Available online www.jocpr.com

Journal of Chemical and Pharmaceutical Research, 2014, 6(7):2584-2588

Research Article

ISSN : 0975-7384
CODEN(USA) : JCPRC5

Study and application of amine based anti-collapse drilling fluid in sulige gas field

Ming Zhang[1,2], Tiantai Li[2] , Da Li[3] and Deqiang Yi[3]

[1]*College of Petroleum Engineering, China University of Petroleum, Beijing, China*
[2]*College of Petroleum Engineering, Xi'an Shiyou University, Xi'an, China*
[3]*Research Institute of Sulige, Changqing Oil field Company, Xi'an, China*

ABSTRACT

A new type of amine based anti-collapse drilling fluid is developed with strong inhibition for solving hydration swelling, hole shrinkage, and serious mud-making problems while meeting with mud shale formation in horizontal drilling in Sulige gas field. Performance evaluation results show that the good compatibility between organic amine inhibitors and drilling fluid is conducive to maintain the high temperature stability of the drilling fluid, and improve the drilling fluid filtration performance; the amine based drilling fluid, with good inhibition, strong pollution resistance, temperature resistance, resistance to calcium, and small damage for gas reservoirs, belongs to the clean water based drilling fluid system. Field application results show that the drilling fluid system is beneficial to improve wall stability of mud shale formation in Sulige gas field, solve the problem of hard control of drilling fluid rheological property in mud shale formation, and to achieve the requirements of protecting reservoir. This amine based drilling fluid can satisfy the need of drilling in Sulige gas field.

Keywords: horizontal well, drilling fluid, amine based polymer, inhibitive capability, wall stability

---

INTRODUCTION

Amine based drilling fluid is a new kind of water-based drilling fluid developed in recent years [1-3]. Been already extensively used in foreign countries, it is the preferred system for water sensitive mud shale drilling. Due to the higher inhibition and anti-balling ability of organic amines, the amine based drilling fluid has the characteristics of strong inhibition, high rate of penetration, good reservoir protection, and the environmental protection[4-6]. With the large-scale development of horizontal wells and horizontal section extending, sticking and other malignant accidents occurred frequently while meeting with mud shale because of strong heterogeneity of gas reservoir in Sulige gas field. The density of drilling fluid will be increased usually to balance formation pressure, but leading to high drilling fluid solid content, high friction, and also can't effectively inhibit mud shale collapse, and then bring great risk to horizontal section construction. According to the characteristics of gas geology in Sulige gas field, based on a large number of lab experiments[7], this paper determined the strong inhibitory amine based drilling fluid formula, experimented and evaluated the related performance to the drilling fluid system, and analyzed the field application effect.

EXPERIMENTAL SECTION

1.Formula of amine based anti-collapse drilling fluid

Formula of amine based anti-collapse drilling fluid is as follows:1.0-1.5%G319-FTJ（organic inhibitor）+0.2-0.3%KPA（non-permeability stabilizer）+0.2-0.3%G310-DQT（viscosifier）+2%-3%G309-JLS（fluid loss additive）+2-3%G301-SJS（fluid loss additive）+0.02-0.03%FW-134（wettability reversal agent）。

2.Performance evaluation of amine based anti-collapse drilling fluid

2.1 .High-temperature resistance evaluation

In order to accurately simulate the site conditions, add 0.3%G310-DQT to the base slurry to measure temperature resistance of this drilling fluid system. After being fully dissolved, measure the corresponding performance before and after hot rolling 120 □16 hours, the results are shown in the following Table 1.

Tab.1 results of drilling fluid resistance temperature experiment

NO.	pH	AV (mpa.s)	PV (mpa.s)	YP (pa)	YP/PV	Primary recovery (%)	Secondary recovery (%)
before hot rolling	8	32.5	20	17	0.85	95.44	94.58
after hot rolling	8	27.5	17	10.5	0.61		

Table 1 shows that after 120 □ hot rolling, this drilling fluid system performance is good, especially the primary recovery and secondary recovery, around 95%; The reduced rate of secondary recovery is very low, and it has good inhibition. Therefore, the amine based anti-collapse drilling fluid can resist 120 □ high temperature.

