APPLICATION INFORMATION

RHEOLOGICAL SOLUTIONS FOR NON-AQUEOUS DRILLING FLUIDS

Contents

Introduction

BYK manufactures a wide range of rheological additives to provide and augment rheology in your non-aqueous drilling fluid formulas. BYK's rheology additives aid in the lifting of drill cuttings out of wellbores and in the suspension of weighting agents. This includes our **CLAYTONE** family of organoclays, our **GARAMITE** line of mixed mineral thixotropes, and our **BYK-GO** rheology modifiers. For every non-aqueous drilling challenge, BYK has a rheological solution.

More information about **additives for drilling for oilfields.**

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Note

To ensure the best appearance and full functionality, please open in Adobe Acrobat.

Watch the incorporation of GARAMITE vs. traditional organoclay.

CLAYTONE organoclays

BYK CLAYTONE additives offer an extensive range of organoclays to meet your performance and economic criteria. CLAYTONE products are used to build rheology over a broad range of base fluids and temperature gradients. CLAYTONE organoclays can improve filtration control and can stabilize an emulsion. BYK manufactures economy-grade dry process organoclays (CLAYTONE-II and CLAYTONE-3) and specialty wet process organoclays (CLAYTONE-SF, CLAYTONE-ER, CLAYTONE-EM, and CLAYTONE-IMG 400).

The effectiveness of the wet process organoclays over the dry process organoclays is shown for a 14-ppg, 80/20 mineral oil invert test system after hot rolling for 16 hours at 300 °F (T. 01). The organoclay concentrations varied from 7 to 10 lb/bbl. The organoclay loading levels were adjusted to meet a 6-rpm reading between 7 and 12 and a yield point range between 12 and 20 lb/100 ft^2. The test system was a 14-ppg, 80/20 mineral oil invert.

The efficiency of BYK's wet process organoclays meets rheology targets with lower treatment levels. To further demonstrate this, the six organoclays were all added at the ratio of 7 lb/bbl. The test system was the same: a 14.0-ppg, 80/20 mineral oil invert. For this study, the system was run at two temperatures. The first data set was hot rolled for 16 hours at 250 °F (T. 02). The work was repeated with hot rolling for 16 hours and the temperature raised to 300 °F (T.03).

Influence of CLAYTONE organoclays after hot rolling at 300 °F

Organoclay	Dosage	Dial reading at 150 °F						cP	lb/100 ft^2			Volts
	lb/bbl	600-rpm	300-rpm	200-rpm	100-rpm	6-rpm	3-rpm	PV	YP	10″ gel	10′ gel	ES
CLAYTONE-SF	7	84	52	40	28	11	10	32	19	10	10	1037
CLAYTONE-ER	7	78	47	37	26	10	9	31	16	9	9	998
CLAYTONE-EM	9	72	42	33	23	8	8	30	12	8	8	866
CLAYTONE-IMG 400	8	72	42	33	23	8	8	30	12	8	8	866
CLAYTONE-3	10	65	38	29	20	7	6	27	12	6	7	835
CLAYTONE-II	10	88	54	42	30	12	11	35	19	11	11	947
Targets						7–12			12–20			>500

ES: electric stability, PV: plastic viscosity, YP: yield point

T. 01

Comparison of CLAYTONE organoclays after hot rolling at 250 °F

Organoclay	Dial reading at 150 °F						cP	lb/100 ft²			Volts	HTHP FL at 250 °F	250 °F 3-day static sag
(at 7 lb/bbl)	600-rpm	300-rpm	200-rpm	100-rpm	6-rpm	3-rpm	PV	YP	10″ gel	10′ gel	ES	ml	Δ Bottom, lb/gal
CLAYTONE-SF	91	56	43	30	12	11	36	20	11	11	984	1.6	0.12
CLAYTONE-ER	84	50	39	28	11	9	34	17	9	9	955	1.7	0.09
CLAYTONE-EM	73	46	36	26	11	10	28	18	10	11	882	1.7	0.40
CLAYTONE-IMG 400	77	45	35	24	9	8	32	14	8	8	892	1.5	0.24
CLAYTONE-3	61	37	29	21	8	7	24	13	7	8	855	1.8	0.49
CLAYTONE-II	65	38	29	20	7	7	28	10	6	7	852	1.6	0.36

