Salt-zone properties are widely variable in composition, aggression of attacks on wellbore fluids, plasticity and pressures, thicknesses and boundaries, solubility and contamination. As such, salt sections are particularly unpredictable, making them very challenging not only during drilling and cementing operations, but throughout the producing life of the well.

Salt zones are notorious for causing problems such as wash out from dissolution of salt into the cement slurry or casing collapse, making it difficult for operators to stay within the authorization for expenditure and avoid non-productive time. Unpredicted issues can range in costs from a few thousand dollars to multiple millions of dollars. This is particularly true in deepwater fields where these zones are known as pre-salt zones and where rig costs are high and materials more constrained. Reactive salts can gel conventional cement slurries during placement to the point of no longer being pumpable. Formation salts can dissolve into the slurry and adversely affect curing and/or weaken the formation.

Halliburton offers the SaltShieldSM cementing service, a combination of an advanced modeling tool for planning along with an advanced cement system.

**Modeling Tools for Planning Salt Operations**

Halliburton has developed an advanced finite element analysis (FEA) tool, WellLife® service. This tool models the cyclic stresses to the cement sheath induced by pressure and temperature changes throughout the life of the well. While modeling the cyclic stresses from planned operations during drilling, testing, completions and production operations, this tool can also account for the dynamic influence of the salt zone.

Halliburton’s modeling includes analysis of pressure-induced changes involving tensile and compressive forces from the salt zone. The cement failure phenomena that can be modeled include de-bonding from casing, de-bonding from the formation, radial cracking, and shear failure. The model simulates the well structure, properties of formation, and long-term critical well conditions to predict the competence of a cement sheath. Going further, the model then generates thermal and mechanical properties required to survive downhole stress conditions. The properties estimated in the modeling include Young’s Modulus, Poisson’s Ratio, shrinkage, thermal expansion, compressive strength, tensile strength, thermal conductivity, and specific heat.

The ability to withstand the downhole stresses is presented via histograms. These charts show the percent of remaining capacity available before succumbing to stress-related cement failure phenomena. If the sheath is shown to have a high risk of failure, WellLife service has a powerful module that indicates modification to the various cement-property options for increased capacity and decreased failure risk.

**Resilient Salt-zone Slurry**

SaltShield™ cement delivers properties that overcome simple salts like halite, and even the aggressive salts such as carnallite and tachyhydrite. The aggressive salts contain Magnesium Chloride, which can move at rates 100 times faster than Halite and could chemically react with cement. SaltShield cement can enable placement of full columns of cement across the salt zone, quickly stabilizing the wellbore, minimizing wait-on-cement time due to rapid compressive strength development, and expanding while curing to help mitigate effects of salt creep. SaltShield cement is field-proven to help operators more predictably mitigate the unexpected non-productive time and operational expenses from salt zone issues.

One unique threat to well integrity from salt zones is plastic flow. Plastic flow, or salt creep, can damage the cement sheath, the casing or both. SaltShield cement helps distribute the formation load more evenly to alleviate stress loading even the stress loading from aggressive salts, thus helping prevent casing deformation and/or casing collapse. This is accomplished with specific properties for both the slurry state (during placement) and the set state (as a cement sheath). For instance, minimal changes in rheology, even after 12% salt contamination (by weight of water), helps facilitate full coverage and efficient displacement during pumping. Once pumping stops, this system quickly develops compressive strength, withstanding load from moving salt. It is designed with tight control of properties such as fluid loss, volume reduction during hydration, compressive and tensile strength, and elasticity, helping avoid compromise to the cement system as well as the salt formation. Even at 12% salt contamination, thickening time, as well as initial and final strength development are not compromised, which can enable this cement to quickly stabilize the casing and the formation, while reducing non-uniform load points that can cause casing failure.
SaltShield cement expands while curing. Conventional slurry systems shrink during hydration and can thus invite irregular stress loading that can then induce casing failure.

SaltShield cement withstands chemical effects when in contact with salts. Magnesium ions present in harsh salts can dissolve in slurry systems and the reaction results in gelation, which can impede pumping. This slurry system is resistant to gelation from salt contamination, helping facilitate successful slurry placement even across long and chemically-aggressive salt sections such as zones found in offshore Brazil, West Africa and the North sea presenting as much as 2000 meters of salt rock involving aggressive salts.

SaltShield cement also helps prevent formation weakening or washout from dissolution of formation salts. Early static gel strength development and shortened transition time to a set sheath helps minimize formation fluid influxes, particularly important when exiting the salt zone where the casing could be set in the pre-salt reservoir or zones with potential for fluid flow.

In corrosive environments, CO₂ gas dissolves into formation fluids and forms carbonic acid. This acid can damage a conventional cement sheath with a reactive mechanism that lowers the mechanical properties and increases permeability of the cement sheath. SaltShield cement is resistant to CO₂ for seamless use when the reservoir contains CO₂ and is below the salt section, such as in Brazil and Angola.

SaltShield cement demonstrates a resistance to gelling from salt contamination, remaining pumpable even at 12% (bwow) carnalite (salt) contamination.

**Benefits**

- Helps mitigate gelation of cement slurry upon salt contamination, including aggressive salts containing magnesium chloride.
- Rapid compressive strength and early static gel strength development helps quickly stabilize the wellbore and facilitate further drilling while mitigating uneven point loading on casing that could otherwise cause collapse or failure due to salt creep.
- Compatibility with all concentrations of salt overcomes salt dissolution issues helping mitigate washouts or weakening of the salt formation.
- No significant variation in slurry properties before and after dissolution of formation salt in the slurry.
- Expands during hydration in contrast to conventional cement that shrinks 0.5% - 4%.
- Can withstand loads induced by plastic salt flow.
- Demonstrates low permeability and good compressive strength after one year of exposure to carbonic acid.
- Single system resistant to corrosive fluids from salt and CO₂ for use across salt and reservoir section.
- Demonstrates low permeability and good compressive strength after extended exposure to carbonic acid.
- Can be used at bottomhole circulating temperatures (BHCTs) ranging from ambient to 190°F (88°C); higher temperatures would require a retarder in the slurry.
- Poses little or no risk to the environment (PLONOR).

For more information on SaltShield™ Cement, please call your local Halliburton representative or email us at cementing@halliburton.com.