
Average of All Areas for Organo-Clay-Free NAF							
	2,488	**86**	**0.5**	**5**	**3**	**0.2**	**15.3**

Table 3—Standard NAF vs Organo-Clay-Free NAF tripping performance for Areas A, B, and C.

Area/Section (in.)	Hard Reaming Events	Precautionary Reaming Events	Reaming Free Sections	Total Reaming Events
A/12.25	7	6	0	13
A/8.5	7	1	0	8
A/6 1/8	0	2	0	2
B/12.25	4	2	0	6
B/8.5	2	1	0	3
B/6 1/8	0	1	0	1
C/12.25	4	1	0	5
C/8.5	5	5	0	10
C/6 1/8	3	3	0	6
Average % of reaming events in all Areas for standard NAF				**54**
	59%	**41%**	**0%**	

Area/Section (in.)	Hard Reaming Events	Precautionary Reaming Events	Reaming Free Sections	Total Reaming Events
A/12.25	2	1	0	3
A/8.5	0	1	2	3
A/6 1/8	0	2	0	2
B/12.25	1	3	3	7
B/8.5	1	2	4	7
B/6 1/8	0	3	0	3
C/12.25	1	2	0	3
C/8.5	2	7	4	13
C/6 1/8	0	2	0	2
Average % of All Areas for Organo-Clay-Free NAF				**43**
	16%	**53%**	**30%**	

Optimized Logistics

Optimized logistics in drilling operations can help save transportation/shipping costs, as well as rig space. Organo-clay-free NAF systems contain fewer products than standard NAF systems, and the higher water ratio can help optimize consumption and rig space for calcium carbonate bulk bags (2,200 lb). The required organo-clay-free NAF chemicals on pallets are 60% less than standard NAFs (Fig. 1) In addition, the higher water ratio used in Organo-Clay-Free NAF system reduced the weighting materials consumption as calcium carbonate bulk bags (2,200 lb); in standard NAF, weighting material is used in larger quantities to compensate for the difference between base fluid density, and brine density. The required Organo-Clay-Free NAF weight of chemicals are 39% less than standard NAFs. Using the standard NAF system, the average weight of chemicals used was 1.6 MT for Area A, 1.1 MT for Area B, and 1.2 MT for Area C. However, for the same number of sections and using the Organo-Clay-Free NAF

system, the average weight of chemicals was 0.4 MT for Area A, 1 MT for Area B, and 0.1 MT for Area C (Fig. 1).Using the standard NAF system, the average number of pallets was 72 for Area A, 48 for Area B, and 54 for Area C. However, using the organo-clay-free NAF system, the average number of pallets was 18 for Area A, 44 for Area B, and 6 for Area C.

A comparison performed as per customer request to estimate the space for the chemicals required to build 3,000 bbl using a standard NAF vs. the same volume using the organo-clay-free NAF system (Fig. 2). The organo-clay-free NAF chemicals require 21% less space compared vs. the standard NAF system. Fewer chemicals mean less lifting, reduced health, safety, environmental (HSE) hazards, and less time.

Recycled Volumes

NAF systems can provide cost-saving benefits because they are recycled from one well to another, which helps save rig time associated with mixing new volumes and optimizes chemicals consumption. The organo-clay-free NAF system built with a 60:40 OWR, whereas standard NAF systems are normally built with an 80:20 OWR. This means a 20% reduction of base oil consumption, in addition to cost savings for shipping base oil to the rigs. The stable 60:40 OWR of the organo-clay-free NAF system with the minimum required dilution and fewer lost circulation incidents helped increase the recycled volumes percentage vs. standard NAF systems, hence meeting the KPI of minimizing dilution rates and obtaining less treatment. A 17% improvement in recycled volumes recorded using the organo-clay-free NAF vs. the standard NAF system (Fig. 3).

Incidents of Downhole Losses

Downhole losses while drilling with NAFs is costly, in terms of lost volumes and the rig time necessary to cure losses, particularly during drilling operations. Increasing the mud weight could help provide wellbore stability while drilling a buildup section and prevent caving in of the sensitive shale; however, it might induce losses. During drilling in Areas A, B, and C, overall downhole losses incidents recorded at 21% using the standard NAF system compared to 5% using the organo-clay-free NAF system.

Using standard NAF system, average downhole losses recorded at 23% in Area A, 22% in Area B, and 17% in Area C. Using the organo-clay-free NAF system, lost circulation incidents recorded at 0% in Area A, 10% in Area B, and 5% in Area C. The overall downhole losses incidents reduced by 18% using the organo-clay-free NAF system (Fig. 4). This indicates that organo-clay-free NAF systems provide stable performance, in terms of induced losses, which helps optimize costs of both rig time and chemicals consumption.