ES: electric stability, PV: plastic viscosity, YP: yield point, HTHP FL: High-temperature, high-pressure fluid loss

T. 02

Comparison of CLAYTONE organoclays after subsequent hot rolling at 300 °F

Organoclay	Dial reading at 150 °F						cP	lb/100 ft²			Volts	HTHP FL at 300 °F	300 °F 3-day static sag
(at 7 lb/bbl)	600-rpm	300-rpm	200-rpm	100-rpm	6-rpm	3-rpm	PV	YP	10″ gel	10′ gel	ES	ml	Δ Bottom, lb/gal
CLAYTONE-SF	84	52	40	28	11	10	32	19	10	10	1037	6.0	0.52
CLAYTONE-ER	78	47	37	26	10	9	31	16	9	9	998	6.8	0.64
CLAYTONE-EM	54	31	23	16	5	4	23	8	4	5	812	10.4	2.11
CLAYTONE-IMG 400	73	43	33	23	9	8	30	13	7	8	910	4.0	0.42
CLAYTONE-3	48	27	20	12	4	3	21	6	3	4	744	10.8	2.73
CLAYTONE-II	57	31	23	15	5	4	26	5	4	4	701	6.4	1.12

ES: electric stability, PV: plastic viscosity, YP: yield point, HTHP FL: High-temperature, high-pressure fluid loss

T. 03

The results highlight the performance difference between the different organoclays. The wet process organoclays, CLAYTONE-SF, CLAYTONE-ER, CLAYTONE-EM, and CLAYTONE-IMG 400, all demonstrated greater efficiency over the dry process organoclays, CLAYTONE-II and CLAYTONE-3. This confirms the results of the study, in which the clay levels were adjusted to meet the desired targets.

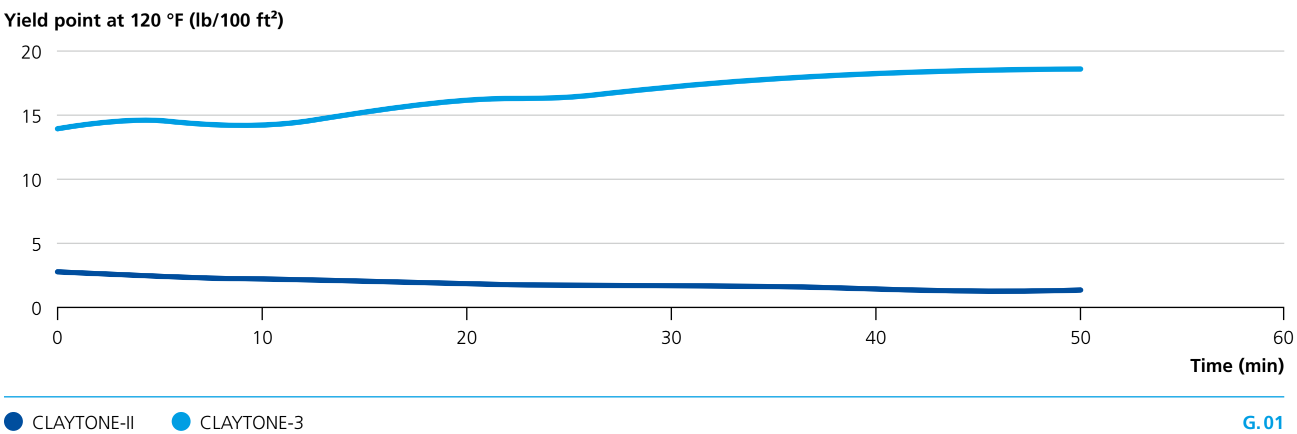
CLAYTONE-SF, CLAYTONE-ER, CLAYTONE-IMG 400, and CLAYTONE-II are organically treated to be stable up to 350 °F. This fact is most prominent in the 3-day static sag results at the two temperatures. CLAYTONE-EM and CLAYTONE-3 have been organically modified to yield more quickly in cold temperatures and/or low mixing conditions with temperature stability up to 300 °F. The differences in temperature stability explain why CLAYTONE-EM and CLAYTONE-3 exhibit poorer properties than the other CLAYTONE organoclays in terms of rheology, fluid loss, and 3-day static sag after 16 hours of hot rolling at 300 °F.

