QDRILL

Generic System Name: Inhibitive fluid system having a potassium source.

General description:

Category: The system is an inhibitive water based polymer fluid.

Application: The QDRILL mud system is applicable where highly reactive formations are present and water based fluids are required. The QDRILL mud system key component is a clay inhibitive salt. Up to 4% glycol can also be added to the system. Addition of glycols may impart environmental concerns for disposal.

The combination of glycol and potassium ion yields a highly inhibitive, solids tolerant fluid. It is resistant to contaminants and reduces bit-balling occurrences. Potassium chloride has been used to provide K^+ ion off-shore in either fresh or sea water formulations while potassium nitrate, sulfate, acetate, carbonate and formate used for some land operations with fresh water as the base. MAXCAP D is added to supply additional wellbore stabilization by the encapsulation of reactive formations and cuttings.

The QDRILL system can be formulated with potassium acetate or formate without any chlorides additions in order to help prevent the environment by not releasing the harmful chloride ions into the under-ground water table. The base formulation resolves environmental and disposal concerns that may arise with oils or elevated chlorides, sulphates or nitrates.

Potassium ion is a very effective clay swelling/hydration inhibitor. The concentration of potassium ion required varies with the type of shale being drilled.

Key aspects

- Keep low drilled solids content
- Concentration of K^+ depletes rapidly
- Solubility of potassium Sulphate is limited
- Work with all SCE

Replacement for: Other inhibitive WBM such as Silicates or Amine salts based inhibitive systems.

Components: QDRILL system

QMax Product	Function
Water	Continuous phase
Caustic Soda	Alkalinity control
Potassium source	inhibitor
*QPAC LV	Fluid loss control
*QPAC HV	Fluid loss control
*MAXCAP D	Encapsulator
*QXAN	viscosifier
*QSTAR ENV	Fluid loss control
Barite	Weighting agent
*GLYMAX	Secondary inhibitor
$CaCO_3$	Bridging Agent
*QCIDE	Biocide

* Proprietary or brand name products

Key aspects

- K+ content depend on formation salinity
- GLYMAX will enhance lubricity
- Fibers can be used besides $CaCO_3$
- Compatible with QMAX DRILL (amine)

Typical System Properties

QDRILL		
Property	***Range***	***Min / Max recommended***
Mud Weight, ppg (kg/m³)	9.5 - 18.3 (1130 - 2200)	18.3 Max. (2200)
Plastic Viscosity, cP	ALAP	ALAP
Yield Point, lb/100ft² (Pa)	10 - 20 (5 -10)	> 20 (>10)
Gels, lb/100ft² (Pa) 10”/10’	2-10 / 16-30 (1-5 / 8-15)	As required
pH	9.0 - 9.5	10.0 Max.
K+ ion content, ppb (kg/m³)	20 - 30 (57 - 85)	As required
MBT, ppb-eq (kg/m³)	5.0 - 12.5 (14 - 36)	15 Max. (43)
API Fluid Loss - cc/30min	5.0 - 8.0	< 8.0
HPHT Fluid Loss - cc/30min	16 - 24	< 20

Key aspects

- Use proper MW for plastic formations
- Maintain low MBT
- Wash the hole when drilling plastic clays
- Monitor closely K^+ ion content

Field Operations

Mixing Procedures

For new system: Start with clean tanks and fresh water. Make-up water should be checked for calcium and magnesium. If the hardness check indicates a calcium ion concentration in excess of 200 mg/L, the water must be pre-treated with the right amount of soda ash. Do not over-treat as it can create flocculation in the system. Add Potassium source salt, GLYMAX (if required), viscosifier and fluid loss additives to desired properties. Add caustic soda to desired pH. System may be pre-mixed at a 2x concentration (without the PHPA) to reduce tank space. Circulate system to homogenize the concentrations. Recommend to drill out cement with water and viscosified sweeps from a short circulating system and discard. If drilling out with the mud system, pre-treat with bicarb and add citric or sulfamic acid as required when drilling to maintain pH below 10.0.

If pre-mix tank available, follow “shot gun” procedure below to pre-hydrate MAXCAP D.

“Shot-gun” procedure:

- Start with a 2 compartment pre-mix tank; add fresh water to 1 compartment. While pumping over to empty tank, rapidly add MAXCAP D into the mix hopper. Concentrations above 3.5 ppb (10 kg/m^3) have been achieved with this method. Keep circulating until polymer is sheared (~ 4 hours). Start MAXCAP D additions once all cement contamination has been removed from system by adding a stream of this concentrate to active system
- If a high shear mixing device (i.e. LobeStar Shear Hopper) is available, concentrations of up to 7 ppb (20 kg/m^3) of MAXCAP D have been achieved while pre-hydrating this polymer.

For mix “on the fly”: Not recommended but possible.

