HIGH TEMPERATURE APPLICATION OF DRILLING SPECIALTIES POLYMERS FOR FILTRATION CONTROL

DRISPAC® POLYMER, DRISTEMP® POLYMER AND DRISCAL® D POLYMER

Depending on mud formulation, polymers based on cellulose chemistry such as Drispac® Regular Polymer, Drispac® Superlo® Polymer, Drispac® Plus Regular Polymer and Drispac® Plus Superlo® Polymer, are generally considered to be thermally stable to 250° F in laboratory testing for high temperature and high pressure (HTHP) Filtrate control. In the lab the addition of oxygen scavengers, to optimize the polymers thermal stability, boosts functional HTHP filtrate control to +300° F. Starches have a somewhat lower thermal stability and while some improvements in starch thermal stability has been achieved with single or double derivatives of hydroxypropyl and/or carboxymethyl starches, they still have not achieved the thermal stability of the cellulose derivatives. As the bottom hole temperature (BHT) increases above 300°F it becomes necessary to change mud formulation to utilize more thermally stable additives. Field use typically allows PAC polymers to be used with bottom hole temperature (BHT) exceeding maximum laboratory temperature stability by 25-50°F. This is because in actual field muds oxygen is scavenged from the mud by additives such as lignosulfonates and tannin based thinners such as Desco® Deflocculant, C.F. Desco® Deflocculant, C.F. Desco® II Deflocculant, and Drill-Thin® Thinner. Typically in field muds the accepted thermal stability of Drispac® Polymers for HTHP Filtrate control is 320°F BHT. Above this temperature something more is needed.

An improved synthetic polymer **(Dristemp® Polymer)** has been introduced for HTHP drilling, completion and workover fluids. The improved polymer imparts stable HTHP fluid loss control and viscosity to fluids that have exceeded the thermal stability limits of the most commonly used natural polymers such as cellulose derivatives Polyanionic cellulose (PAC), carboxymethylcellulose (CMC)) and any of the starches. Dristemp® Polymer will work in fresh water, sea water, saturated sodium chloride (NaCl) brines, potassium chloride (KCl) brines and formate brines. Dristemp® Polymer will tolerate up to 5,000 ppm free calcium contamination. Data presented in this brochure demonstrates the utility of the polymer in muds formulated with sea water, NaCl brine, KCl brine, and potassium formate brine. Depending on the system in which it is tested, the thermal stability limit of the Dristemp® Polymer is 375° F as tested in the laboratory.

Experience indicates the most economical drilling fluid program for HTHP wells is to formulate the mud with PAC in the upper section of the well and drill ahead until the BHT becomes high enough that the PAC polymer consumption begins to increase as a result of thermal degradation. At this point, switching to Dristemp® Polymer will give a relatively seamless transition to a mud, which is thermally stable to about 400° F in field applications. For very high temperature field applications (>400°F) we recommend using Dristemp® Polymer to about 375°F while beginning to replace it with Driscal® D Polymer at approximately 350°F.

For temperatures above 400°F **Driscal® D Polymer** will perform in a wide variety of muds to control HTHP filtrate in muds at any salinity in either NaCl or KCl systems. Driscal® D Polymer is calcium tolerant and has proven effective in drilling fluids with calcium counts reaching 100,000 ppm. For best results it is advised that Driscal® D Polymer be used at temperatures above 330°F and introduced before polymers such as Dristemp® Polymer begin to degrade in order to again insure a seamless transition. Driscal® D Polymer has delivered good fluid loss control as well as improved barite suspension after aging at temperatures up to 475°F. The highest BHT in which Driscal® D Polymer has been used is reported to be in excess of 500°F in California geothermal wells and in a steam flood project in Alberta, Canada.

In silicate muds, Drilling Specialties Company's hostile environment product, **HE® -300 Polymer**, is recommend for HTHP fluid loss control.

Oxygen Scavengers

Sodium sulfite, sodium bisulfite and ammonium sulfite are offered by various mud companies as O_2 scavengers. The use of these scavengers helps to reduce oxidation of polymers and keeps the pH from falling. Generally O_2 scavengers are used at concentration of (1.0 – 3.0ppb), for best results visit with your drilling fluids provider about the use of these materials.