BYK wet process organoclays have many advantages beyond the efficiency shown above. CLAYTONE-SF, CLAYTONE-ER, CLAYTONE-EM, and CLAYTONE-IMG 400 yield more quickly in less polar base fluids. This becomes important in areas where regulations dictate the use of specific environmentally sound, non-aqueous base fluids. The CLAYTONE wet process products range from mid grades such as CLAYTONE-IMG 400 to the premium grades, CLAYTONE-ER and CLAYTONE-SF, in addition to the fast-yielding CLAYTONE-EM, which is designed for cold environments. The differences become apparent when formulating your system for specific drilling conditions, whether the emphasis is on low-end rheology, yield time, static sag, or flat rheology.

BYK dry process organoclays are the workhorse of the industry. BYK CLAYTONE-II and CLAYTONE-3 are used in base fluids that are more polar. These fluids fall under the category of diesel fluids. In the dry process, bentonite clay is grinded and sized, and organically modified. BYK manufactures two grades of dry process CLAYTONE organoclays.

CLAYTONE-II features temperature stability up to 350 °F, while CLAYTONE-3 is stable up to 300 °F. CLAYTONE-3 is a faster yielding clay, which makes it the workhorse for colder drilling conditions and liquid mud plants. The difference in yield time was evaluated by measuring two muds that had not been mixed with high-speed shear. The two diesel-based formulas were the same, and each had a clay loading of 7 lb/bbl, one with CLAYTONE-II and the other with CLAYTONE-3. The two muds' yield points were measured every 5 minutes over 10 cycles. Between cycles, the muds were mixed at 600 rpm at 120 °F. From the graph below, we see that CLAYTONE-3 started with a yield point of 14, which increased to 18 over the test run. Conversely, CLAYTONE-II started with a yield point of 3 and did not progressed after the first 5 minutes. This suggests that CLAYTONE-II needs greater energy to fully yield than CLAYTONE-3.

Yield point over time



G.01

BYK-GO rheology modifier

BYK GO-8721 rheology modifier is a synergist liquid additive designed by BYK to augment organoclay performance. The base system that was formulated was a 14-ppg 80/20 mineral oil invert drilling fluid. Each fluid was heat rolled for 16 hours at 300 °F. The base formula contained 1.0 lb/bbl of CLAYTONE-EM. The data below demonstrate how the addition of 1.0 lb/bbl of BYK-GO 8721 complements the system. The addition of BYK-GO 8721 to the system increased the 6-rpm dial reading and the yield point with minimal effect on the plastic viscosity. The testing procedures focused on the ability of BYK-GO 8721 to augment flat drilling profiles at 40 °F, 100 °F, and 150 °F.

