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AADE 2009-NTCE-18-03: 4.1-SG BARITE: CURRENT APPLICATION STATUS AND FUTURE POSSIBILITIES

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Abstract

Depletion of deposits of 4.2-SG barite ore suitable for widespread use in drilling fluids has caused the industry to focus on use of lower specific gravity material for many applications. To this end API is currently addressing the establishment of a second barite specification based on 4.1-SG material. In the meantime, 4.1-SG barite is enjoying growing applications in drilling fluids.

Most of the applications to date have been on land wells and selected data presented will confirm that field performance matches that predicted from lab test results. Moreover, the use of lower density barite has had no negative impact on any facet of the drilling process when the lower density of the material is considered in fluids design. Additional laboratory work has shown that from both technical and environmental perspectives, the lower density material has potential for use in offshore applications where discharge of cuttings is commonly applied. Laboratory data will be presented to support this position and implications for future use of 4.1-SG barite in drilling fluids will be addressed.

Introduction

There has been much speculation over the years as to even the period in history when fluids were first used in the drilling process. In the US, the first application of something akin to what we now consider to be a drilling fluid is associated with Spindletop when cattle were reported as being used to generate a viscous clay slurry in a pond close to the drilling operation. While speculation may be entertaining, history teaches that the development of drilling fluids to address the increasing inventory of drilling challenges leaned heavily on use of easily accessible additives, many of which were of natural origin. Easily obtained mineral sources provided materials to address many of the early requirements. The first fluids incorporated such materials as bentonite (for viscosity, suspension and fluid-loss control), barite (for density control), lignite (for thinning and fluid-loss control), as well as a few others. As time progressed Gilsonite was used for HTHP fluid-loss control primarily in non-aqueous fluids. High purity calcium carbonates were discovered to be beneficial for reservoirs by virtue of their acid-solubility properties.

The industry proceeded to use the highest quality sources of all these minerals in a less than judicious fashion, and apparently without regard to the finiteness of the reserves of these products. The outcome has been that we have progressively depleted the highest quality fraction of key minerals as the industry has moved to progressively more challenging wells.

In the case of bentonite, the addition of extenders to the product has become a standard practice. This indicates that the reduction in the yield of the bentonite being mined is becoming an issue. API has established specifications for both untreated and the much more common treated bentonites.

Lignite derivatives are becoming increasingly difficult to manufacture as the quality of the lignite feedstock deteriorates. The same trends are seen in other minerals used in drilling fluids.

Barite could reasonably be claimed to be the most crucial additive used in drilling fluids. Annual consumption, which is currently well in excess of two million tons per annum, exceeds those of any other additive in the industry. It is not, therefore, difficult to appreciate the pressure that currently exists on sources of high-gravity barite that are able to conform to the technical and environmental requirements placed on the mineral by the industry and various environmental bodies worldwide. It has become increasingly difficult to supply industry's demand for 4.2-SG barite that complies with current API specifications while demand has increased and reserves have become depleted.

To preserve the dwindling reserves of compliant 4.2-SG materials, suppliers have steered the industry in the direction of sanctioning the use of environmentally acceptable 4.1-SG materials for low to medium density fluid applications. Field applications have shown that differences in performance between fluids densified with 4.2-SG and 4.1-SG materials are imperceptible. It is anticipated that, with the acceptance of the 4.1-SG material as a robust alternative to the current 4.2-SG standard, the lower density material will become dominant in the marketplace in the same way as extended or treated bentonite has. 4.2-SG barite will then fill the role of a non-routine additive (in much the same vein as non-treated bentonite) and its application will become limited to those scenarios where it is really needed. By these means industry will preserve the high-gravity material for applications in which it is crucial and routine applications will proceed to use the 4.1-SG material.

The Case for a New Specification

Bruton et al.[1] laid out the case for establishment of an alternative barite specification, emphasizing the suitability of barite as opposed to competing high-density minerals as the preferred weighting agent for drilling fluids. They provided a comprehensive insight into the supply issues which the industry is now facing and the implications if we fail to act now. Compositional data presented allayed the fears of those who believed that the lower density material may contain undesirable minerals. The lower density (4.1-SG) material was reported to contain 86.9 wt% of barium sulfate as compared to 90.8 wt% for the higher density (4.2-SG) material. The other major difference was in quartz content, with the lower density material showing 10.9 wt% as opposed to 7.7 wt % for the higher density offset. Abrasion testing carried out as part of an industry investigation of the subject showed no significant difference in performance between materials of both gravities obtained from different commercial sources.

