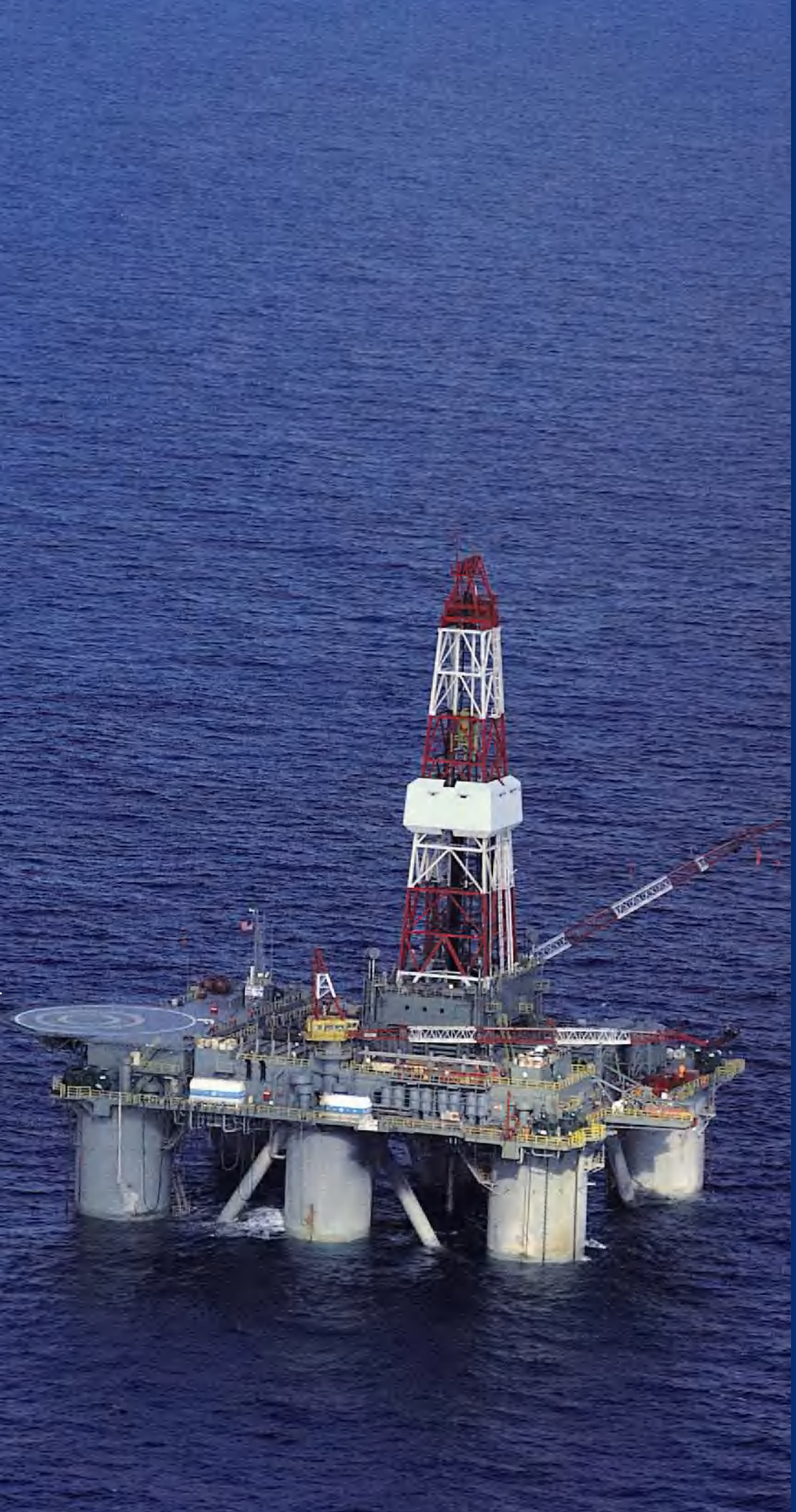


FLODRILL™
For the Drilling Industry

SNF FLOERGER

Water-based mud additives

Successfully completing an oil well at reasonable costs depends considerably on the properties of the drilling fluids. Many specific requirements are placed on the fluid to achieve several purposes which are described below:

