

POLYSIL Potassium is an effective inhibitor of clay and shale hydration and softening, the basis of inhibiting solution for well drilling on all its intervals.



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Scientific and Production Company «Geochemservice» and Chemical Company «GCHS»

- enterprises which develop and produce the products of industrial purpose in accordance with principles of Green Chemistry – getting the required product by the way which doesn't harm the environment during its production and further application.

Description of polymer silicate Reagent “POLYSIL Potassium”

POLYSIL Potassium is the reagent of complex action:

- effective stabilizer of active and reactive argillaceous deposits;
- filtration stabilizer;
- stabilizer of structural-rheological characteristics;
- flocculant;
- facilitates the reduction of reservoir contamination .

POLYSIL Potassium is the synergetic mixture of components, when dissolved in water they form indivisible tree-dimensional spatial structures (associates):

- resistant to saline aggression of alkaline and alkaline-earth metals to saturation;
- resistant to high temperatures action (till 150°C);
- can't penetrate and prevent solution from penetration deep in pore medium on a long distance, which makes it possible to drill in productive strata;
- supporting the high structural-rheological properties of solution and compensating the action of mechanodestruction.

Mechanism of clay and shale inhibition by polymer silicate reagent “Polysil Potassium”

Inhibition of hydration:

- Reduction of surface hydration by replacement of cations of surface clay complex by cations K^+ ;
- Reduction of surface hydration by forming the thin polymer silicate film which prevents the rock from liquid penetration and gives resistance to water;
- Decrease in the radius of aqueous phase penetration in the inter-packet space of minerals by high penetrating and blocking capacity of cations K^+ which by diffusion carry anionic inhibitors (associates of polymer, silicate and polyelectrolyte).

Analysis of “POLYSIL Potassium” inhibitory properties

1. Rock dispersion test allows to evaluate the rock tendency to dispersion in the chosen solution in dynamic conditions. The core of argillite which was grinded and sifted through strainer 2-4 mm and dried at 105 °C in drying box during 2 hours is loaded in the cells of aging, filled with the solution and it rotates in the roller furnace during 16 hours at the determined temperature (the temperature of break-in was 120 °C) and rotary speed (6 turns per minute). At the end of the test the core material is washed and sifted through strainer 1 mm. Then the core material is dried in the drying box to the constant weight at temperature 105°C. The sieve residue characterizes the solution ability to disperse shale. The core material – argillite of Viseysk layer provided by Drilling Company “Ukrburservis” – was used for the tests.

2. Rock moistening test allows to evaluate the inhibitory power of solution. The research was carried out in accordance with Technique of evaluation of inhibitory properties of drilling muds (RD 39-2-813-82). The samples of pressed bentonite gel powder of moisture 20%, diameter 20 mm and height 32 mm (colloidity coefficient – 0,65) were used to determine the speed of clay moistening by the solutions. The samples with paraffined ends were sunk in the test solutions of volume 200 ml for 4 hours at the room temperature.

Table 1 Summary results

Samples of solutions, mas. %	1 mm sieve residue ,%,	Moistening Π_0 , cm/h, for 4 hours
Distilled water - 100	92,14	the samples were heavily swollen
KCl – 5, service water – 95	95,34	1,66
Liquid glass – 4, service water - 96	97,72	the samples were heavily swollen
ASPHASOL SUPREME – 2, service water – 98	95,40	5,72
POLYSIL Potassium – 1, service water - 99	97,00	4,95
POLYSIL Potassium – 2, service water – 98	97,18	3,40
POLYSIL Potassium – 2, KCl – 3, service water – 95	97,74	1,42
Kerosene - 100	98,40	0

Results of testing:

- KCl works better to prevent hydration of active clays and can't prevent dispersing of argillites
- Liquid glass works better to prevent dispersing of argillites and can't prevent moistening of active clays.
- POLYSIL Potassium prevents hydration of active clays and dispersion of argillites.
- The combined use of POLYSIL Potassium with a small addition of KCl (3%) improves both indices – inhibition hydration and softening.

