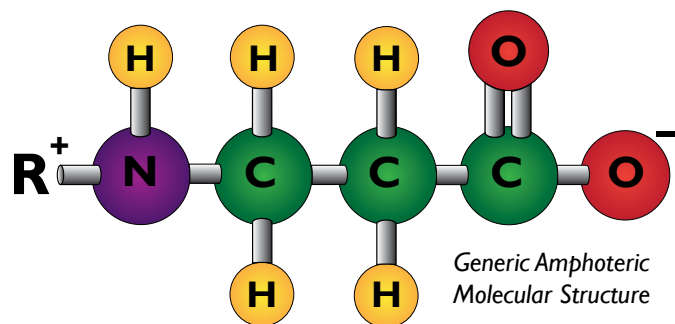


Saving Money, Time and the Environment Through Chemistry

A Performance-Enhancing
Case Study with Parker
Lane Directional Drilling
Using Amphoteric-Style
Drilling Fluid

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Since 1990, KEM-TRON Technologies Inc. (KEM-TRON) has been providing sophisticated solids control and dewatering products to customers around the world. In doing so, KEM-TRON has developed a unique set of core competencies that have made us a service leader in separation technology. By combining expertise in both dewatering polymers and solid/liquid separation technologies, KEM-TRON has developed an organization capable of providing complex chemically-enhanced mechanical separation solutions.



In an effort to further demonstrate the importance of chemistry in solid/liquid separation technology, KEM-TRON recently completed a sophisticated field trial that demonstrated the benefits of chemically-enhanced mechanical separation. This case study highlights KEM-TRON's success in formulating a hybrid drilling fluid that exhibited formation-appropriate drilling properties, while providing ultra-fine solids removal from the drilling fluid. This ultimately led to improved rate of penetration and a 100% closed-loop waste management system; therefore saving time, money and the environment.

For several years, Parker Lane Directional Drilling (“Parker Lane”) has been working throughout the North-Central Texas area, known as the Barnett Shale Region, using a variety of horizontal directional drilling (“HDD”) rigs. KEM-TRON's recent effort with Parker Lane involved their larger rigs (i.e. one “330x500” and two “100x120” rigs) operating on a single job installing gas transmission lines for XTO Energy. Due to their extensive knowledge of the region, as well as their hands-on approach, Parker Lane was a logical partner.

Section I – Drilling Through Reactive Clays

The Barnett Shale play has plagued both HDD and Oil & Gas drilling contractors trying to maintain low mud weight and viscosity. As mud weight and viscosity increase, drillers experience slowed bit penetration rates, mud loss/frac-out, and pipe torque/drag and bit balling. Soil conditions in and around the area are predominantly limestone, gravel, montmorillonite clay and mudstone. The montmorillonite clays and mudstone are highly dispersive in water (“reactive”), causing a host of drilling-related problems. To exacerbate the issue, the required use of drill pipe, mud motors and reaming bits used in long laterals, further degrade the already fragile clays before exiting the borehole. This taxes conventional solids control equipment and the capabilities of even the best decanter centrifuges.

Prior to the study, KEM-TRON collected samples from a near-by Parker Lane project. Each sample was subjected to a Particle Size Distribution (“PSD”) Analysis. The results of this analysis painted a bleak picture; the mean particle size was 5.6 microns, the median particle size was 3.7 microns, and



Figure 1 - KEM-TRON's KT-1448 Decanter Centrifuge

mode particle size was 5.4 microns. Ultimately, 85% of all solids shown were less than 10 microns and 100% were less than 50 microns. Figure 3 illustrates the results of the PSD analysis.

Given the nature of conventional drilling fluid reclamation systems, even with the support of high-efficiency desilter hydrocyclones, the best cut point that can be practically achieved would be 20 microns. Given Parker Lane's situation, this is just 15% of all solids present (Assuming that the entire solids/liquid phase from the hydrocyclone underflow was discarded from the drilling mud circulating system). Instead, the underflow from the hydrocyclone's liquid phase contains fine solids that pass thru the pore openings of the screens. Most operators don't use screen mesh sizes less than an API 200 screen number (69.0 to 82.5 micron), due to wet, "soupy" solids discharge from the mud cleaner. The result is silt-sized particles that continue to be re-circulated and ground up into ultra-fine/colloidal sized particles that can only be removed by hauling off-site or chemical enhanced solid/liquid separation using a decanter centrifuge.

Section 2 – Job Site Description

Specific to the jobsite, the 330x500 rig was to drill a 26" (66 cm) diameter borehole with 4,700 feet (1,433 meters) of lateral for 16" (41 cm) of pullback pipe located beneath Interstate 20 and a residential community in Benbrook, Texas. Additionally, there were three shorter bores to be completed. The first was 1,600' (488 meters) of 16" steel pipe (41 cm) in a 24" hole (61 cm). Second, was 250 feet (46 meters) of 16" (41 cm) steel pipe in a 24" hole (61 cm) and finally a 20" (51 cm) hole was cut to pull in 250 feet (46 meters) of 12" (31 cm) steel pipe.