Lab Formulation Comparisons

Of course the ultimate test is found in the impact which the change to lower gravity barite would have on fluid properties. Bruton et al. showed comparative data on a series of formulations (primarily water-based fluids) covering various fluid types and densities. Perhaps the most enlightening results are seen when the alternative materials were used to densify non-dispersed polymer-based fluids which tend to show lower tolerance for elevated solids surface areas than do some other fluid types. Two fluid formulations at two densities (12.0 lb_m/gal and 14.0 lb_m/gal) were investigated with the alternate weighting materials, with and without solids contamination, before and after hot rolling. While some differences were noted, variability in properties between fluids with the different weight materials was neither consistent nor very significant. Field trials were needed to ascertain whether any significant differences in performance would be noted in real life applications.

Multi-Well Field Comparison

Occidental O & G has a very active drilling program in the Elk Hills field. The company has moved from exclusive use of 4.2-SG barite to an interim period in which barite of both densities has been used and finally to exclusive use of the lower density product. Data has been collected from a total of 428 wells, 186 of which were vertical and 242 directional. TVD's ranged from 3,000 to 6,500 ft and directional well inclination to as high as 70°. Fluid formulations and treatments showed limited variability within each class of well enabling meaningful comparisons to be carried out. Total drilling fluid additive additions were also tracked for all wells. No discernible increases in treatment levels were noted for fluid–loss-control products, deflocculants or defoamers in the fluids utilizing the 4.1-SG barite.

Vertical wells

Data was drawn from 102 wells on which 4.2-SG barite was used and 84 wells which utilized the 4.1-SG material. Fluid properties were tabulated by fluid density range and are presented graphically in Figures 1-5.

While the anticipated increase in plastic viscosity (PV) does appear to occur when the lower SG material is used (Fig. 1), no such trend is seen when any other property comparisons are carried out. The field's apparent inability to detect any difference in solids contents (Fig. 3) in fluids using different gravity weight materials is worthy to note. No deleterious trends associated with fluids using the lower gravity material are evidenced in the yield point (YP) and gel strength data (Figs. 2, 4 and 5).

Plastic Viscosity

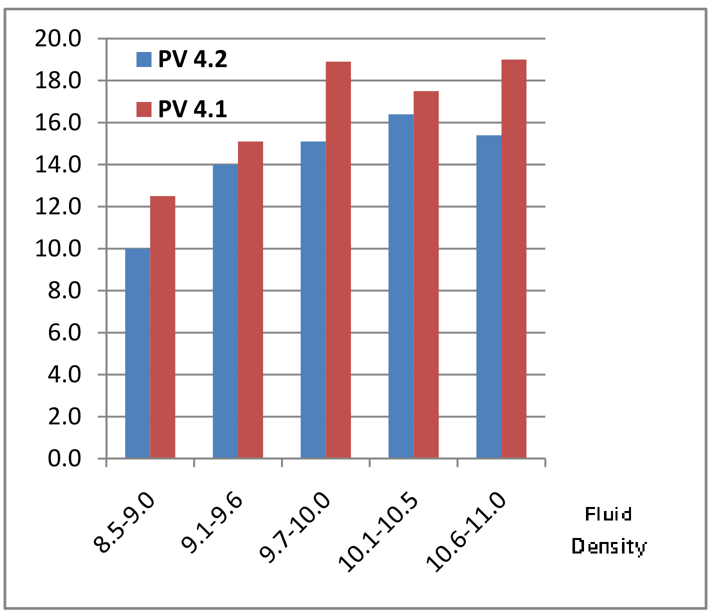

Figure 1: Plastic viscosity comparisons for fluids utilizing 4.2-SG and 4.1-SG barite in vertical wells.