Visual observations

In experiments on swelling of the pressed samples in water solutions of the reagent Polysil Potassium it was seen their stiffening ability.

The following picture shows the samples from the pressed bentonite gel powder (colloidity coefficient – 0,65), which were moistened in solutions during 4 hours (pictures after drying of samples).



Po=3,41 cm/h
Uninhibited fluid: 4%
of Alta-Mud
(bentonitic gel
powder) + Celpol-
0,5%, the rest is water

Po=0,88 cm/h
Inhibited fluid: 4%
of Alta-Mud (bentonitic
gel powder) + Celpol-
0,5% + Polysil
Potassium-2%+KC1-
3%, the rest is water

Po=1,65 cm/h
Inhibited fluid:
Polysil – the basis
Potassium-3%,
the rest is water

Po= 1,98 cm/h
Inhibited fluid:
Polysil Potassium-
3%,
the rest is water

- The pressed samples after moistening in solutions with POLYSIL Potassium have the minimum number of cracks
- There is the light brown stiffening crust
- In solutions KCl (5 – 7%) without POLYSIL the samples of the pressed bentonite have the minimum moistening, but microcracks appear (softening effect of KCl)

Analysis of inhibitor properties LLC TyumenNIIGiprogas

(specialized institute of PJSC Gazprom in Western Siberia)
(2006, 2008, 2011.)

The tests have determined that multifunctional reagent can be used in drilling muds with the aim:

- to prevent swelling and hydration of clay rocks
(reduction of swelling degree compared to Silicor K to 50%, evident advantages of 3% Polysil solution compared to 10% KCL solution, low rate of capillary suction)
- to stabilize filtration
- to increase thermal stability
- to improve lubricating properties

Optimal use of Polymer silicate reagent POLYSIL in clayless and thin clay drilling muds, including highly mineralized and heavy ones. Combined with biopolymers it's possible to use it in conditions of directional and horizontal drilling.

Drilling mud in Kharasavevsky and Bovanenksky fields

Surface casing and hole drilling (interval 0 – 450 m)

The main requirements to the drilling mud for drilling-out this interval:

- high density (to 1420-1480 kg/m³) to prevent possible gas flows while opening gas lenses and cryopegs with high indices of abnormal pressure;
- high inhibitory properties to reduce operating time of drilling mud under high active clays conditions;
- resistance to saline aggression to ensure stability of the drilling mud while opening cryopegs with local water of high salinity;
- pseudoplasticity and high lubricating and wear-resistant properties.