MAXIMUM DENSITIES FOR K+ SALT SOLUTIONS	
Salt	**Maximum density (ppg, kg/m^3)**
Potassium Chloride - KCl	9.68, 27.58
Potassium Formate – HCO_2K	13.1, 37.4
Potassium Nitrate – KNO_3	9.7, 27.7
Potassium Acetate – CH_3CO_2K	11.79, 33.6
Potassium Sulphate – K_2SO_4	9.03, 25.7

Maintaining Properties

Add Potassium source salt, MAXCAP D and GLYMAX (if required) to the suction tank to maintain the inhibitive concentration as per depletion rates. Small additions of the viscosifier may be required to maintain or improve rheology. Mix required fluid loss additive. Maintain calcium below 200 mg/L with additions of soda ash.

Monitor potassium to maintain at the required concentration. Pre-hydrate high concentration polymers in premix tank if available and add to the active system. Add sufficient potassium material to compensate for water additions and down-hole depletion. A water meter is recommended to determine dilution volumes.

Adequate solids control equipment, desander/desilter (if still in use), fine mesh screen shakers, and centrifuges should be considered absolute necessities with this mud system.

Control pH in the 9.0 to 10.5 range with mono ethanol amine or caustic soda. Corrosion rates can be reduced with oxygen scavengers (sodium sulfite).

Diligent monitoring and maintenance of pH required. It is important that some hydroxide is evident in the alkalinity analysis to help keep the system stable and reduce bacterial contamination.

Fluid Specific Tests and Equipment

- Potassium ion test kit to measure K+ ion concentration
- Electronic temperature controlled retort for glycol concentration
- PHPA test kit to monitor MAXCAP D polymer concentration
- Complete WBM testing kit

Contaminants: effect and treatment

Contaminant	Mud Effect	Treatment
Aeration	"Gritty" mud; Pump jacking	Identify cause; eliminate air source; defoamers
Bacteria	Filtration increase; pH drop; carbs/bicarbs increase; odour; aeration; viscosity drop	Bactericides; increase pH to 9.5 – 10.0
Calcium	NA – if MBT is low; lower effectiveness of PHPA and other polymers if > 200 mg/L, high filtration	Soda ash
Cement	High pH with high calcium; pH > 12.0 decrease in rheology if MBT low	Citric or Sulfamic Acid; Bicarb to lower calcium < 200 mg/L
CO_3-/HCO_3-/CO_2	No OH^- in alkalinity analysis; "gritty" mud if > 3,000 mg/L combined	Lime to precipitate carbonates and Caustic soda to increase OH^-
H_2S	Odour; black mud; corrosion	Zinc carbonate or oxide; Zinc chelate; scavenging amine; pH 9.5 – 10.0
Inhibition	Over treating with MAXCAP D may cause screen blinding	Reduce PHPA concentration.
LGS	High PV's; K^+ and MAXCAP D depletion	Centrifuge and / or dilution; increase concentration of inhibitors
pH	High pH, lower effectiveness of polymers	Citric or Sulfamic Acid
Salt	Increase chlorides	Live with the effects or convert to a salt system
Surfactant	Foaming	Prevention from cement water and rig wash; Antifoam agents premixed in the makeup water and/or defoamers
Water Influx	Dilution	Density increase to stop flow; replenish products concentrations

Operational Recommendations and "Best Practices"

- Recommend drill out cement with fresh water from a short circulating system and discard.
- Use of an antifoam agent in the premix water may alleviate subsequent foaming issues.
- System is easier to maintain with "proactive" measures such as daily maintenance regime. Concentrated pre-mixes for maintaining or manipulating properties an option.
- Thin fluid while drilling with solids control equipment and dilution.
- If the application requires corrosion inhibitors (e.g. QTDL-15), the simultaneous addition of defoamer reduces foaming.
- Diligently measure Potassium ion concentration, especially in new wells/areas as depletion rates may be high.
- Residual bentonite or solids in tanks deplete K^+ concentration before drill out.
- For mud up "on the fly" from floc water section, stop calcium additions 100 – 200 m prior to mud up. Reduce calcium content with soda ash to under 200 mg/L and start additions of Potassium source salt, GLYMAX, viscosifiers and fluid loss additives. Increase pH with MEA, caustic soda or potash.
- Run LGS as low as possible to prevent artificial depletion of the K^+.
- Thin fluid while drilling with solids control equipment and dilution. Avoid use chemical thinners.
- This system is simple and easy to maintain. For effective hole cleaning, special attention must be paid to rheological properties.
- Always run all the solids control equipment to avoiding LGS build up in the active system.
- Pilot tests high anionic chemicals to determine effect on mud properties (especially rheology) prior to use in the whole fluid.

- CEC testing is recommended to measure the shale activity for proper inhibitor concentration.
- Premix polymers with fresh water before add them to the system.
- Keep entrained air out of the system by:
  - Shutting the mud hopper down when it is not in use.
  - Submerging mud guns to prevent aeration.
  - Careful use of hydrocyclones.
- Highly concentrated shore-based mixture reduces inventory requirements in off-shore operations. Check saturation and TCT values prior to mixing.