- Carry cuttings from down hole to the surface and permit their separation
- Cool and keep the bit clean
- Reduce the friction between the drilling string and the sides of the hole
- Prevent the inflow of formation fluids such as gas, oil or water
- Maintain the stability of the uncased sections of the borehole
- Form a thin and permeable layer called filter cake which seals formation openings and prevents fluid losses
- Assist in data collection and interpretation of well logs

SNF has developed a wide range of polymers for water-based drilling mud systems. Each range SNF polymers covers one or several drilling fluid requirement such as fluid loss control, viscosity improvement, shale inhibition…

Synthetic polymers are produced in a variety of forms, molecular weights and compositions for specific applications. For instance, the same Partially Hydrolyzed Polyacrylamide (PHPA) can provide viscosity or thixotropic behavior, drag reduction effect or fluid loss properties to the fluid.

Viscosity Improvements

Three main products are used to enhance the viscosity of the drilling fluid which is for instance useful to carry efficiently the cuttings up to the surface: Bentonite, Partially Hydrolyzed Polyacrylamide (PHPA) and Xanthan Gum.

Bentonite is a phyllosilicate composed mainly of montmorillonite. Few percentage in water leads to an increase of viscosity resulting from the absorption of water between the tiny crystalline platelets and the consecutive swelling of the minerals. Bentonite is used mainly in fresh water.

PHPA is a water-soluble polymer. Interactions between the polymer molecules increase the viscosity of the drilling mud proportionally to the molecular weight of the product. PHPA can be used in fresh water, sea water or NaCl and KCl systems. PHPA is not compatible with high divalent contents in the water and high temperature applications. However, sulfonated co-polymers improve temperature stability and rheological profile and can be made associative or with protective groups for applications where PHPA will not work.

Product	Form	Molecular weight	Anioncity
Flodrill EM533	O/W emulsion	High	Anionic
Flodrill PAM1040	Powder	High	Anionic

Flodrill PAM 1040 performance in fresh water based mud

		Polymer concentration in ppb		
Flodrill PAM 1040		0	0,5	1
Rheology at 80°F	P.V (Cp)	6	17	23
	Y.V.(lbf/100ft²)	6	7	27
Rheology at 185°F	P.V (Cp)	4	11	3
	Y.V.(lbf/100ft²)	0	10	41

125ppg Water Based Mud
13ppb Bentonite
Barite used as weighting agent

Flodrill EM 533 performance in fresh water based mud

		Polymer concentration in ppb		
Flodrill EM 533		0	1,5	3
Rheology at 80°F	P.V (Cp)	6	18	23
	Y.V. (lbf/100ft²)	6	7	26
Rheology at 185°F	P.V (Cp)	4	11	4
	Y.V. (lbf/100ft²)	0	10	41

125ppg Water Based Mud
13ppb Bentonite
Barite used as weighting agent

Anti-clay swelling agent (Shale inhibitor)

Polymer is adsorbed on the surfaces of drill cuttings and on the borehole wall. The encapsulation of drilled solids promotes flocculation and minimizes the disintegration and the dispersion of the suspended solids. These larger cuttings are then carried up to the surface where they can be more efficiently removed by solids control equipment. The adsorption of polymers onto the borehole wall also enhances the stability of water-sensitive formations such as shales to avoid caving and hole enlargement.

Anionic polymers may act by the long chain with negative ions attaching to the positive sites on the clay particles, or to the hydrated clay surface through hydrogen bonding. Surface hydration is reduced as the polymer coats the surface of the clay.

Low cationic polymers can also be used for shale inhibition. High cationic polymers can interact with other chemicals used in the drilling mud and lead to compatibility issues.