Figure 2 - Parker Lane's 330 x 500 Vermeer Drilling Rig

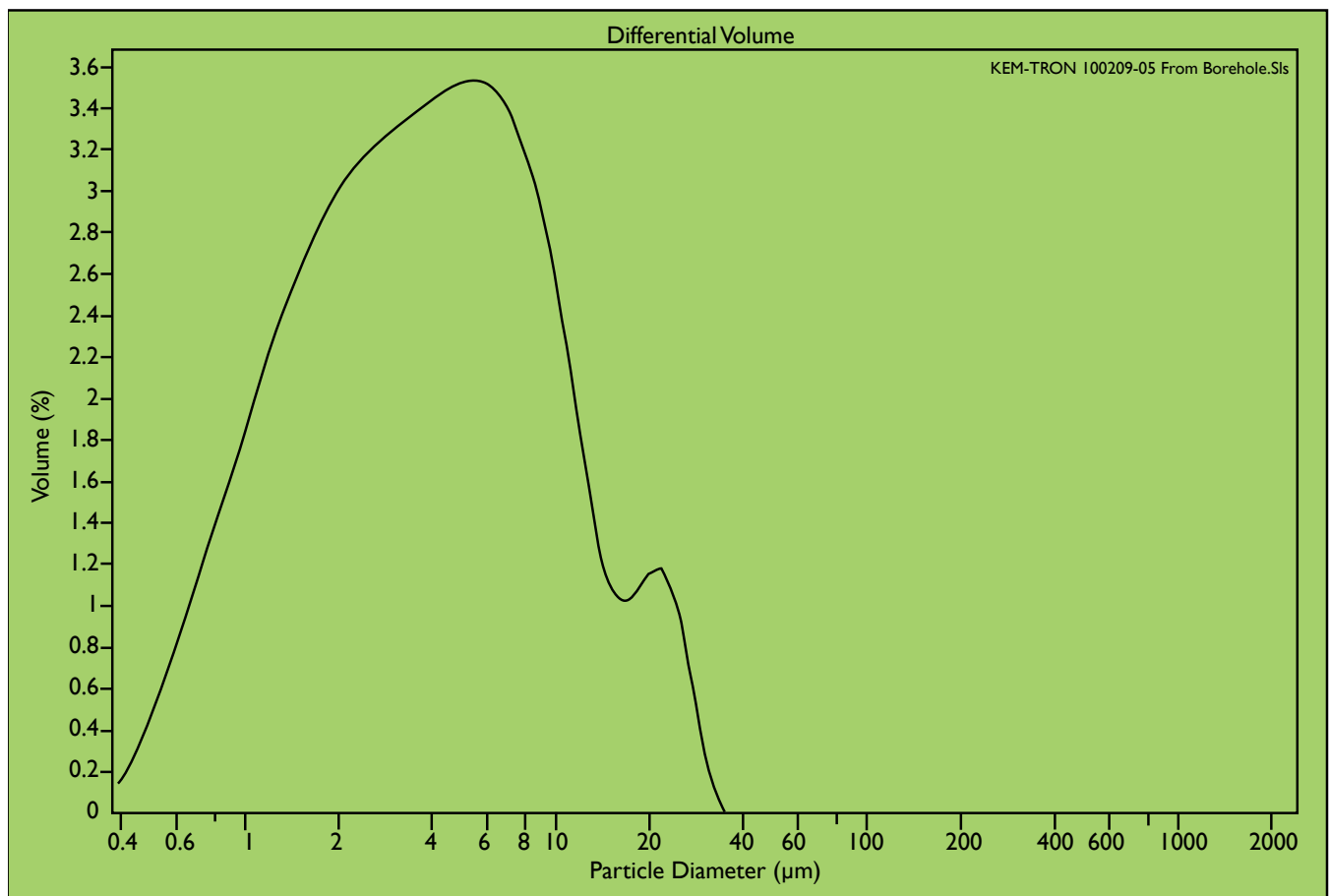


Figure 3 - Parker Lane Soil PSD Analysis

Each of the shorter bores was completed with a 100x120 drilling rig and used KEM-TRON's Tango 500T as the primary mud recycling system (Figure 2). As mud weights from these three bores increased over 10 pounds/gallon (1.2 g/cm³), the mud was transferred to the 330x500 rig-side earthen pit and introduced to the dewatering system prior to becoming new circulating volume (As illustrated in the top-center of Figure 7). This caused intermittent spikes in mud weight, but generally was brought back under control within 1 to 2 hours. Throughout the course of the long bore, no less than 75,500 gallons (185,800 liters) of 10 to 11 lbs/gal mud (1.2 to 1.3 g/cm³) from all three shorter bores was received. The daily average was approximately 1,887 gallons (7,143 liters). The primary mud system, triplex pump package, polymer hydration/dosing system, and trailer-mounted decanter centrifuge were located approximately 200 feet (71 meters) behind the rig in a linear arrangement.

Section 3 – Use of Amphoteric Chemistry

The primary goal of the closed-loop dewatering system was to control mud weight throughout the bore and eliminate spoiled drilling fluid disposal. The target mud weight was 9.0 lbs/gal (1.1 g/cm³) with a viscosity of approximately 32 to 35 seconds per quart. Mud weight and viscosity was measured though-out each day with mud rheology, API fluid loss, pH, sand content, hardness, chlorides, and methylene blue test (“MBT”) conducted at the conclusion of each day.