2.2. Weighting performance evaluation

Lime powder is added into this drilling fluid to measure weighting performance, and then measure the corresponding performance before and after hot rolling 120 □16 hours.

Tab.2 results of drilling fluid heavyweight additive experiment

Formula	Density (g/cm^3)	AV (mpa.s)	PV (mpa.s)	YP (pa)	FL (ml)	Gel10″ /10′ (Pa/Pa)	PH
1 before hot rolling	1.14	24.5	15	9.5	7.8	4.5/8	8
# after hot rolling	1.14	25.5	17	8.5	6.6	3/6	8
2 before hot rolling	1.27	29.5	16	13.5	8	5/9	8
# after hot rolling	1.27	33.5	21	12.5	7.8	4/8	8
3 before hot rolling	1.38	32	19	13	10	5/9	8
# after hot rolling	1.38	31.5	19	12.5	16	4/8	8

After hot rolling, standing to observe the stability of weighting system, Table 2 shows that the sample is not layered after standing for 24h, and no change to the rheological properties; it is the same after standing for 48h; the sample is some layered, but little change to the rheological properties after standing for 72h. Therefore, the rheological properties of this drilling fluid system are stable after weighting, only water loss increased.

2.3.Clay pollution resistance evaluation

Amine based anti-collapse drilling fluid contains cationic groups, and organic amine polymer will flocculate clay when the clay content in the system increases to a certain value, making the viscosity of this drilling fluid system rise suddenly and changing the rheological property. In order to investigate the clay resistance of this amine based drilling fluid, adding qingtongxia bentonite into the base slurry to measure the related performance, as shown in Table 3.

The Table 3 shows that the viscosity of drilling fluid system slowly rises along with the increase of bentonite content, when the bentonite content is more than 4%, the viscosity rapidly rises along with the increase of bentonite content, and the drilling fluid form appearance of beancurd when the added amount is above 5%.Therefore, bentonite content should be strictly controlled in this drilling fluid system.

Tab.3 results of drilling fluid clay pollution resistance experiment

NO.	AV (mpa.s)	PV (mpa.s)	YP (pa)	FL (ml)	pH	Test phenomenon record
base slurry+1% bentonite	26	16.5	9.5	10	8.5	good rheological property
base slurry+2% bentonite	34.5	22	12.5	9.2	8.5	good rheological property
base slurry+3% bentonite	37	23	14	8.6	8.5	good rheological property
base slurry+4% bentonite	47	27	20	7.4	8.5	Change to rheological property，Mud thickening
base slurry+5% bentonite	/	/	/	/	/	Rapidly form appearance of beancurd
base slurry+6% bentonite	/	/	/	/	/	Rapidly form appearance of beancurd

2.4.Anti-pollution ability on calcium evaluation

Add amount of CaCl2 into the base slurry of drilling fluid, the results are shown in the following Table 4.

Tab.4 results of drilling fluid calcium contamination resistance experiment

Formula	The viscosity meter reading(φ)							Gel10″ /10′(Pa/Pa)
	600	300	200	100	6	3	PH	
base slurry	58	40.5	32	22	6	4	7	4/6
base slurry +200mg/lCa^{2+}	48	30	25	17	5	4	7	4/6
base slurry 400mg/lCa^{2+}	49	30	24	17.5	5.5	4	7	4/6
base slurry +600mg/lCa^{2+}	48.5	30	25.5	17	6	4	7	4/6
base slurry +800mg/lCa^{2+}	48	30	25	17	5	4	7	4/6
base slurry +1000mg/lCa^{2+}	49	31	25	17	5	4	7	4/6
base slurry +1200mg/lCa^{2+}	48	30	25	17	5	4	7	4/6

The Table 4 shows that the rheological property of drilling fluid is stable after adding CaCl2, so the resistance to calcium of this drilling fluid system can reach 1200 mg/l.