Hole Instability and Stuck Pipe

Stuck pipe incidents are a primary contributor to NPT during drilling operations. Shale inhibition, wellbore instability, and differential sticking in the lower completion in the lateral reservoir sections are the primary causes of stuck pipe incidents. Stuck pipe incidents recorded while using standard NAF was 12% compared to 4% while using organo-clay-free NAF, additionally 36% improvement/reduction in wellbore instability recorded using the organo-clay-free NAF system vs. the standard NAF system in Areas A, B, and C. The organo-clay-free NAF system showed smooth, stable performance, particularly while drilling the sensitive shales, despite the higher water content. All shale cuttings coming out at the shakers were highly inhibited, and no major hole cleaning issues were encountered while drilling the buildup section with doglegs up to 6° in some cases. Even with the high differential pressure in the buildup sections, no indicators of differential sticking observed in Areas A, B, and C. The good filter-cake quality along with formation data helped to engineere bridging package of organo-clay-free -NAF system helped to run lower completion screens through the lateral reservoir section smoothly, without stuck pipe issues, showing good improvement vs. the standard NAF system (Fig. 5). The organo-clay-free NAF system helped save rig time and costs associated with directional downhole tools and lower completion production screens.

Tripping Performance

Tight hole and back reaming issues were also reported, particularly in the buildup section through the sensitive shale of Formations D and F, which resulted in excessive reaming and back reaming before running the casing. The stability of the organo-clay-free NAF system and applying a sweep strategy helped to achieve the target by minimizing the average tripping time by 32%, from 21.4 to 15.3 hours (Fig. 6). Hole cleaning simulations helped optimize hole cleaning conditions, particularly on rigs where applying the optimum drilling parameter was not applicable because of rig capabilities.

Geomechanical study results based on offset data and logs used to help determine the optimum mud-weight window, particularly while drilling the buildup sections during batch drilling operations. The geomechanical model was updated from one well to another based on logging data collected while drilling, which helped stabilize and provide the required wellbore support.

A lesson learned that was applied in Areas A, B, and C was to increase the mud weight at the section total depth (TD) to compensate for ECD and ensure smooth tripping and running of casing without issues. Using the organo-clay-free NAF system with lower OWR helped to reduce total solids content by 3% hence increase the mud weight smoothly without induced losses. Tripping with the organo-clay-free NAF system was smoother and easier than the standard NAF system. Reaming operations recorded at 16% of the wells where the organo-clay-free NAF system used vs. 59% of the same wells where the standard NAF system used. Conditioning trips eliminated in 30% of the wells where the organo-clay-free NAF system was used (Table 3). The savings during each reaming trip was equivalent to an average of 12 hours of rig time.

Conclusion

The successful use of the organo-clay-free NAF system provided added value; the customized formulation delivered a fluid with superior performance compared to standard NAF systems. This is evident through the lower induced losses by 16% vs. the standard NAF system, which helped increase recycled volumes by 21%. Base oil consumption was reduced by 20% because the organo-clay-free -NAF was formulated at 60:40 OWR compared to 80:20 OWR in the standard NAF system. Although the water content in the organo-clay-free NAF system was higher, shale formations drilled without issues related to inhibition. Stuck pipe and wellbore stability issues were reduced by 36% and better hole condition, better hole cleaning, and smoother tripping and running of casing operations were achieved using the organo-clay-free NAF system with a significant reduction in trips. The overall optimization for rig time, performance, logistics, and increased recycled volumes helped reduce the final cost per barrel of the organo-clay-free NAF system and optimize the drilling operation.

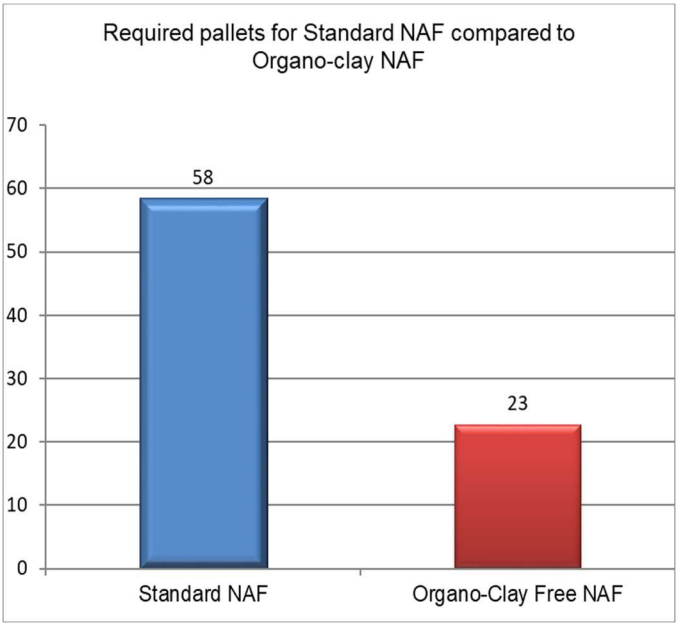


Fig. 1—Difference in chemicals on pallets required for the standard NAF vs. the organo-clay-free NAF (OCF-NAF) system.