Synergistic effect of BYK-GO 8721 after heat aging at 300 °F

Rheology	CLAYTONE-EM			CLAYTONE-EM + BYK-GO 8721			CLAYTONE-SF + BYK-GO 8721			CLAYTONE-ER + BYK-GO 8721			CLAYTONE-IMG 400 + BYK-GO 8721			CLAYTONE-II + BYK-GO 8721			CLAYTONE-3 + BYK-GO 8721		
	40 °F	100 °F	150 °F	40 °F	100 °F	150 °F	40 °F	100 °F	150 °F	40 °F	100 °F	150 °F	40 °F	100 °F	150 °F	40 °F	100 °F	150 °F	40 °F	100 °F	150 °F
600-rpm	142	68	46	153	83	65	169	92	69	175	94	68	172	92	67	172	92	67	158	90	69
300-rpm	87	40	27	93	55	43	107	61	46	111	62	45	109	60	44	109	61	44	97	60	45
200-rpm	67	31	20	71	45	35	84	50	37	88	51	36	86	49	35	86	51	36	76	49	37
100-rpm	44	21	13	47	34	26	58	37	28	61	38	27	59	37	26	60	38	27	51	37	28
6-rpm	14	6.9	4.0	18	17	13	24	18	14	26	19	13	24	18	12	25	18	13	20	18	14
3-rpm	12	6.2	3.4	17	16	12	23	17	13	24	17	12	23	17	11	23	17	12	19	17	12
PV (cP)	55	28	19	60	28	22	62	31	23	64	32	24	63	32	24	63	31	23	62	30	23
YP (lb/100 ft^2)	33	12	8	33	27	21	45	30	23	47	30	21	46	28	20	46	30	21	35	29	22
10” gel	12	6	3	17	16	13	24	17	13	25	17	12	24	16	12	24	17	12	20	17	13
10’ gel	13	6	4	25	21	16	30	20	15	31	20	14	29	19	13	30	20	14	26	20	15
ES (V)			654			1002			967			975			958			983			947

ES: electric stability, PV: plastic viscosity, YP: yield point

T. 04

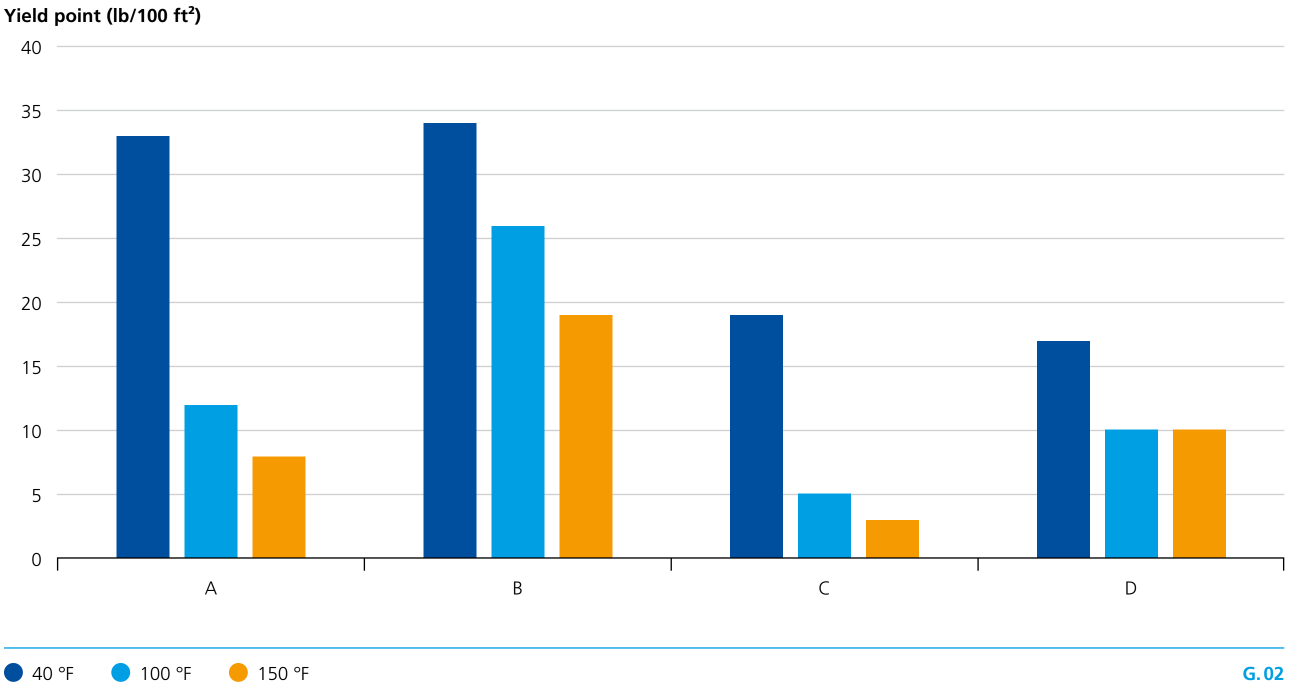
To better visualize the benefits that BYK-GO 8721 brings to your formulation, the four systems described in the table below were tested and the yield point of each is shown in graph G. 02.

