DRILSMOOTH

Generic System Name: MMO (Mixed Metal Oxide) system.

Introduction:

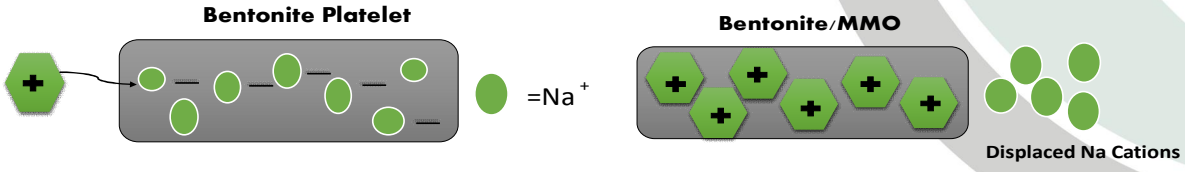
Category: Water based mud system. Highly thixotropic fluid.

Application: The system is recommended whenever severe losses are encountered in multiple zones where LCM pills won't be practical. Also it is recommended whenever hole cleaning is a concern such in big hole sizes, highly deviated and horizontal wells, casing milling operations, etc.

Mechanism:

The exclusivity of this fluid type directly related to the interaction between the MMO compound and clays, both added and drilled. It is theorized that the viscosity results from the interaction of water envelopes that fully encompass the MMO/clay complex, which reacts in an optimum pH range of 10.2-10.5.

When MMO crystals are added to a suspension of bentonite platelets, the cationic crystals displace the naturally "resident" sodium or other cations and form strong associations with the anionic sites on the faces of the clay. The mechanism appears to be electrostatic in nature, which makes it very unusual and accounts for the unique characteristics.

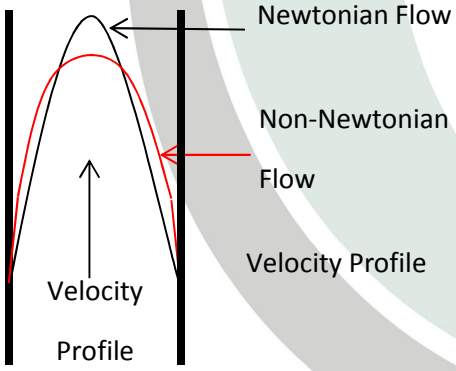


For example, an electrostatic field-based mechanism could explain the “elastic” or deformable solid behavior seen in the absence of shear and could also explain both the dramatic, instantaneous onset of the solid-to-liquid transition and reversibility of the process.

Conventional drilling fluids commonly obtain their rheological characteristics from the interaction of charged clay platelets which orientate under static conditions. This kind of gelation requires a much higher level of energy to disrupt the structure and initiate fluid motion than for the simple water/water interface thought to occur in the MMO system.

Flow Profile:

When fluids contain particles, such as clays (bentonite), polymers or other colloidal material, these particles tend to collide with each other increasing the shear stress (or force) necessary to maintain a given flow rate (shear rate). If these particles are long compared to their thickness, the particle interference will be large when they are randomly orientated in the flow stream. But, as the shear rate increases, or flow rate increases, the particles will orientate in the direction of flow and the effect of particle interaction is decreased.



This causes the velocity profile in a pipe to be different from that of a fluid like water. In the center of a pipe, where the shear rate is low, the particle interference is high and the fluid tends to flow like a solids mass. The velocity profile is flattened as shown (right). The same effect occurs if particles in the fluid are electrically attracted to each other. At low shear rates, the particles link together, increasing the resistance to flow, but at high shear rates the linking bonds are broken. Under these circumstances, the shear stress does not increase proportionally to the shear rate as in Newtonian fluids, and fluids that behave in this manner are called Non Newtonian Fluids. Nearly all drilling fluids are of this type Non-

Newtonian fluids, and the term ‘shear thinning’ is used to describe the degree to which a fluid is thinner at higher shear rates.