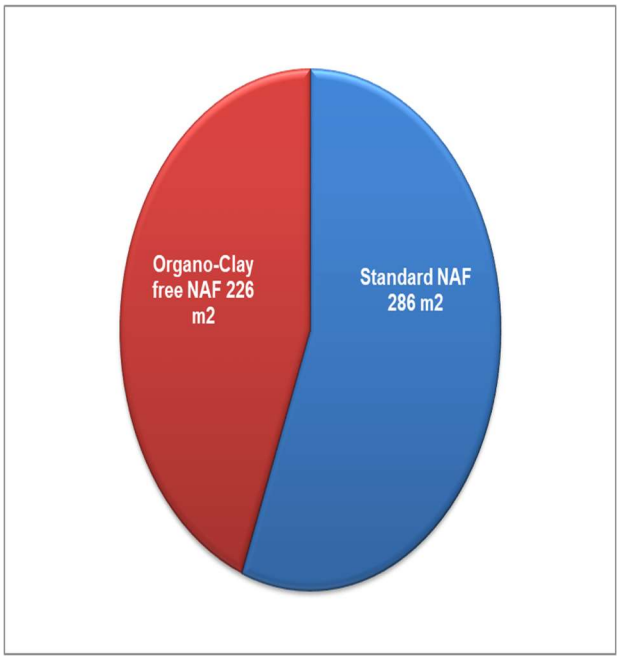


Fig. 2—Estimated space for chemicals required to build 3,000 bbl of the standard NAF vs. the organo-clay-free NAF system.

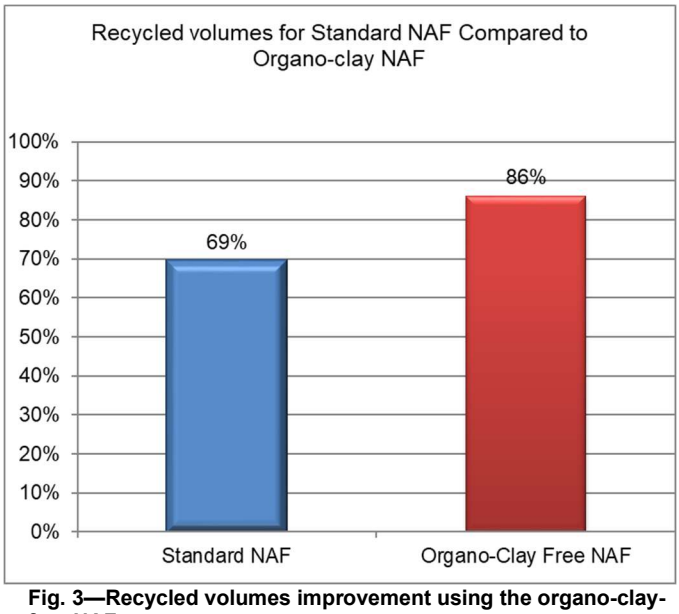


Fig. 3—Recycled volumes improvement using the organo-clay-free NAF system.

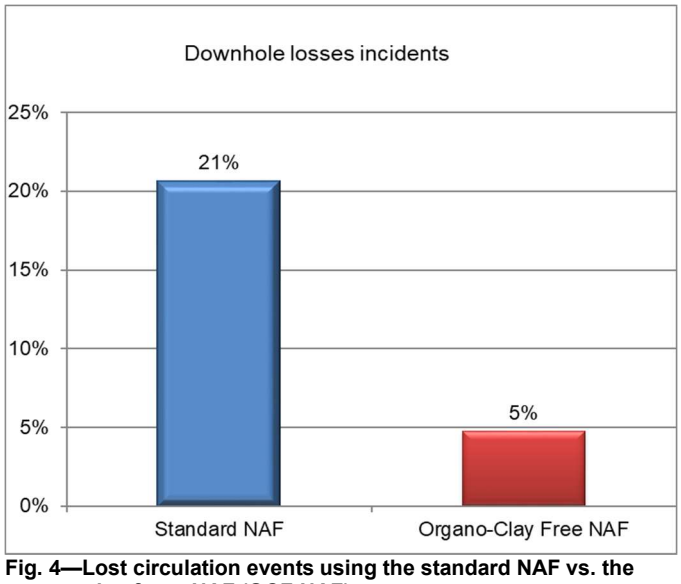


Fig. 4—Lost circulation events using the standard NAF vs. the organo-clay-free - NAF (OCF-NAF) system.

