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Clay Ste ADV™ Comparison

Two mechanisms are responsible for the swelling and migration of clays, surface hydration and osmotic swelling.

Surface Hydration shows little visible signs of swelling, however the pressure greater than 60,000 psi is required to desorb surface hydration moisture.

Swelling and softening of clays due to Osmotic differences is a bigger problem. This occurs when concentration of Ions (like Na+, Ca++, Cl-, etc) in the clay at the wellbore walls is higher than that of the drilling fluid. Due to this difference in ion concentrations (aka osmotic pressure), water moves toward the clay surface causing swelling. The amount of swelling depends up on the concentration of salts in the clay relative to the salts in the fluid.

Hence the objective is to keep a sufficiently high ion concentration in the fluid to prevent swelling.

In 1973 O'Brien and Chenevert, researchers from Exxon, demonstrated the effectiveness of using Potassium Chloride as a Clay Stabilizer. Using KCl for this purpose is the norm in the drilling industry, and KCl is used as the standard of measurement for all new generation Clay Stabilizers.

Clay Stabilizers work on the principle of Cation Ion Exchange, similar to water softeners resins. Water softeners can be regenerated using Salt, KCl, and many other cations. Similarly, Clay's can be stabilized using a variety of cations.

Capillary Suction Time (CST), Methylene Blue Capacity (MBC), Ensilin or Fluid Adsorption, Specific Surface Area, Gulf Swellmeter, X-Ray Diffraction and Atterburg Limit tests can be used to test effectiveness of Clay Stabilizers.

CST is a relatively simple test that can be performed on site, which is probably why it has gained popularity in the industry. However, CST results can be manipulated using different shear rates and times for sample preparation. Shear rates of Frac Fluids differ substantially as compared to the standard CST which is simulating a drilling operation. Also, data obtained from CST tests is not very reproducible and should be used qualitatively. CST in combination with MBC is a better approach, but in the fast paced business environment, increased testing is difficult.

Using sacks of KCl is a difficult approach, especially with the increased fluid volumes used in fracturing. Handling, mixing and disposal costs related to sacks of KCl are prohibitive. Herein, we will discuss a few potential Clay Stabilizers, compare their performance and economics.

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Several options are available as KCl replacements or Clay Stabilizers:

1. **TMAC 50%** (Tetramethylammonium Chloride 50%): This cheap and easy to apply quat gives a lower performance than that of 2% KCl. However, TMAC is toxic! Hence its use is dwindling.
2. **Choline Chloride 75%**: Also know as (2-hydroxyethyl) trimethylammonium chloride is very similar in structure to TMAC. It costs slightly more than TMAC, and its performance better than that TMAC but lower than that of 2% KCl. It is used in feed additives and vitamin pills, is safe & biodegradable. This is becoming the product of choice in the industry due to its safety features.
3. **Choline Chloride 50%**: On a per unit of Choline Chloride, the 50% is marginally more expensive.
4. **Clay Ste Adv™**: Is a blend of Choline Chloride, Cations and Conditioners. It is cheaper than all of the above, and performs better than any of the above listed Clay Stabilizers due to presence of various additional ions. The Tetramethylammonium and (2-hydroxyethyl) trimethylammonium are relatively large ions. Also, both these are monovalent. Clay Ste Adv™ contains other smaller sized monovalent, divalent and trivalent ions which help in a faster ion exchange and the conditioners help in preparing the surface of the clay for a better interaction with the cations present.

Comparison of CST Times for various Clay Stabilizers*:

Product	Clay Ste ADV™ @ 2 gpt	50% Choline Chloride @ 2 gpt	75% Choline Chloride @ 2 gpt	2% KCl	DI Water
CST Filtration Time in secs	142	335	199	33	716

* Test Method: Solutions of the Clay Stabilizers were prepared in 5 ml DI Water and 1 gram of ground up core samples from West Texas was added to it. Using a CST instrument, the time required for each solution to travel a fixed distance along a Whatman No. 17 chromatography filter paper was determined.