Yield Point

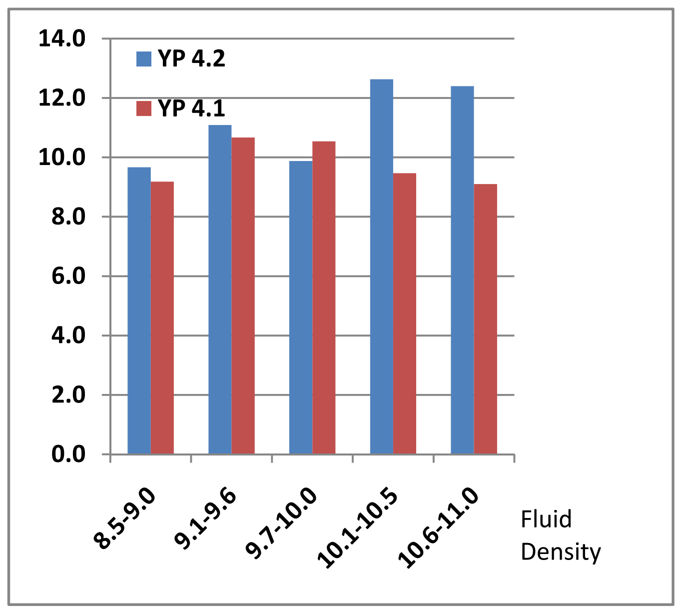

Figure 2: Yield point comparisons for fluids utilizing 4.2-SG and 4.1-SG barite in vertical wells.

Solids

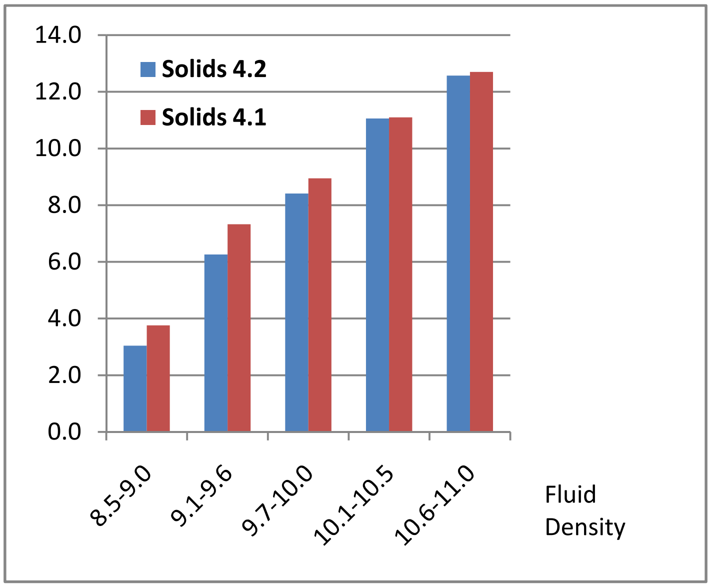

Figure 3: Solids comparisons for fluids utilizing 4.2-SG and 4.1-SG barite in vertical wells.

10-Second Gel

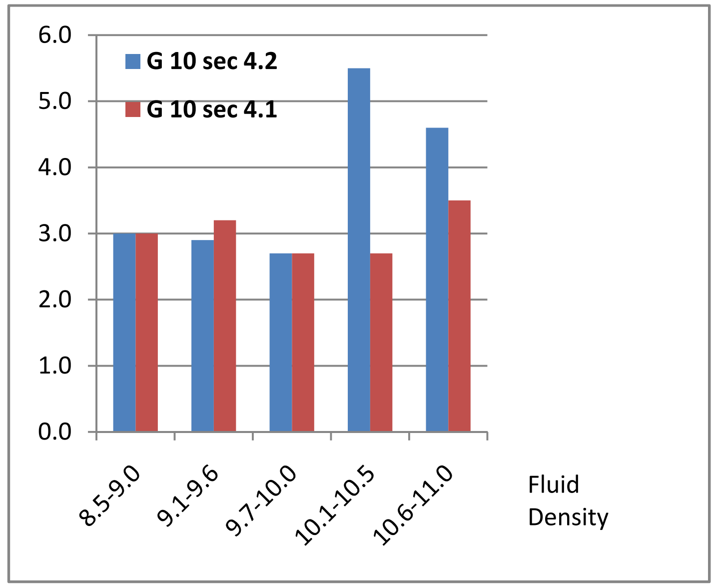

Figure 4: 10-second gel strength comparisons for fluids utilizing 4.2-SG and 4.1-SG barite in vertical wells.