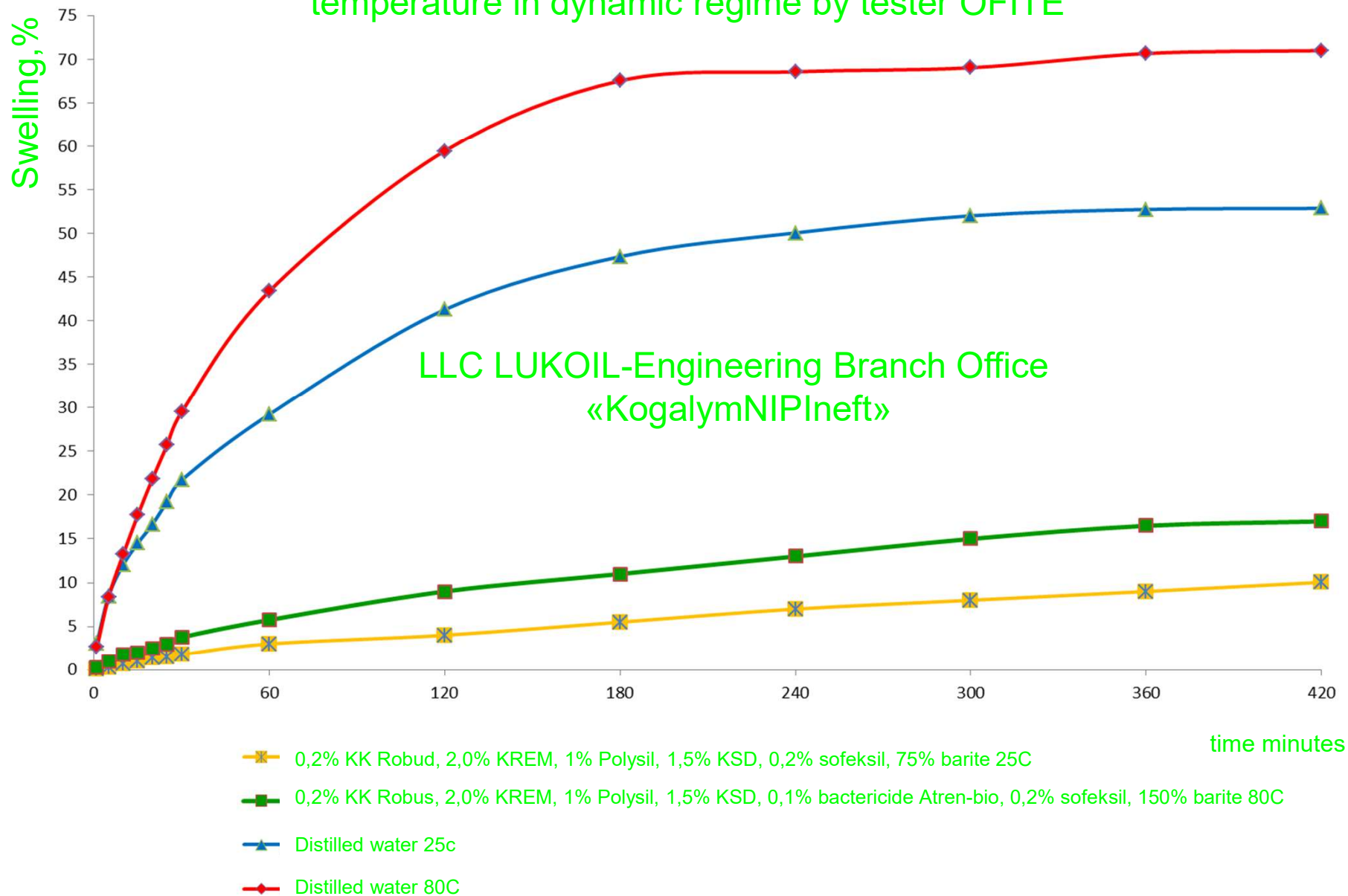
This composition makes it possible to get drilling muds with density 1600-1835 kg/m³, which meet the requirements of drilling-out underlying intervals (high inhibitory power, thermal stability to 150°C, salt-resistance).

Drilling mud composition

Composition	Concentration
Biopolymer	0,2%
Polysil	1,0%
Starch	2,0%
Lubricant additive	1,5%
Bactericide	0,1%
Antifoaming agent	0,2%
Barite	to the required

Solution composition	Properties of the solution														
	ρ , kg/m ³	T, c	CHC _{10/1/10} , дPa	Φ , cm ³ /30 min	h, mm	$\varphi_{ск}$	$\eta_{пл}$, мPa c	τ_0 , дPa	n	$\varphi_{тр}$	pH	turn/min	φ	τ_i , дPa	η_{φ} , мPa c
1. Solution without barite	1010	56	41/48/58	4,8	0,4	0,2	14,5	127,5	0,45	0,19	9,38	600	54,0	276	27
												300	39,5	202	40
												200	33,0	169	50
												100	25,0	129	75
												60	20,5	105	103
												30	16,5	84	165
												6	10,0	51	500
												3	8,5	43	850
2. Solution + 75% barite	1485	52	46/49/61	2,4	0,5	0,15	29	158,1	0,57	0,204	9,3	600	89,0	455	45
												300	60,0	307	60
												200	49,0	250	73
												100	35,0	179	105
												60	28,0	143	140
												30	21,5	110	215
												6	12,0	61	600
												3	9,5	49	950

Kinetics of “bogadynsky” clay swelling with output 2,4 m³/t in heavy clayless fluid with Polysil depending on temperature in dynamic regime by tester OFITE





Н.Г. Кашкаров, Н.Н. Верховская, Р.В. Плаксин,
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**Исследования ингибирующих свойств
реагентов для обработки буровых
растворов при бурении глинистых пород
на нефтегазоконденсатных
месторождениях Заполярья**

Кашкаров Н.Г., Верховская Н.Н., Плаксин Р.В., Новикова Е.В., Козлова Н.В.