2.5.Stability evaluation

Due to the long construction time onsite, stability of drilling fluid must be considered. Compare and measure the related performance before and after adding organic amine polymer G319-FTJ, the results are shown in the following Table 5.

Tab.5 results of drilling fluid stability experiment

Formula		The viscosity meter reading(φ)						PH	Gel10″ /10′(Pa/Pa)	FL (ml)
		600	300	200	100	6	3			
1% bentonite + 0.5%G319-FTJ+ 0.3 %KPAM+ 0.3%G310-DQT +0.5%PAC-L	0h	56	41	33	24	8	5.5	7	7/14	12.8
	24h	54	39	30	23	7	5	7	7/14	13.6
	48h	53	44	36	26	8	6	7	8/16	12.6
	72h	55	42	34	24.5	7.5	5	7	8/16	13
	144 h	52	35	28	19	5	4	7	6/12	16
1% bentonite + 0.3 %KPAM+ 0.3%G310-DQT +0.5%PAC-L	0h	50	33	27	19	5.5	4	7	5/10	18
	24h	49	32	27	18	5	3	7	4/8	17.6
	48h	36	24	19	13	4	3	7	2/4	22
	72h	33.5	22	17.5	12	4	3	7	2/4	22.4
	144 h	27	17	14	10	3	2	7	2/4	24

Experiment data in Table 6 show that the rheological properties of this amine based anti-collapse drilling fluid can remain relatively stable even after 144 hours, but it will significantly reduced after 48 hours if G319-FTJ is absent, which shows that the adding of organic amine polymers G319 - FTJ is conducive to the stability of the drilling fluid system.

3 .Comparison between different inhibitive drilling fluid system

In order to show the advantages of this amine based anti-collapse drilling fluid, inhibitive comparison is made between this amine based drilling fluid and several inhibitive drilling fluid systems currently used in Sulige gas field (including Double potassium ion polymer drilling fluid system, silicate drilling fluid, and cationic polymer drilling fluid), the results are shown in the following Table 6.

Tab.6 inhibitive comparison of several kind of drilling fluid systems (below 80□)

Drilling fluid	First recovery (%)	Secondary recovery (%)
amine based polymer drilling fluid	95.64	94.78
silicate drilling fluid	100	86
double potassium ion polymer drilling fluid	88.4	72.6
cationic polymer drilling fluid	94.14	92.52

Table 6 shows that silicate drilling fluid has the highest first recovery, but with the secondary recovery 86%; although the first recovery and secondary recovery of Amine based polymer drilling fluid and cationic polymer drilling fluid is very close, the cationic polymer drilling fluid system can't resist 120 □ high temperature.

4.Lab core evaluation

The following Table 7 is core damage evaluation data, showing obviously that four core damage rate is 6.1% on average, belonging to minor damage. Amine based anti-collapse drilling fluid system, with small reservoir damage, basically belongs to the cleaning fluid.

Tab.7 results of core damage experiment

Well NO.	Core NO.	Formation	$K_1(10^{-3}\mu m^2)$	$K_2(10^{-3}\mu m^2)$	Damage rate (%)	Damage rate on average (%)
Su 1#-18	75#	He 7	0.7644	0.7147	6.5	6.1
Su 1#-18	77#	He 7	0.8599	0.8195	4.7	
Su 1#-19	103#	He 8	0.3320	0.3078	7.3	
Su 3#-13	215#	He 7	0.5690	0.5354	5.9	

Note: Differential pressure: 3.5 Mpa; Time: 2.5 h; The temperature: 24-27 ℃, K1 and K2 represent the permeability before and after damage.

5 .Field application

Field application is carried out in 3 wells in Sulige gas field, the drilling fluid performance parameters are shown in the following Table 8. Su 2#-30H well drill in large section of the continuous mudstone, cumulatively 318m, with the longest one up to 252 m ($4038m -- 4290m); Su 2#-38H drill through 331m mudstone safety; Su 5#-56H drill in 30m fragile mudstone, no dropping pieces, no collapse, and no hole shrinkage, borehole unimpeded, well diameter regular, friction coefficient of drilling fluid slider is controlled below 0.07, the torque is less than 9KN.m, keep tripping friction under 12T, without blocking and sticking phenomenon, which show that this amine based anti-collapse drilling fluid has good effect of preventing collapse.