High MW PHPA with KCl salt are used as Anti-clay swelling agents

Flodrill PAM 1040	High Mw Medium anionic
Flodrill EM533	High Mw, medium anionic
Flodrill TS056	Low Mw, low cationic
Floquat FL 2250	Very low Mw, highly cationic
Floquat TS 45RD	Very low Mw, highly cationic

PHPA LT

	Property	Unit	Results required	Results obtained
1	Relative dispersibility of Bentonite Pellets in 0.2 % (w/v) polymer solution at 60 ± 5 °C with respect to distilled water.		175 (Maximum)	138.49
2	Apparent viscosity of 0.2 % (w/v) polymer solution in distilled water.			
(i)	At 24 ± 2 °C	cp	9.0 (Mini)	13
(ii)	After aging at 110±2°C for 18 hrs.	cp	Should not be less than 80% of the value obtained at 6 (i)	12.5
3	Effect on 4 cp Bentonite suspension at 0.2 % (w/v) polymer concentration			
(i)	AV at 24±2°C and at pH 9.0	cp	15.0 (Minimum)	23
(ii)	AV after aging at 110 ± 2 0C for 24 hrs.	cp	Should not be less than 80% of the value obtained at 7 (i)	21
4	Calcium Tolerance test :			
(i)	Apparent viscosity of 0.4 % (w/v) polymer in distilled water.	cp	To be determined	23,5
(ii)	Apparent viscosity of 0.4 % (w/v) polymer solution in distilled water in presence of 100 ppm Ca++.	cp	It should not be less than 60% of the value obtained at 8 (i)	17

PHPA HT

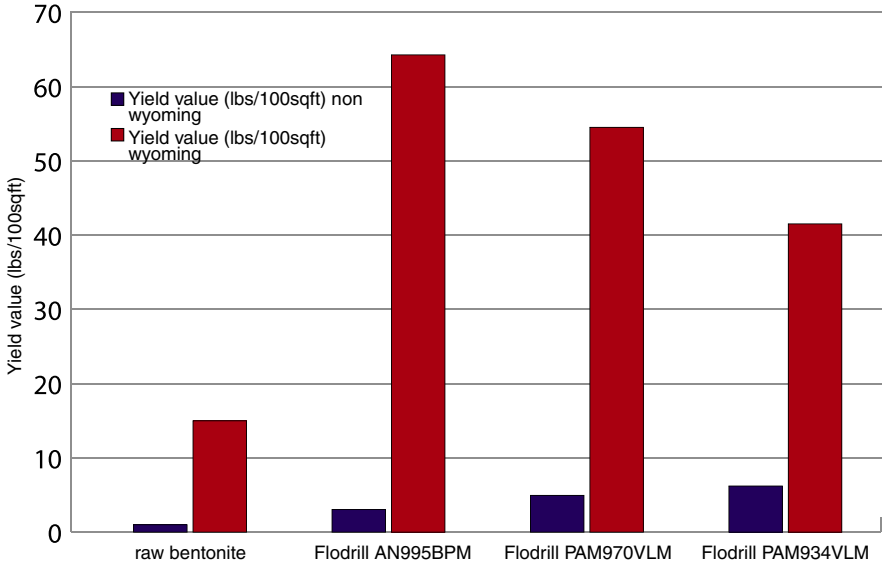
	Property	Unit	Results required	Results obtained
1	Relative dispersibility of Bentonite Pellets in 0.2 % (w/v) polymer solution at 60 ± 5 °C with respect to distilled water.	-	175 (Maximum)	136
2	Apparent viscosity of 0.2 % (w/v) polymer solution in distilled water.			
(i)	At 24 ± 2 °C	cp	9.0 (Mini)	15
(ii)	After aging at 140±2°C for 18 hrs.	cp	Should not be less than 80% of the value obtained at 6 (i)	12
3	Effect on 4 cp Bentonite suspension at 0.2 % (w/v) polymer concentration			
(i)	AV at 24±2°C and at pH 9.0	cp	15.0 (Minimum)	18.5
(ii)	AV after aging at 140 ± 2 0C for 24 hrs.	cp	Should not be less than 80% of the value obtained at 7 (i)	15
4	Calcium Tolerance test :			
(i)	Apparent viscosity of 0.4 % (w/v) polymer in distil-led water.	cp	To be determined	24
(ii)	Apparent viscosity of 0.4 % (w/v) polymer solution in distilled water in presence of 100 ppm Ca++.	cp	It should not be less than 60% of the value obtained at 8 (i)	15