0,3–1,5 %-х растворов «Софэксил 40» и «Основа ГС» и 0,3–1 %-х растворов ГЖЖ-11 (рис. 5.14, 5.15). Анализ кривых набухания 1,5 %-х растворов (рис. 5.17) показывает, что более эффективным ингибитором набухания в сравнении с водой является «Основа ГС» и, в меньшей степени, ГЖЖ-11. «Софэксил 40» занимает промежуточное положение. При разных температурах (25 и 80 °С) исследовался процесс набухания глины только в водных растворах «Софэксил 40» (табл. 5.2, позиции 45–52). Установлено, что при 25 °С кратность снижения средней скорости набухания в диапазоне исследованных концентраций «Софэксил 40» не претерпевает значительных изменений. Эта зависимость увеличивается при 80 °С (рис. 5.18).

Проведенные испытания набухания «богандинской» глины в динамических условиях по тестеру OFITE 150-80 водных растворов нескольких групп химических реагентов, используемых в бурении, позволили выявить наиболее эффективные ингибиторы набухания глины, которые относятся к группе силикатных реагентов («Полисил» и «Силикор К» при добавках 3–5 %).

GAZPROM

Overview
2010

N.G.Kasharov, N.N.Verkhovskaya, P.V.Plaksyn, E.V.Novikova,
N.V.Kozlova

**Analysis of the inhibitory properties of reagents for
processing of the drilling muds at drilling of clay rocks on
the oil-gas condensate fields of the Arctic Circle**

The conducted tests of “bogadensky” clay swelling in dynamic conditions by tester OFITE 150-80 water solutions of several groups of chemical reagents used in drilling showed the most effective inhibitors of clay swelling which belong to the group of silicate reagents “Polysil”

Haliburton Baroid (Russia, Moscow) (2011)

Analysis of inhibitory properties was carried out on the fresh drilling mud BOREMAX

Influence of the polymer silicate Reagent «POLYSIL Potassium» sample on the samples swelling and rock dispersion is shown in the following table:

Samples of the solutions	BOREMAX	BOREMAX + POLYSIL POTASSIUM (15 kg/m ³)
LSM Δ, %	Samples swelling, %	
For 24 hours	32,2	27,8
Dispersion	Sieve residue 2000 mcm, % Talitskaya suite	
Recovery test, %	82,77	93,2

Recommendations: polymer silicate Reagent «POLYSIL Potassium» is recommended for tests in field conditions.

Application experience

LLC LUKOIL-Engineering Branch Office
«KogalymNIPIneft»
(2011- 2012)

Side horizontal boreholes drilling

“Lukoil” programme of pilot works for 2011-2012 for application of the drilling mud Flosil (Polysil)-DAF at drilling one side horizontal borehole on layer AB8¹ (№ 5323 L of bush №147 for development of the fluid application and two side horizontal boreholes on layer BV1 (№ 4106L of bush №93 and №5235L of bush №132) on Vat'-Yegansk field.

Aim of pilot works is the increase of borehole resistance at drilling of side horizontal boreholes in intervals of reactive clays and argillites (Pockachevsky bundle) and reduction of repression at reservoir drilling-out.