The rheology of DRILSMOOTH is an extreme example of a Non Newtonian fluid. Not only do the colloidal bentonite particles contribute to the non-Newtonian behavior of the system, but the electrostatic interaction between bentonite and the DRILSMOOTH Mixed Metal Oxide crystal further enhances the non-Newtonian fluid behavior. The resulting flow profile is close to what is known as ‘plug flow’ in which the velocity profile in a pipe is flat. It means the fluid velocity at the wall of the pipe is nearly static but the bulk of the fluid is moving at the nearly same velocity at the center of the pipe.

Replacement for: Any type of muds.

Components: DRILSMOOTH

QMax Product	*Function*
Water	Continuous phase
Soda Ash	Hardness
****Bentonite Premium***	Viscosifier
****DRILSMOOTH***	MMO
****QMMO FL***	Acid soluble bridging
Caustic Soda	Alkalinity control
Sized Carbonate	Bactericide

* Proprietary or brand name products

Key aspects

- Maintain 10:1 ratio Bentonite to MMO
- Excellent for cleaning big hole diameters
- Do not use anionic products
- Anionic products will destroy thixotropy

Typical System Properties

DRILSMOOTH		
Property	***Range***	***Min / Max recommended***
Mud Weight, ppg (kg/m^3)	8.8 – 12.5 (1,050 - 1,500)	< 12.5 (< 1,500)
Plastic Viscosity, cP	ALAP	ALAP
Yield Point, lb/100ft^2 (Pa)	30 - 35 (15 - 17)	30 - 70 (15 - 35)
Gels, lb/100ft^2 (Pa) 10"/10'/30'	20-30/30-40/40-45 (10-15/15-20/20-22)	As required
pH	9.5 - 10.5	10.0 - 10.5
Calcium, mg/l	80 - 150	< 100
MBT, ppb-eq (kg/m^3)	0 - 15 (0 - 43)	< 15 (< 43)
API Fluid Loss - cc/30min	10 - 12	< 15

Key aspects

- Low pH will thin the fluid
- % LGS should be less than 6%
- Low filtration values are hard to achieve
- Gels must be high and flat

Field Operations

Mixing Procedures

For New System:

1. Start with clean tanks and fresh water. Use Soda Ash to reduce hardness below 50 mg/l.
2. Add caustic soda for a pH between 10.5 and 10.8.
3. Add Bentonite Premium and let it pre-hydrate for as much as possible. Concentration of bentonite should be 10 ppb (28 kg/m^3).
4. Add 1 ppb (2.8 kg/m^3) of DRILSMOOTH
5. Check low viscometer reading at 6 and 3 rpm. Adjust concentration of Bentonite or DRILSMOOTH if necessary for higher readings.
6. Add QMMO FL if required.

For mix “on the fly”: Not recommended. Bentonite has to be pre-hydrated.

Maintaining Properties

Close monitoring of the calcium level is crucial. Depending on the clay reactivity of the formations drilled, it has to be at a certain value to provide some inhibition. It is recommended that CST tests are run on area formations to evaluate the grade of inhibition and estimate the amount of calcium nitrate that is needed prior to drilling. Adjust polymer additions to maintain viscosity.

DRILSMOOTH should be added through a chemical barrel where the material should be also pre-wet. Because DRILSMOOTH has a very low solubility in water, it is advisable to pre-wet to improve dispersion in the mud. MMO is commonly maintained at a concentration of 1 lb/bbl (2.8 kg/m^3) and adjusted as indicated by fluid profile and cuttings integrity.

Prehydrated bentonite should be maintained at a concentration of 10-12 lb/bbl (28 – 34 kg/m^3). QMMO FL should be added through the hopper as needed for fluid loss control. QPAC LV can be used to control the system rheology, but in range of 0.5 lb/bbl at maximum.