Bentonite Extender

Low solids mud systems typically use a polymer additive as a viscosifier or commonly called a bentonite extender. These products are used to increase the viscosity in non-dispersed, fresh water mud systems. They can be added to the mud system on site or directly to the bentonite at the mill.

The polymer and the bentonite particles interact together thanks to their respective electrostatic charges; the created links between these particles consequently increases the viscosity yield. SNF produces a complete range of polyacrylamides for this application. Low molecular weight and very highly charged anionic polymers are used as bentonite extenders.

Flodrill AB 995 BPM	Polyacrylate very low Mw, beads
Flodrill AN 995 BPM	Polyacrylate low Mw, powder, particle size<500µm
Flodrill PAM 970 VLM	High anionic polyacrylamide, powder
Flodrill PAM 934 VLM	Medium Anionic Polyacrylamide, powder



Fluid loss control agent

The purpose of fluid loss control additives is to reduce water loss from the slurry to the drilled formation. Sensitive formations are protected from damage and premature dehydration of the slurry is avoided. If the loss of fluid to the formation is too important, a layer of filtrate will build up on the walls causing reduced flow and increased friction pressures due both to the restricted flow path and the higher viscosity of the slurry.

Polyelectrolytes are added to low solids and bentonitic water-based mud systems to improve fluid loss control and therefore avoid formation damage. It also increases the drilling rate.

Very low MW anionic or amphoteric polymers are used for fluid loss control agent. The use of poly-acrylate homo- and co-polymers is limited in systems with high divalent content with high temperature due to precipitation of the polymer.

Fluid-loss agents for mud system and moderate temperature

Flodrill TS655	Powder	Up to 300°F

High filtration performance is required when drilling under high temperature and high pressure conditions, especially when dealing with harsh brines. The products must be stable and effective even at high temperature; SNF has therefore developed fine-tuned polymers to fit these conditions.

Sulfonated co and ter-polymers are known to build stronger interactions between mud components, and these monomers are salt and thermally stable. They are therefore used for high temperature fluid loss control. They also may contain additional thermally stable co-monomers for HP-HT resistance such as dimethyl acrylamide, N-vinyl pyrrolidone, or acrylamide derivate. They can incorporate humate or lignosulfonate at the manufacturing stage to optimize mud and cement viscosity.

Fluid-loss agents for mud system and high temperature

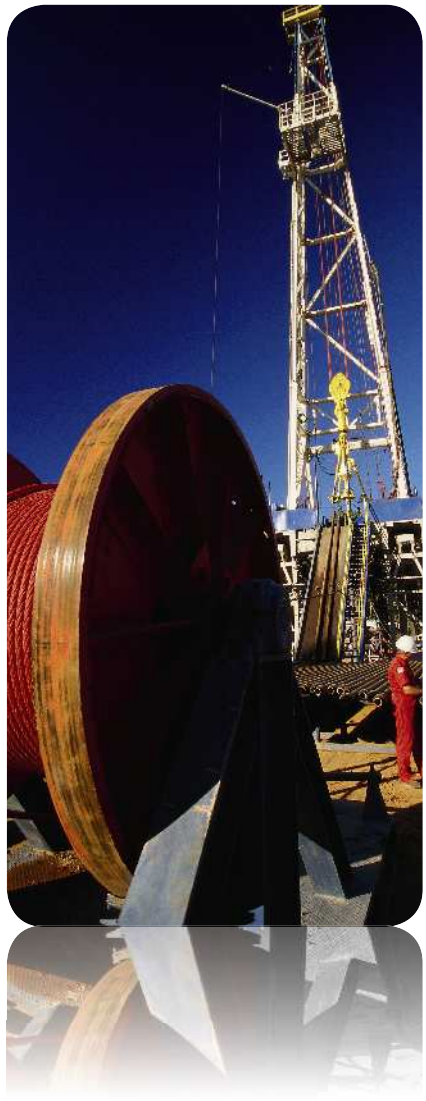
Flodrill TS 30 LC	Powder	Up to 400°F
Flodrill TS 28 L	Powder	Up to 350°F
Flodrill AB 89L	Beads	Up to 350°F