Filtration analysis of solution with DAF-Polysil on core samples of reservoir BV0-2 of Vat'-Yegansky field of average $(30-40) \cdot 10^{-3} \text{ mcm}^2$ permeability

Conditions of experiment

Temperature, °C	70
Rock pressure, MPa	47,0
Reservoir pressure, MPa	21,2
Repression, MPa	3,6
Depression, MPa	5,0
Kerosene viscosity $\text{mPa} \cdot \text{s}$	0,748

Results of research of drilling mud influence

№	Drilling mud	Coefficient of permeability restoration after filtration of the drilling mud (β), %
1	Inhibited with DAF and POLYSIL	85

Brief technical and economic characteristics of side horizontal boreholes drilling

Technological process	Time, h				
	№№ borehole				
	CJSC «IKF-Servis» (BASE SOLUTION)			OHP (DAF-POLYSIL)	
	8149/174	5127/101	8145/29	4106/93	5235/132
Drilling	121,92	183,16	106,00	116,47	96,08
Troubles	95,83	159,01	-	-	-
Accidents	8,42	-	158,00	-	-
Total time of drilling:	391	680	578	363	357
Calendar time of construction	1031	1336	1130	716	820
Hole making, m	749	784	594,7	723	725,3

Conclusions:

- Duration of side horizontal borehole construction while using the developed solution is less than according to traditional technology.
- Average value of hole making for the test boreholes is 43 m/day, whereas the average value for base boreholes is 27,6 m/day.
- There were no troubles and accidents at the process of drilling
- Project debit for the test side horizontal boreholes is achieved (№5323L of bush №147 – 54t/day at the expected one 17 t/day, №4106L of bush №93 – 30 t/day at the expected one 20 t/day, (№5235L is completed, but it was not yet put into operation at the time of reporting, data are not available).

LLC LUKOIL-Engineering Branch Office
«KogalymNIPIneft»
(2012-2013)

“Lukoil” programme of pilot works for 2012-2013 for application of nondispersive drilling muds

The aim of pilot works is to increase technical and economic characteristics of drilling and to provide trouble-free hole-making by using nondispersive drilling mud, to reduce operating time and content of solid phase to mud density 1,10 kg/m³, to increase the quality of opening out and preparation for casing pipe lowering and cementing.

Drilling of directional wells (I stage)

Location of pilot works – multiple well platform №212 Tevlinsko-Russkiy field, wells №№5051, 5672, 5675, 5674.

Nondispersive drilling mud with polymer silicate reagent «POLYSIL Potassium»

Technological properties of the drilling mud

Name of the solution	ρ , kg/m ³	T, c	Φ , before formation exposing cm ³ /30min	Φ , at formation exposing cm ³ /30min	CHC _{1/10} , дПа	$\eta_{пл}$, мПа с	τ_0 , дПа	h, mm	Cl _п	pH
Thin clay nondispersive «NEDRA»	1080 - 1120	25 - 60	≤ 6	3 - 5	15-30/ 20-60	15-30	40-100	0,2 – 0,5	0,09 – 0,16	9,5 – 10,5

Filtration analysis of thin clay nondispersive solution on core samples of UV1 formation of Uryevsky field of average $((36-45) \cdot 10^{-3} \text{ мкм}^2)$ permeability

Conditions of experiment

Temperature, °C	86
Rock pressure, MPa	62,7
Reservoir pressure, MPa	24,8
Repression statics/dynamics, MPa	4,6/5,1
Depression, MPa	1,8/3,6
Kerosene viscosity, мПа*с	0,65

Results of research of the drilling mud influence

№	Drilling mud	Coefficient of permeability restoration after filtration of the drilling mud (β), %
1	Thin clay nondispersive «NEDRA»	79

The developed solution has the high coefficient of permeability restoration despite the high value of repression 5,1 (4,6) MPa.