A	1.0 lb/bbl CLAYTONE-EM with drill solids
B	1.0 lb/bbl CLAYTONE-EM + 1.0 lb/bbl BYK-GO 8721 with drill solids
C	1.0 lb/bbl CLAYTONE-EM with no drill solids
D	1.0 lb/bbl CLAYTONE-EM + 1.0 lb/bbl BYK-GO 8721 with no drill solids

T. 05

BYK-GO 8721 had minimal effect on the 40 °F yield point and was able to increase the yield point at 100 °F and 150 °F, flattening the rheology profile. The performance was consistent in the systems with and without drill solids. BYK-GO 8721 is a key additive for formulating systems for difficult and challenging drilling conditions, and is especially efficient when the fluid circulates through different temperature zones requiring a flat rheology.

BYK-GO 8721 synergistic influence on yield point



G. 02

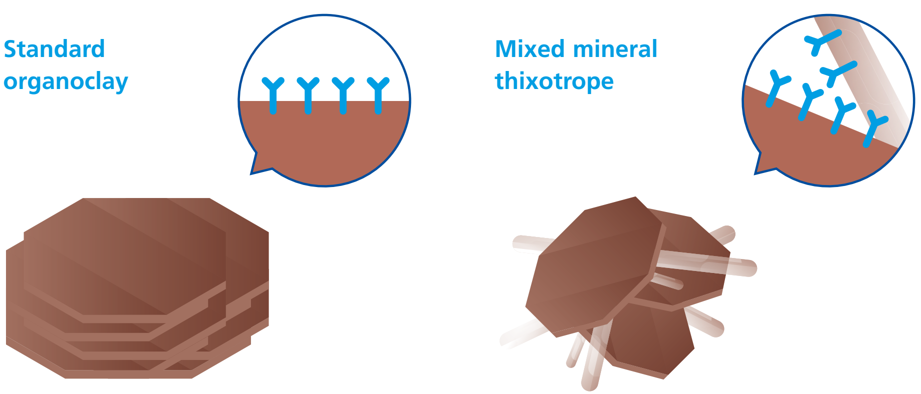
GARAMITE mixed mineral thixotropes

The GARAMITE family of mixed mineral thixotropes offers many advantages for customizing your non-aqueous drilling fluid. The mixed mineral thixotrope is a unique product which combines platelet and rod minerals in an organically modified wet process organoclay. This allows for a novel product. Because of the unique morphology, the product disperses and yields rapidly. The illustrations below show how these products differ from standard organoclays.

In these illustrations, the blue anchors represent the organic modification which makes the clays organophilic. The first picture is a standard organoclay, which in its dried state is like a stack of plates. Adequate energy is required to disperse these plates. The key to good efficiency of organoclay products is to obtain maximum dispersion, which increases the surface area available for plate-to-plate interactions, typically described as hydrogen bonding at the edges. The second picture is the mixed mineral thixotrope, in which the two morphologies (shapes) disrupt the stacking of the rods and platelets, thus resulting in easier dispersion, which facilitates rapid yielding.