For higher temperatures and up to 500°F, the performance of the polymer additives is dependent on the typical mud formulation and requires case by case development.

Products	Flodrill TS 28L		Flodrill TS 30 LC		Flodrill AB89L	
Fann Viscosity Speed (rpm)	Fresh water	salt water	Fresh water	salt water	Fresh water	salt water
600	124	85	114	81	147	121
300	69	53	62	49	84	69
200	51	40	41	36	62	51
100	31	26	24	22	37	32
6	7	8	5	8	10	10
3	6	6	4	6	8	8
Plastic viscosity (cP)	55	52	52	45	63	87
Yield Point (lbf/100ft²)	14	18	10	19	21	34
10 min Gel (lb/100ft²)	9	9	5	10	11	12
HPHT filtrate, ml (350°F, 500psi)	7,8	10,2	5,7	19,2	8,2	4,3

Water	0,65 (bbl)
bentonite Na	6 (lb)
dispersant	12 (lb)
polymer	2 (lb)
NaOH	1 (lb)
bentonite Ca	10 (lb)
barite	399,4 (lb)
Mud weight	15,8 (ppg)

Water	0,63 (bbl)
NaCl	9 (lb)
bentonite Na	8 (lb)
dispersant	12 (lb)
polymer	5 (lb)
NaOH	2 (lb)
bentonite Ca	20 (lb)
barite	391 (lb)
Mud weight	15,9 (ppg)



Dispersant

Dispersants are used to reduce viscosity and gel strength. Besides lignosulfonates and polyphosphates, polyacrylates of low molecular weight are widely used for this kind of application. Modified dispersants based on sulfonated polymers are also available for high temperature and high salinity water-based muds.
These products can be fine-tuned by changing the molecular weight, their physical form (solid, liquid), their structure, their composition to resist harsh brines and high temperatures (incorporation of sulfonated and phosphate monomers).

Flosperse OW38	Liquid	41% active	Polyacrylates
Flosperse TS 38	Powder		Polyacrylates
Flosperse 3018CS	Liquid	40% active	Sulfonated polymer
Flosperse 5005CP	Liquid	41% active	Phosphonic polymer
Floset TS1	Powder		Acrylic comb polymer

Fluid-loss agents for cement

Cement filtration control additives are used in well cement compositions to decrease the fluid loss to permeable formations or zones into which the cement compositions are pumped, avoid its premature gelation. Filtration control additives are added to cement for the same reasons that they are used in drilling fluids. However, untreated cement slurries have much greater filtration rates than untreated drilling muds so it is paramount to limit the loss of fluid for the following reasons:

- Minimize hydration of water sensitive formations
- Allow suffi cient water to be available for cement hydration
- Avoid a modification of the slurry properties
- Avoid bridging of the annular gap
- Reduce the loss of compressive strength
- Reduce annular gas migration

Flodrill TS443	Powder	Up to 185°F
Flodrill AK820	Beads	Up to 185°F
Flodrill PP247	Powder	> 185°F