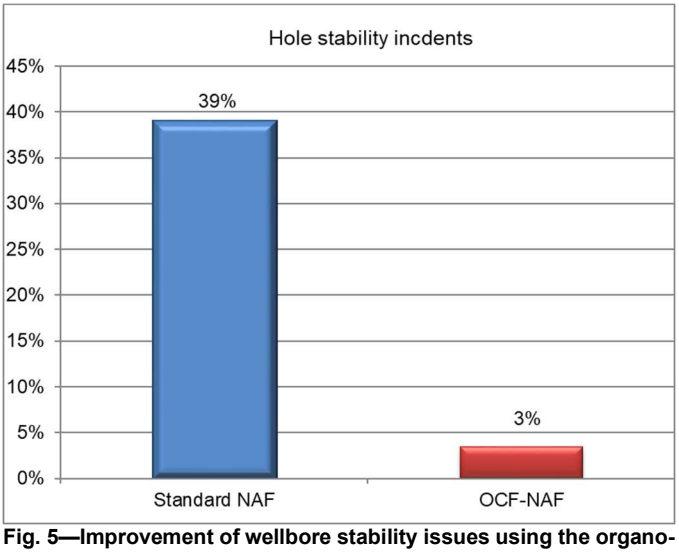


Fig. 5—Improvement of wellbore stability issues using the organo-clay-free NAF (OCF-NAF) system vs. the standard NAF system.

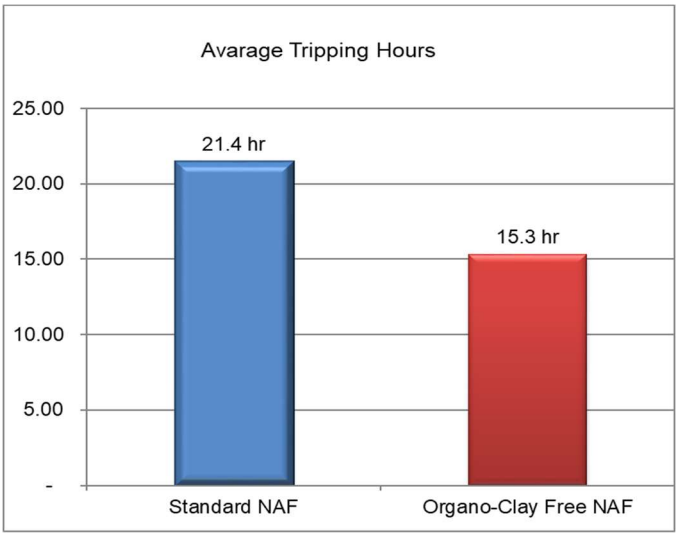
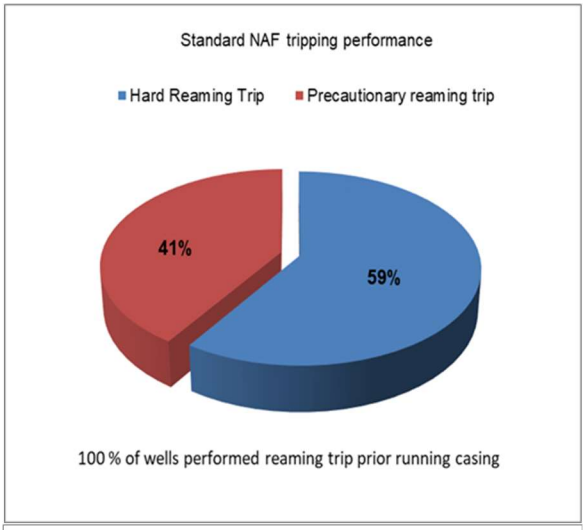


Fig. 6—Average tripping hours for both fluids.



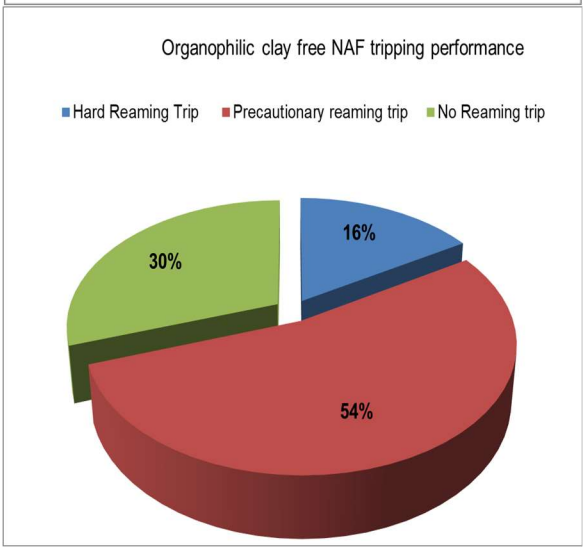


Fig. 7—Comparison shows 30% of the wells drilled and cased without reaming trip using Organo-Clay-Free-NAF.