The following data shows Dristemp® Polymer to be more efficient than a commonly used "high temperature" polymer in a variety of HTHP muds at temperatures beyond those where starches and cellulose polymers fail. **(Note: lab testing generally takes twice as much as polymer to achieve the results seen in field applications.)**

Table 1
17 lb/gal, 15% KCl Water Mud with Dristemp® Polymer

Materials, lb/bbl	Control mud	#1	#2
Bentonite, lb/bbl	3	3	5
50% w/v NaOH	0.25	0.2	0.25
Potassium Chloride	35	35	35
Na-lignite, lb/bbl	5	5	5
Dristemp® Polymer, lb/bbl	----	6.0	----
Competitive used HTHP polymer,lb/bbl	----	----	7.5
Barite, lb/bbl	420	420	420
50% w/v NaOH	1.25	1.25	1.25
Rev dust, lb/bbl	15	15	15

Initial Results @ 95°F			
Plastic Viscosity, cp	13	105	67
Yield Point, lb/100 ft^2	1	54	15
6/3 rpm readings, lb/100 ft^2	2/2	16/12	3/2
Gels, lb/100 ft^2	3/11	6/11	3/7

Aged 16 Hours @ 350°F, cooled, mixed 10 minutes, and tested @ 100°F			
Settling?	Yes	No	Yes
Plastic Viscosity, cp	14	86	51
YP, lb/100 ft^2	0	30	6
6/3 rpm readings, lb/100 ft^2	2/2	5/3	2/1
Gels, lb/100 ft^2	3/9	3/5	1/2
HPHTWL, ml, (500 psi/300° F)	No Control	17.8	25.6

Table 2
16.8 lb/gal, Sea Water Mud with Dristemp® Polymer

Materials, lb/bbl	#1	#2
Bentonite, lb/bbl	3.00	3.00
Na-Lignite, lb/bbl	0.25	0.25
50% NaOH, lb/bbl	0.13	0.13
Sea Salt, lb/bbl	10	10
Na-lignite, lb/bbl	5	5
Dristemp® Polymer, lb/bbl	4.5	----
Competitive HTHP polymer, lb/bbl	----	4.5
Barite, lb/bbl	420	420
NaOH	0.5	0.5
Rev dust, lb/bbl	15	15

Initial Results @ 95°F		
Plastic Viscosity, cp	92	59
Yield Point, lb/100 ft^2	65	22
6/3 rpm readings, lb/100 ft^2	16/12	5.5/4
Gels, lb/100 ft^2	11/24	5/13

Aged 16 Hours @ 350°F, cooled, mixed 10 minutes, and tested @ 100°F		
Plastic Viscosity, cp	53	34
Yield Point, lb/100 ft^2	22	0
6/3 rpm readings, lb/100 ft^2	3/2	1/1
Gels, lb/100 ft^2	3/5	2/2
WL, ml	3.4	5.9
HPHTWL, ml (500 psi/300° F)	31.0	57.8

Table 3

11.8 lb/gal K-Formate Mud with Dristemp® Polymer

Materials Used		Control Mud	#1	#2
Potassium Formate 13.2 SG, ml		179	179	179
Tap water, ml		80	80	80
Attapulgite, lb/bbl		7.5	7.5	7.5
Glycol, ml		8	8	8
Flowzan® Biopolymer, lb/bbl		1.5	1.5	1.5
Dristemp® Polymer, lb/bbl		---	8.0	---
Competitive HTHP polymer, lb/bbl		---	---	10.0
Mg-Oxide, lb/bbl		0.5	0.5	0.5
Bentonite, lb/bbl		5	5	5
Rev dust, lb/bbl		10	10	10

Initial Results at 95°F				
Plastic Viscosity, cp		23	24	29
Yield Point, lb/100 ft²		31	48	48
6/3 rpm readings, lb/100 ft²		12/10	20/17	19/16
Gels, lb/100 ft²		10/17	15/23	15/23

Rolled 4 hours at 250°F, the hot samples were aged 16 hours at 400°F, cooled, observed, mixed 5 minutes, and tested at 95°F				
Plastic Viscosity, cp		10	40	26
Yield Point, lb/100 ft²		1	19	6
6/3 rpm readings, lb/100 ft²		4/6	2/3	2/3
Gels, lb/100 ft²		2/2	2/1	2/2
WL, ml		131	1.1	1.2
HPHTWL, ml (500 psi/300° F)		No Control	11.6	14.2
HPHT Cake		----	2/32”	2/32”