10-Minute Gel

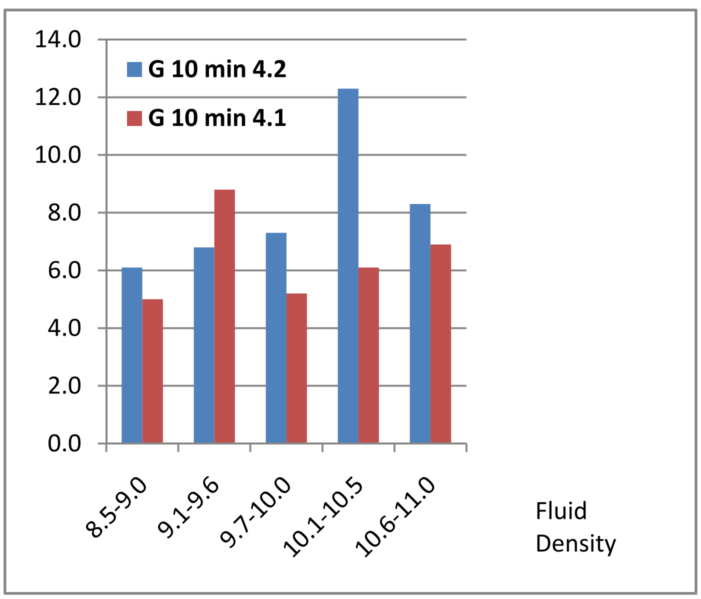

Figure 5: 10-minute gel strength comparisons for fluids utilizing 4.2-SG and 4.1-SG barite in vertical wells.

Directional Wells

The 242 wells used in this study comprised 133 wells using the conventional 4.2-SG material and 109 wells using the alternate 4.1-SG material. Graphical comparisons (as for the previous section) follow:

Plastic Viscosity

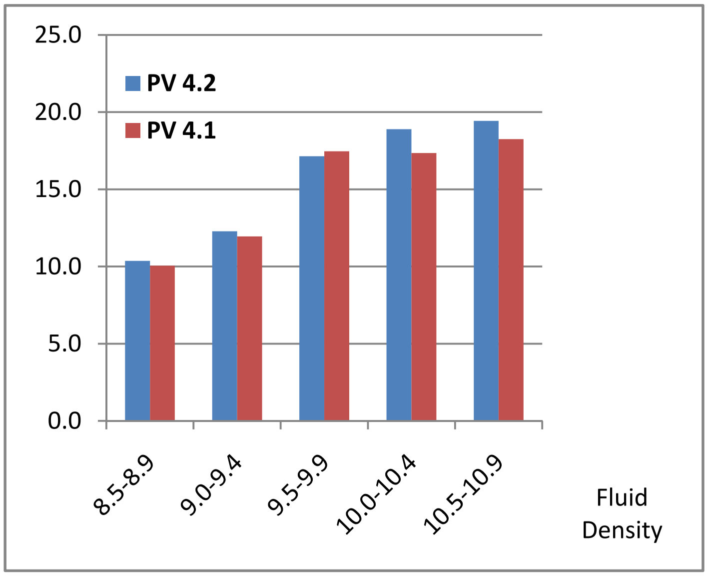

Figure 6: Plastic Viscosity comparisons for fluids utilizing 4.2-SG and 4.1-SG barite in slant wells.

Yield Point

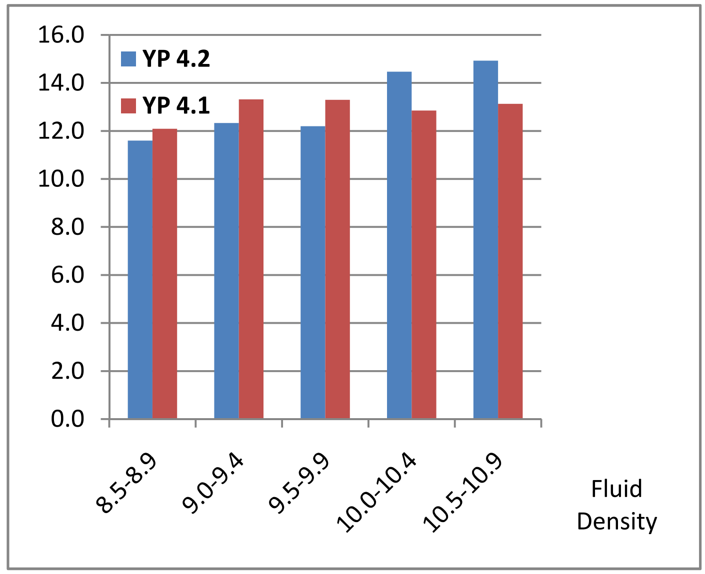

Figure 7: Yield Point comparisons for fluids utilizing 4.2-SG and 4.1-SG barite in vertical wells.