Products	Flodrill TS 443			Flodrill AK820			Flodrill PP247		
Fann Viscosity Speed (rpm)	185°F - Fresh water	185°F - salt water	> 250°F - fresh water	185°F - Fresh water	185°F - salt water	> 250°F - fresh water	185°F - Fresh water	185°F - salt water	> 250°F - fresh water
HPHT filtrate, ml (1000psi)	42	110	> 200	120	> 150	120	37	100	47

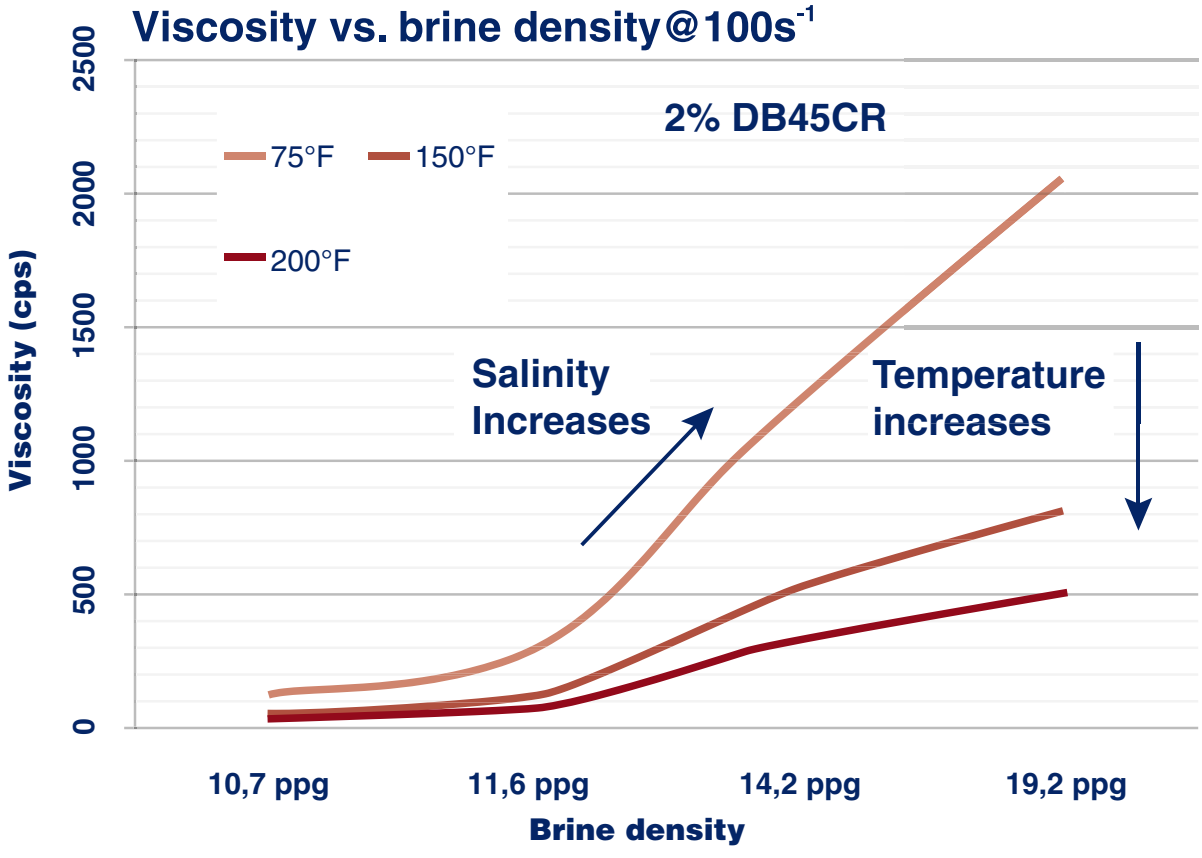
Water : 44% / cement
Retardant : 0.3% / cement
Dispersant : 0.2% / cement
Cement: 600g