Tab.8 performance parameters of drilling fluid in horizontal section

Well NO.	Depth (m)	$\rho(g/cm^3)$	FV(s)	PV(mPa.s)	YP(Pa)	FL(ml)	Kf	PH
Su 2#-30H	4085	1.25	72	32	18	2.0	0.0437	9
	4127	1.25	78	34	19	2.0	0.0437	9
	4250	1.25	70	34	22	2.0	0.0437	9
Su 2#-38H	3728	1.22	66	28	13	3	0.0349	9
	3829	1.22	66	27	13	2	0.0437	9
	3947	1.22	65	26	13	3	0.0612	9
Su 5#-56H	4069	1.16	55	26	6	2	0.0437	8
	4190	1.16	55	26	8	3	0.0612	8

RESULTS AND DISCUSSION

The amine based anti-collapse drilling fluid has good inhibition, and can resist 120 ℃ high temperature. The rheological properties of this drilling fluid system are stable after adding lime power, the resistance to calcium of this drilling fluid system can reach 1200 mg/l.

The viscosity of drilling fluid system slowly rises along with the increase of bentonite content, when the bentonite content is more than 4%, the viscosity rapidly rises along with the increase of bentonite content. Therefore, bentonite content should be strictly controlled in this drilling fluid system.

Compared to the inhibitive drilling fluid currently used in Sulige gas field, the recovery of this amine based anti-collapse drilling fluid is higher. With small damage to reservoir, this drilling fluid is conducive to the borehole wall stability and protects the reservoir.

Field application is carried out in 3 wells in Sulige gas field, which show good effect in wall stability and hole cleaning, no collapse, no dropping pieces, and no sand setting, and no obvious blocking and sticking in tripping. This drilling fluid can meet the requirements of horizontal well drilling in Sulige gas field, and has wide application prospect.

Acknowledgements

This work was supported by the Joint Funds of the National Natural Science Foundation of China (U1262201),Industrial Research Plan in Shaanxi Province (2012K08-07),Special Scientific Research Plan in Shaanxi Province Department of Education (12JK0807)，and Xi'an Promote Project of Technology Transfer (CX12184-6).

REFERENCES

[1]AL-Ansari A,Yadav K，Anderson D，et al. Diverse application of unique high-performance water-based-mud technology in the Middle East. SPE 97314,**2005**.
[2]Patel A，Stamatakis E，Young S，et al.Advances in inhibitive water-based drilling fluids-Can they replace oil-based muds? . *SPE* 106476,**2007**.
[3] Keqin Zhang, Lun He, Shufang An, etc. Introduction of overseas high performance water base drilling fluid [J]. *Drilling Fluid & Completion Fluid*,**2007**,24(3),68-73.
[4] Hongwei Zhang, Fengjiang Zuo, Dongmin Jia, etc. Research on New High Inhibition Amino Drilling Fluid [J]. *Drilling Fluid & Completion Fluid*,**2011**,28(1),14-17.
[5] Xiuchun Su, Hongjun Li, Liyang Dai, etc. Research on Organic Amine Inhibitor Used in High Inhibitive Drilling Fluid [J]. *Drilling Fluid & Completion Fluid*, **2011**，28(2),32-35.
[6] Kaihe Lyu, Liguo Han, Tao Shi, etc. Influence on drilling fluid performance of organic amine inhibitor [J]. *Drilling & Production Technology*, **2012**,35(2),75-76.
[7] Da Li，Ming Zhang，Deqiang Yi, etc. The Development and Evaluation of a New Organic Amine Inhibitor Used in Drilling Fluid[J]. *Henan Science*, **2013**,31(12),2203-2208.