Chemical maintenance of the DRILSMOOTH system is quite simple. Field experience quickly indicated optimum fluid performance for a pH of 10.0 - 10.5.

As pH drops, a loss of low-end rheology can be experienced. Other mud parameters, such as phenolphthalein and methyl orange alkalinity end points (Pf/Mf), chlorides, hardness, and carbonates have to be monitored, but variances in these parameters do not appear to affect system performance.

For the most part, simply monitoring the mud and maintaining its pH around 10.5 with either sodium hydroxide or potassium hydroxide promotes optimum product performance and maximum system stability.

It is critical that the Un-treated bentonite be suitable for the application. Bentonite Premium is recommended for use and all other stocks of bentonite must be validated as suitable well in advance of the project. Testing in the laboratory has led to a tentative conclusion that if a 30 lb/bbl (85 kg/m^3) slurry prepared as detailed above has Fann 600 rpm and Fann 3 rpm readings of > 120 and > 25, respectively, it is probably suitable for the application. The only fool proof way to ensure that the bentonite is suitable is to carry out a full pilot test of the proposed formulation.

The longer the time allowed for pre-hydration and mixing in the early stages of the formulation, the better the early yield will be.

Use all available shear while mixing.

The inclusion of soda ash in the quantities shown at the stages indicated is important.

The yield for the DRILSMOOTH system is not instantaneous. Additional yield can be expected during the first few circulations.

Follow the mixing order shown in the “Field Mixing Procedures for DRILSMOOTH Fluids” section of these engineering guidelines. This procedure has been established through rigorous testing.

If ID-MMO FL additive is to be used, add a minimum of 3.0 – 5.0 lb/bbl (8.5 – 14.5 kg/m^3) at the initial mixing stage to avoid any danger of temporary loss of rheology.

Increases in rheology can be achieved by additions of prehydrated Bentonite, DRILSMOOTH additive, pH increase or any combination of these. Pilot test!

Take caution to ensure there is no pit communication that will allow for cross contamination with another mud system stored in a reserve pit. Especially take care that no anionic material (such as a PAC product) comes in contact with the DRILSMOOTH system as this will permanently break the bonds creating

the desired rheology. This caution applies when ensuring a clean pit and associated transfer lines prior to mixing.

Fluid Specific Tests and Equipment

- Complete WBM testing kit
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Contaminants: effect and treatment

Contaminant	Mud Effect	Treatment
Cement	Thickening of solids-laden muds	Treat with soda ash or bicarb
Bacteria	Fluid is resistant	Biocide is not normally used
$CO_3^{2-}/HCO_3^-/CO_2$	None	Add lime and caustic
H_2S	None	High pH and add scavenger
Salt	Fluid loss control issues	Dilution. Add QMMO FL.
LGS	High PV	Dilution and efficient SCE
Oil	Toxicity and environmental issues	Tolerates up to 35% Oil
Coal	Rheology reduction	Adjust rheology with Bentonite Premium and DRILSMOOTH
Anionic materials	Rheology reduction. When the fluid has high solids content, this effect is diminished.	Avoid using anionic products
Water influx	Dilution. Loss in thixotropy.	Increase MW. Adjust concentrations.

Operational Recommendations and "Best Practices"

- Be aware of cuttings integrity. This is a sign of the effectiveness of the system.
- Always keep a 10:1 Bentonite:MMO ratio in the system.
- Avoid contamination with cement or other drilling fluids.
- Use non-peptized bentonite. This is a key product for the system to run efficiently.
- Work with gun lines, centrifuge discharge lines and all the agitators to keep the fluid in movement in the mud tanks.
- Work with all SCE available. Do not let the LGS% to go over 6%.
- If mud densities above 13.5 ppg (1620 kg/m^3) are required, it is advisable to convert it to a conventional polymer mud; rheology can be unmanageable at those densities.
- If a new product is to be added to the system, pilot testing is highly recommended. Many products can destroy the thixotropy of the system.