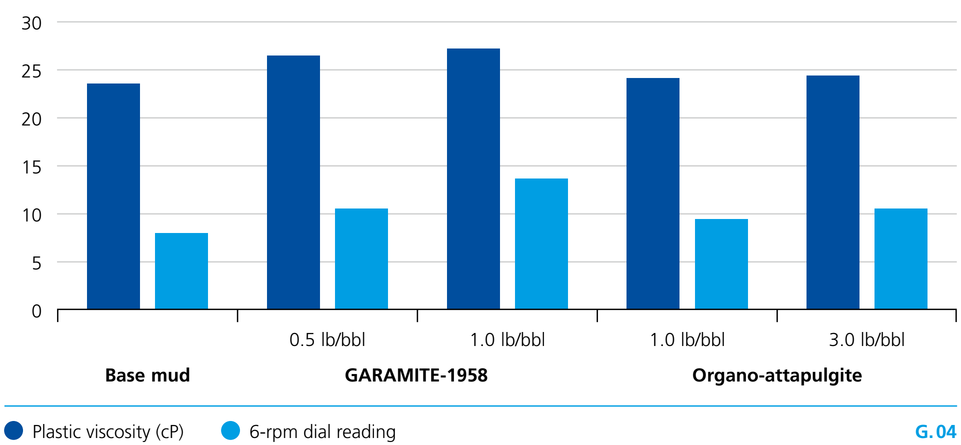
GARAMITE-1958 is a low-end rheology booster for all standard non-aqueous drilling fluids. GARAMITE-1958 improves low-end rheology and yield point, with little effect on the plastic viscosity. The addition of GARAMITE-1958 creates a more robust system. The data below demonstrate how a small amount of GARAMITE-1958 can be added to the drilling fluid at any point, whether at the mud plant or at the rig. The table below shows that 3.0 pounds of organo-attapulgite were needed to provide a similar boost as to 0.5 pounds of GARAMITE-1958, making the latter six times more efficient.

Comparison of organoclays



G. 03

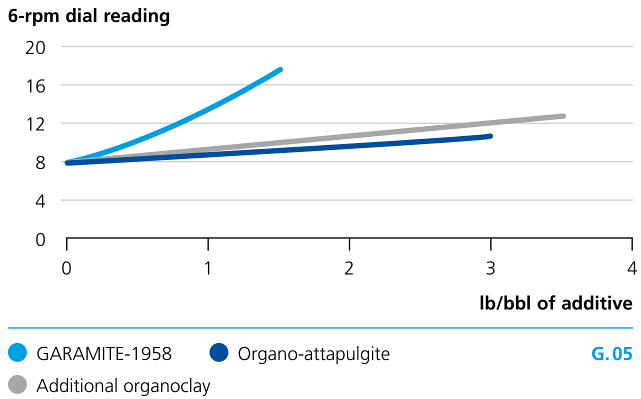
GARAMITE-1958 vs. organo-attapulgite



G. 04

When comparing the dosage with the resulting 6-rpm boost, GARAMITE-1958 is more efficient than both organo-attapulgite and additional organoclay. The efficiency of GARAMITE-1958 in boosting low-end rheology is demonstrated in the graph to the right. Small additions of GARAMITE-1958 have a greater positive impact on mud properties than higher doses of other clay-based additives.

Dosage vs. 6-rpm dial reading



G. 05

High-temperature applications require stable rheology above 350 °F, which standard organoclays cannot provide. A failed system leads to losses of time and money. For these applications BYK offers a solution based on GARAMITE-7303. Combining GARAMITE-7303 and BYK-GO 8721, a liquid rheology modifier, BYK has tested and confirmed stability up to 400 °F. The test system was a 14-ppg, 80/20 mineral oil containing 6 lb/bbl of GARAMITE-7303 and 1 lb/bbl of BYK-GO 8721 in order to balance the rheology. The full rheological data are presented below.