Table 4
16.7 lb/gal, 20% NaCl Water Mud with Dristemp® Polymer

Materials, lb/bbl	#1	#2	#3
Tap Water, ml	225	225	225
Bentonite, lb/bbl	3	3	3
50% NaOH, lb/bbl	0.13	0.13	0.13
NaCl, lb/bbl	58	58	58
Dristemp® Polymer, lb/bbl	3.5	4.5	----
Commonly used HTHP polymer, lb/bbl	----	----	4.5
Polydrill, lb/bbl	5	5	5
Barite, lb/bbl	405	405	405
OCMA clay, lb/bbl	15	15	15
NaOH, pH	9.5	9.5	9.5

Initial Results @ 100°F			
Plastic Viscosity, cp	60	103	48
Yield Point, lb/100 ft²	37	43	10
6/3 rpm readings, lb/100 ft²	4.5/3	9/5.5	3/2
Gels, lb/100 ft²	4/11	7/15	3/12
Aged 16 Hours @ 320°F, cooled, mixed 10 minutes, and tested @ 100°F			
Plastic Viscosity, cp	44	70	38
Yield Point, lb/100 ft²	10	36	4
6/3 rpm readings, lb/100 ft²	2/1.5	4.5/3	1/1
Gels, lb/100 ft²	2/4	3/4	1/2
WL, ml	7.8	8.0	7.7
HPHTWL, ml (500 psi/300° F)	10.8	11.2	15.6
HPHT Cake	3/32”	3/32”	11/32”
After testing, mixed more polymer as shown, adjusted pH to 9.0, aged 16 Hours @ 370°F, cooled, mixed 10 minutes, and tested @ 100°F			
More Polymer Mixed, lb/bbl	1.50	0.00	2.50
Total Polymer, lb/bbl	(5.0)	(4.5)	(7.0)
Plastic Viscosity, cp	43	39	36
Yield Point, lb/100 ft²	7	5	0
6/3 rpm readings, lb/100 ft²	1.5/1	1.5/1	1/1
Gels, lb/100 ft²	2/3	1/2	1/1
WL, ml	1.0	1.2	1.3
HPHTWL, ml (500 psi/300°F)	10.6	10.8	12.8
HPHTWL (R)*	13.2	18.8	15.0

*HPHTWL(R): Retested for HPHTWL after removing settled solids from samples

TABLE 1
FRESH WATER MUD WITH DRISCAL® D POLYMER

Mud Components	Mud Sample Numbers					
Added to Base Mud	#1	#2	#3	#4	#5	#6
Lignite, lb/bbl			2.0	2.0	2.0	2.0
Drispac® Superlo® Polymer					1.0	1.0
Driscal® D Polymer, lb/bbl	2.0		2.0		2.0	
Competitive Polymer* lb/bbl		2.0		2.0		2.0

	Initial Results at 90°F					
600 RPM	125	120	93	93	149	136
300 RPM	89	84	65	65	104	94
PV/YP	36/53	36/48	28/35	28/35	45/59	42/52
Gels 10 sec /10 min.	13/18	16/38	7/11	13/32	17/28	26/44
API fluid loss			5.7	6.0		

Results after Hot Rolling 16 hrs @ 400°F

	Test Temperatures at 120°F**					
600 RPM	75	29	72	33	52	19
300 RPM	46	17	45	17	31	10
PV/YP	29/17	12/5	27/18	16/1	21/10	9/1
Gels 10 sec / 10 min.	7/9	1/2	3/5	1/2	3/3	1/1
API fluid loss	8.8	9.4	5.6	7.2	5.9	7.5
HTHP fluid loss (500 psi/300°F)	27.8	34.0	19.3	36.4	20.4	40.6
Settling***	NO	YES	NO	YES	NO	NO

- * Competitive polymer is produced by major manufacture of high temperature polymer
- ** After hot – rolling, samples were cooled to room temperature, and then reheated to 120°F while stirring at 600 RMP. Base Mud = 340 ml tap water, 15 ppb bentonite, 0.04 NaOH, 10.0 ppb P95 clay, 5.0 ppb fine grind $CaCO_3$. The pH was adjusted to 8.5, prior to initial test, with NaOH.
- *** Observed after aging.