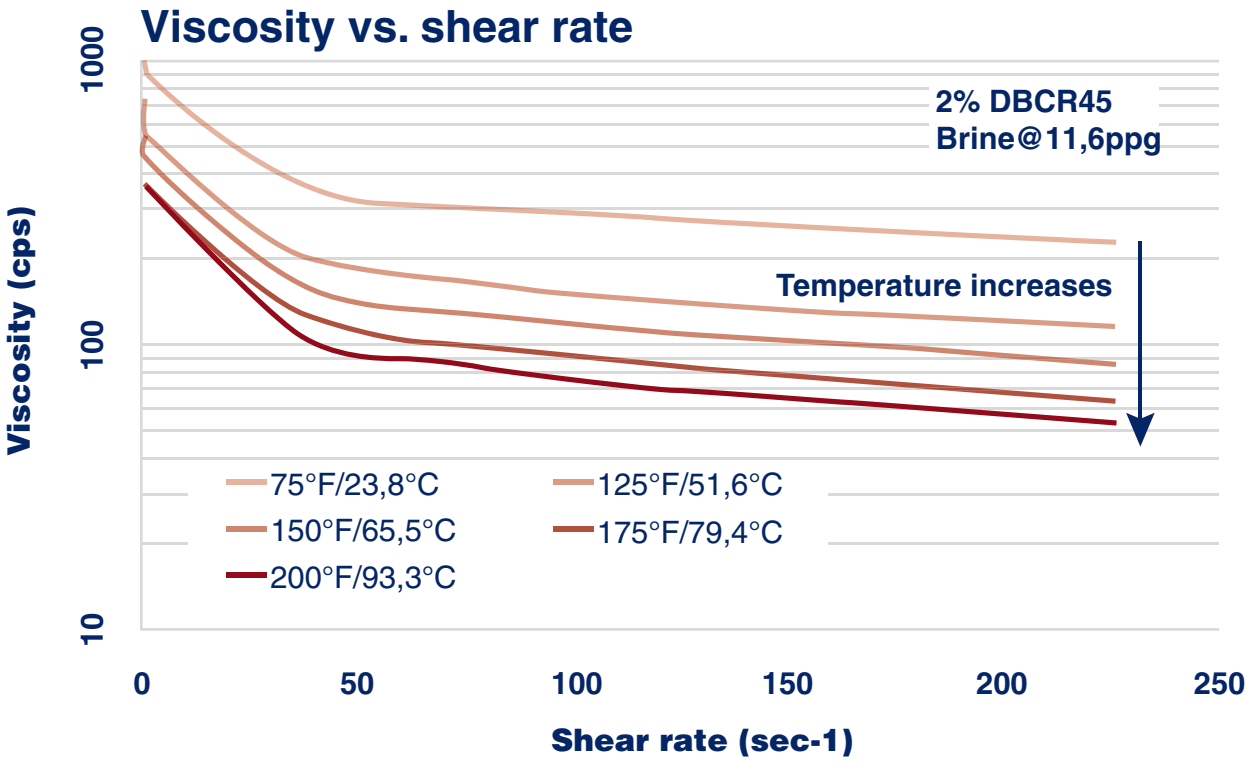
Brine Viscosifiers

Viscosity is a key factor in limiting seepage of the fluid into the rock adjacent to the wellbore, and in solids suspension and removal. Various polymers are routinely used in the oilfield to produce viscosity in fluids. SNF manufactures polymers that are capable of generating shear thinning viscosity, and maintaining that rheological character to high temperatures. These polymers also provide resistance to highly salted brines.

Flodrill DB45CR	Powder	Highly cationic

Flodrill DB 45 CR is a DADMAC based proprietary polymer highly branched and highly cationic. The polymer is produced by inverse suspension process and can be used as such or can be partially or fully grinded to enhance the speed of dissolution.




Viscosity vs. shear rate
Viscosity (cps)
1000
100
10
2% DBCR45
Brine@11,6ppg
Temperature increases
75°F/23,8°C
125°F/51,6°C
150°F/65,5°C
175°F/79,4°C
200°F/93,3°C
0
50
100
150
200
250
Shear rate (sec-1)

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