Thermal stability of GARAMITE-7303 with BYK-GO 8721

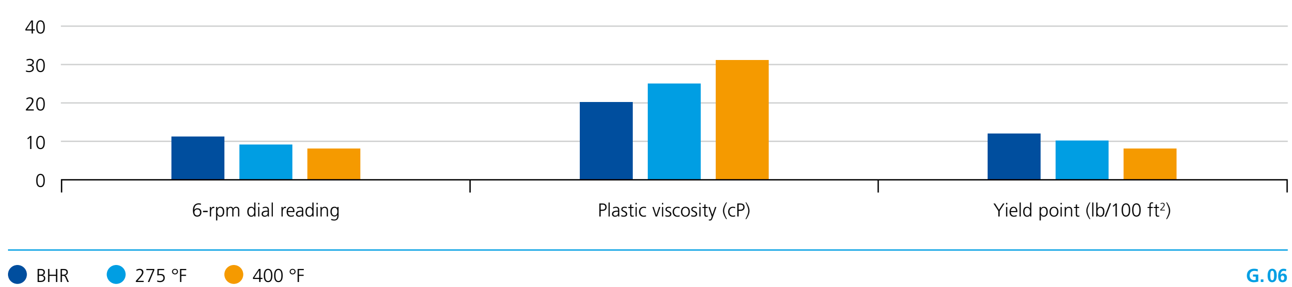
Rheology	Dial reading at 150 °F						cP	lb/100 ft²			Volts
	600-rpm	300-rpm	200-rpm	100-rpm	6-rpm	3-rpm	PV	YP	10″ gel	10′ gel	ES
Before hot rolling	51	31	25	18	**11**	11	**20**	**12**	11	14	473
After hot rolling at 275° F	59	34	27	19	**8.7**	7.8	**25**	**10**	9	10	548
After hot rolling at 400° F	71	39	30	19	**8.0**	7.0	**31**	**8**	8	9	529

ES: electric stability, PV: plastic viscosity, YP: yield point

T. 06

In addition to the electrical stability remaining above 500 volts after the 16-hour heat aging cycles, the 6-rpm dial reading, plastic viscosity, and yield point remained stable (G. 06).

Key rheology parameters



G. 06

Conclusion

BYK's family of non-aqueous rheology additives can provide the perfect fit for all your drilling challenges. The product overview below summarizes the applicability of BYK organoclays.

BYK's broad line of CLAYTONE organoclays, BYK-GO rheology modifiers, and the GARAMITE family of mixed mineral thixotropes can solve all your drilling needs. Whether it is a workhorse product or difficult drilling conditions, BYK has a solution! Let us know how we can help with your future drilling needs and challenges.

Please visit us at
Additives for Drilling for Oilfield – BYK

Product recommendations

Additive/application	Diesel	Mineral oil	Synthetic/ GTL	100 % oil	Polymer slurries	Esters	Rapid yield	350 °F	400 °F	Cold temperature	Low-end rheology	Low-polar	High-polar
Organoclays													
CLAYTONE-II	●	●				●		●					●
CLAYTONE-3	●	●	●			●						●	●
CLAYTONE-IMG 400	●	●	●			●		●				●	●
CLAYTONE-ER	●	●	●	●	●	●	●	●				●	●
CLAYTONE-EM	●	●	●	●	●	●	●			●		●	●
CLAYTONE-SF	●	●	●	●	●	●	●	●		●		●	●
Mixed mineral thixotropes													
GARAMITE-1958	●	●	●	●		●	●	●		●	●	●	●
GARAMITE-7303	●	●	●	●		●	●	●	●		●	●	
GARAMITE-7305	●	●	●	●		●	●	●		●	●		●
Rheology modifier													
BYK-GO 8721	●	●	●	●	●	●	●	●	●	●	●	●	●

T. 07

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