Solids

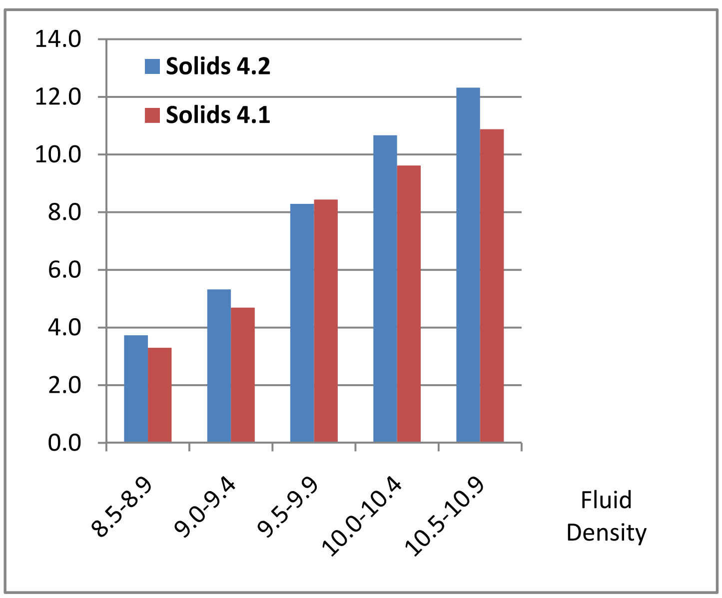

Figure 8: Solids comparisons for fluids utilizing 4.2-SG and 4.1-SG barite in slant wells.

10-Second Gel

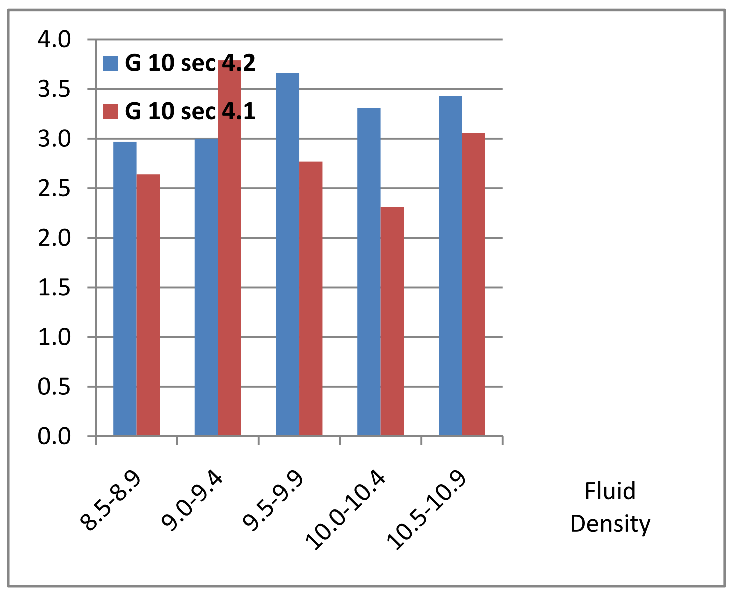

Figure 9: 10-second gel strength comparisons for fluids utilizing 4.2-SG and 4.1-SG barite in slant wells.

10-Minute Gel

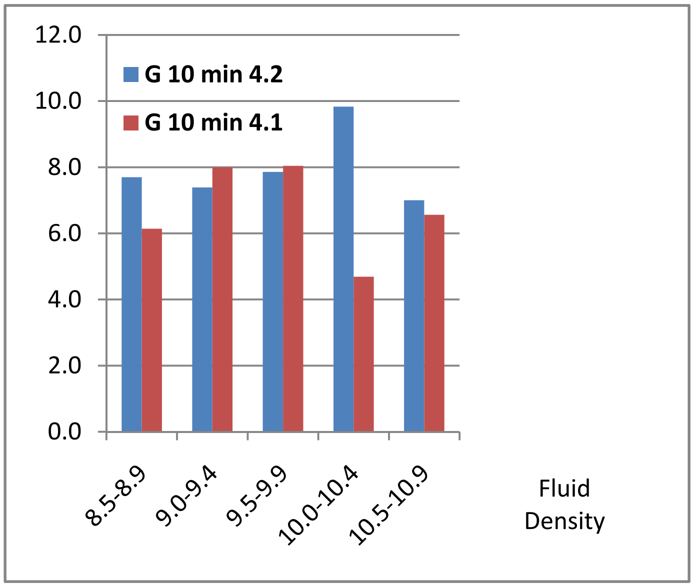

Figure 10: 10-minute gel strength comparisons for fluids utilizing 4.2-SG and 4.1-SG barite in slant wells.