TABLE 2
SEAWATER MUD WITH DRISCAL® D POLYMER

12 ppg Seawater Mud (9 ppb bentonite / 18 ppb drill solids)								
Initial Results					After Aging 16 hrs @ 350°F			
PRODUCT	PPB	PV/YP	Gels	WL	PV/YP	Gels	WL	HTHP
Base Mud*		8/7	6/13	53.4	7/11	5/13		NC
Driscal® D Polymer	3.0	31/28	9/14	4.0	25/24	4/14	5.2	30.0

12 ppg Seawater Mud (9 ppb bentonite / 18 ppb drill solids)								
Initial Results					After Aging 16 hrs @ 400°F			
PRODUCT	PPB	PV/YP	Gels	WL	PV/YP	Gels	WL	HTHP
Base Mud*		8/7	6/13	53.4	12/1	5/12		NC
Driscal® D Polymer	3.0	31/28	9/14	4.0	30/9	1/2	5.4	30.0

16 ppg Seawater Mud (11 ppb bentonite / 7 ppb drill solids)								
Initial Results					After Aging 16 hrs @ 350°F			
PRODUCT	PPB	PV/YP	Gels	WL	PV/YP	Gels	WL	HTHP
Base Mud**		15/17	12/16	68.4	13/46	19/24		NC
Driscal® D Polymer	3.0	69/52	20/37	4.8	46/71	30/48	10.6	34.0

16 ppg Seawater Mud (11 ppb bentonite / 7 ppb drill solids)								
Initial Results					After Aging 16 hrs @ 400°F			
PRODUCT	PPB	PV/YP	Gels	WL	PV/YP	Gels	WL	HTHP
Base Mud**		15/17	12/16	68.4	13/46	19/24		NC
Driscal® D Polymer	3.0	69/52	20/37	4.8	54/48	16/46	5.8	30.0

16 ppg Seawater Mud (7 ppb bentonite / 15 ppb drill solids)								
Initial Results					After Aging 16 hrs @ 350°F			
PRODUCT	PPB	PV/YP	Gels	WL	PV/YP	Gels	WL	HTHP
Base Mud**		41/28	11/15	72.0	36/25	8/12		NC
Driscal® D Polymer	3.0	60/39	15/33	5.3	49/32	6/27	4.5	27.0

16 ppg Seawater Mud (7 ppb bentonite / 15 ppb drill solids)								
Initial Results					After Aging 16 hrs @ 400°F			
PRODUCT	PPB	PV/YP	Gels	WL	PV/YP	Gels	WL	HTHP
Base Mud**		41/28	11/15	72.0	44/32	8/18		NC
Driscal® D Polymer	3.0	69/52	20/37	4.8	49/21	4/8	5.0	32.0

- * Base Mud – contains 290 ml tap water, 9 g bentonite, 4.5 g lignite, 1 g Desco Deflocculant, 12, g sea salt, 176 g barite, 18 g drill solids (1:1 ratio P95 clay/Rev Dust). The pH adjusted to 9.5 with NaOH.
- ** Base Muds – contains 240 ml tap water, (7 – 11 g bentonite), 3.7g lignite, 10g sea salt, barite for density, drill solids (1:1 ratio P95 clay/Rev Dust). The pH was adjusted to 9.5 with NaOH. Base muds were not tested for fluid loss. Aging was done at static conditions.

TABLE 3
DRISCAL® D POLYMER in 20% NaCl Water Mud

Materials	Stirring time minutes	Sample # 1	Sample # 2	Sample #3
Tap Water, ml	20	220.0	220.0	220.0
Bentonite, g	10	3.0	3.0	3.0
NaOH (1 ml=0.5g), ml	10	2.0	2.0	2.0
Lignite, g	10	5.0	5.0	5.0
NaCl, g	10	60.0	60.0	60.0
Barite, g	20	350.0	350.0	350.0
Driscal® D Polymer, g	10	3.5	3.5	3.5
P95 (illite) clay, g	10	15.0		
Rev dust, g	10		15.0	
OCMA clay, g	10			15.0
Initial Results @ 85°F				
AV		67.0	65.0	88.5
PY		58.0	57.0	65.0
YP		18.0	16.0	47.0
Gels		5/15	5/12	14/36
API		2.6	2.8	2.5
pH		8.8	8.6	8.9
After Aging **16 hours @ 400°F**				
AV		41.5	33.5	68.5
PY		36.0	27.0	42.0
YP		11.0	13.0	53.0
Gels (10 sec/10 min)		3/9	1/5	16/46
API		2.8	4.2	4.4
HTHP (300F & 500 Psi)		21.2	24.6	26.4
pH		7.2	7.2	7.4
Settling		None	Slight	None

For more information on Drilling Specialties Company products see our web site at **www.drillingspecialties.com**