Unlike the solutions “OPTIMA” and “INKAPS” (CJSC “IKF-Servis”) which are used for directional wells construction and can be applied only subject to perforation (it is connected with low coefficient of permeability restoration) **the developed composition can be used also for formation exposing with completion by open bottom and filter.**

Brief technical and economic characteristics of directional wells (I stage of pilot works, construction of 4 boreholes)

Index	Type of solution		
	CJSC «IKF-Servis» (OPTIMA)	LLC SC «PetroAlliance» (Basic)	KogalymNIPIneft (NEDRA)
Lowering of flow string without calipering	5 from 6	6 from 9	4 from 4
Vmec at drilling under flow string, m/h / %	42,8 / 123	34,9 / 100	49,3 / 141
Vcomm, m/ct.mec./ %	8553 / 113	7563 / 100	9613 / 127
Quality of fixing	Reduced: - with pipe 1,4 times; - with rock 1,4 times	-	- with pipe comparably; - with rock 1,1 times higher

The drilling was effected by open bottom from the conductor to the project.

The average value of the inclination angle in basic wells – 26,1°, on fluid «OPTIMA» – 23,8°, on fluid «NEDRA» - 32,8°.

The highest mechanical rates in interval of drilling under flow string were achieved on fluid «NEDRA» on wells №5430 (56,1 m/h) and №5355 (53,7 m/h).

Conclusions of the I stage of pilot works:

- Actual commercial rate of construction of directional wells on fluid «NEDRA» is higher, than in the compared ones
- Despite the high mechanical rates while drilling the transport bore it was possible to maintain the density of the fluid and the low content of the solid phase on the minimum possible level due to high inhibitory properties of reagent POLYSYL Potassium and effective cleaning system.
- Drill-string running without calipering was performed in all wells.
- Quality of fixing in interval of reservoir on the fluid “NEDRA” is comparable with the basic one in terms of solid contact with the casing string, and 10% higher than the basic one in terms of solid contact with the rock.

LLC LUKOIL-Engineering Branch Office

«KogalymNIPIneft»

(2013-2014)

Drilling of directional and horizontal wells

(II stage, constructions of 15 wells)

- The application of the nondispersive fluid «NEDRA» with polymer silicate reagent «POLYSIL Potassium» reduced the duration of the well construction due to higher mechanical rate of drilling, проведения ГИС без СПО «воронки», flow string running without calipering in average by 1,3 days for directional wells and 2,8 days for horizontal wells and accordingly reduction of costs depending on time by 170 thousands rubles for directional wells and 1248 thousand rubles for horizontal wells.
- The quality of fixing of experimental horizontal wells in interval of reservoir in terms of solid contact with column and rock is higher compared to the basic wells (bush №933 of Nyvagalsky field – by the solid contact with the string by 37,2%, by the solid contact with the rock by 7,6%).
- **While drilling the transport bore hole of horizontal well № 4021 on Vat'yegansky field the mineralized fluid “NEDRA” with polymer silicate reagent «POLYSIL Potassium» made it possible to finish the well (after unsuccessful attempts on two bore holes on the fluid PHKR).**

Recommendations and prospects of application

- By results of two stages of pilot works it is recommended to use the inhibited drilling mud “NEDRA” developed in LLC LUKOIL-Engineering Branch Office «KogalymNIPIneft» together with polymer silicate reagent «POLYSIL Potassium» at drilling horizontal wells on the fields LLC “Lukoil – Western Siberia” in complex geological conditions (unstable rocks in open-cast – Bazhenovsky suite, Pockachevsk-Savuysky bundle, etc.), on directional wells with high deviation from the vertical (zenith angle more than 40 °, displacement more than 2000 m, length of the open hole more than 2500 m).
- It is offered to test the inhibited drilling mud “NEDRA” with polymer silicate reagent “POLYSIL Potassium” and KC1 for drilling three-string horizontal wells within the pilot projects.
- It is offered to consider the possibility to use the inhibited drilling mud with polymer silicate reagent “POLYSIL Potassium” for drilling horizontal holes on non-traditional shale fields (Bazhenovky suite, etc.)

Use of POLYSIL Potassium in the drilling mud is:

- Well drilling on all intervals without accidents and troubles
- Reduction of operating time of the fluid at drilling
- Qualitative reservoir exposing
- High rates of hole making
- Reduction of well construction time
- Qualitative fixation of the well

and good mood of drillers!

*With respect and thanks,
Volodymyr Liniushyn*

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