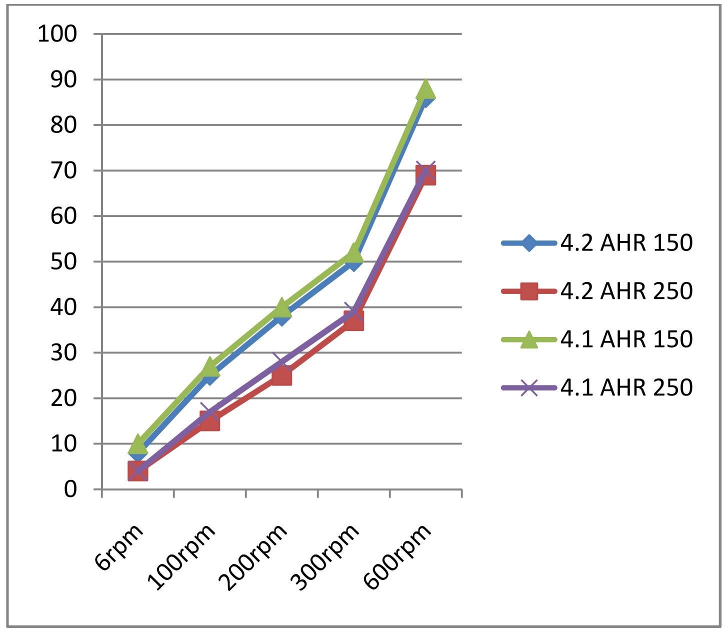

Figure 11: Rheological profiles for 17.0-lb$_m$/gal non-aqueous fluids using 4.1-SG and 4.2-SG barite.

Once again there are no clear trends indicating unequivocally that the lower gravity material has a negative impact on fluid properties. Without a legend identifying which fluid is which, the reader would be forgiven for being confused as to which material was being used in each series. All of the fluids used in this study were of relatively low density. While it may be concluded that the lower SG material can be used in such fluids with no deleterious effect, the question remains as to the utility of the 4.1-SG material in higher density fluids. Bruton et al. showed that lab prepared lignosulfonate fluids with densities as high as 17.0 lb$_m$/gal, whether contaminated or not, showed no perceptible difference in PV and YP values when side-by-side testing was carried out.

Performance in Non-Aqueous Fluids

Gulf of Mexico deepwater applications consume significant volumes of barite on an annual basis and with the projected increase in deepwater rigs coming to market over the next 3 to 4 years, the situation will be exacerbated. The ability to utilize the 4.1-SG material in the non-aqueous fluids utilized on such wells would represent a significant step in preserving the remaining higher density material for future critical applications.

Two non-aqueous base fluids were prepared in the lab to a density of 17.0 lb$_m$/gal. Both had base/water ratios of 80/20. One used the standard 4.2-SG barite while the other used 4.1-SG material. Additive packages were identical with minor adjustments being made in base fluid and brine fractions to accommodate the lower density weight material. Properties were measured after hot rolling sequentially at 150°F and 250°F. Rheological data are shown in Fig. 11.

Gels, static shear, high-temperature/high-pressure (HTHP) fluid loss and electrical stability (ES) values were essentially invariant between fluids rolled at the same temperature. While the nuances of fluids used in pressure critical deepwater applications are acknowledged, it would seem reasonable and responsible of industry to fully investigate the feasibility of moving to routine use of the 4.1-SG material in such applications.

Current Industry Position

API Sub-Committee 13 (SC 13) is currently addressing the establishment of an alternate 4.1-SG barite specification which would lead to application of the API monogram. With the monogram in place, the associated controls would assure end users that the material being supplied conforms to a set of industry standards. At time of writing, a letter ballot of SC 13 members to accept the proposal is imminent.

Conclusions

Depletion of barite reserves suitable for the supply of finished product that complies with current API specifications has forced industry to consider alternatives. Laboratory testing and extensive field use have confirmed that lower density (4.1-SG) barite can be successfully used in many applications while conforming to environmental and performance requirements. To avoid continued depletion of higher density reserves which will be needed for challenging wells in the future, it is proposed that industry (hopefully supported by an alternate API barite specification for 4.1-SG material) continue to test the viability in higher density fluids. Use in deepwater applications would contribute significantly to preservation of the higher density material.

Acknowledgements

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Reference

1. Bruton, J.R., Bacho, J. and Newcaster, J.A. "The Future of Drilling-Grade Barite Weight Material – A Case for a Substitute Specification." SPE 103135, SPE Annual Technical Conference, San Antonio, Texas, September 24-27, 2006.