Amphoteric chemistry takes advantage of both cationic and anionic functional sites. When used properly in drilling fluid, the results can be significant, including shale inhibition, well-bore lubricity, and improved liquid/solids separation efficiency from both the hydrocyclones and the decanter centrifuge. The first step is to make the reactive clays, “less reactive”. This is known as clay inhibition. The inhibition of clays is achieved with the addition of KEM-TRON's CLAY-KATCH™. CLAY-KATCH™ causes cationic exchange with the potential reactive sites found between reactive clay layers. By satisfying these reactive sites with CLAY-KATCH™, the clays become hydrophobic (i.e. water repulsive) and water is unable to attach to the clays. The second step is to protect the inhibited clays from physical break-down. An anionic emulsion-grade friction-reducing polymer, named KEM-VIS HD™, makes up the anionic group along the clay sites to form protective hydration layers (i.e. steric barriers) to prevent further hydration and degradation of the shale particles. In effect, CLAY-KATCH™ creates a bridge between each clay layer, where KEM-VIS HD creates a protective wrap that encapsulates the bridged clay layers therefore being resistant to the shear forces characteristic of solid/liquid separation technologies utilizing centrifugal force (i.e. hydrocyclones and centrifuges). The general physical properties of both CLAY-KATCH 7™ and KEM-VIS HD™ have been outlined in Table 1.

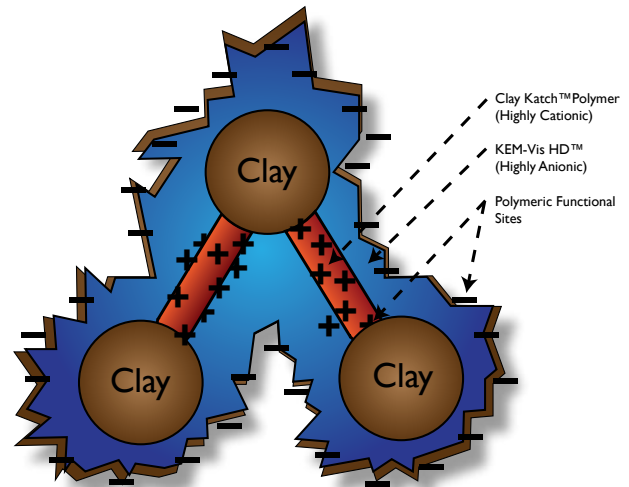


Figure 4 - Amphoteric-style chemistry when utilizing KEM-TRON's CLAY-KATCH™ and KEM-VIS HD™



Figure 5 - KEM-TRON's Multifunctional Mud Cleaner and Tango 500T

KEM-VIS HD™ additions of 1½ to 2 gallons (5.7 to 7.6 liters) were made every 1 to 2 hours in the clean tank (Illustrated in the bottom-right of Figure 7) for “sweeping”¹ the hole, and formed steric barriers. KEM-VIS HD™ does temporarily increase viscosity initially as it is absorbed by clay along the borehole and cuttings.

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¹A sweep is performed to clean any down-hole solids which were not removed during normal drilling. This is accomplished by deploying a relatively high volume of polymer to either the drill stem or the “clean” tank.

²Shear thinning fluids are non-Newtonian fluids due to the fact that their viscosity changes relative to the applied shear stress. Shear stress is a force tending to make part of the fluid slide past another part.

CLAY-KATCH™ additions of 1½ to 2½ gallons (5.7 to 9.4 liters) every 2 hours in the desander’s centrifugal pump suction (Illustrated in the bottom-left corner of Figure 7). This location would allow cationic exchange to occur on the clay sites prior to KEM-VIS HD™ additions being made in the clean tank. All of this occurred prior to the mud being pumped to the 330x500 rig, or going to the PC pump used to supply mud to KEM-TRON’s decanter centrifuge.

The additions of CLAY-KATCH™ and KEM-VIS HD™ allow the hydrocyclones and decanter centrifuge to operate more efficiently in the separation of ultrafine, silt-sized particles. This is specifically due to the amphoteric effect on clay sites and the shear-thinning² effect from the mud and the centrifugal forces being generated. Another KEM-TRON anionic, emulsion-grade polymer named KAN-FLOC E50™ was used to further increase the “floc” strength of the ultra fine-silt sized particles to withstand the high gravitational forces generated by the decanter centrifuge (Illustrated in the middle-right of Figure 7).

| Table 1 | | CLAY-KATCH™ | KEM-VIS HD™ |
|---------------------------------|--|---|--|
| Description: | | PolyDADMAC Water Soluble Cationic Polymer Coagulant | Anionic Polyacrylamide Water Soluble Anionic Polymer Flocculant |
| Form: | | Liquid | Emulsion |
| Molecular Weight: | | Low | Medium |
| Charge Density: | | High | Low |
| Specific Gravity: | | 1.01 to 1.05 | 0.80 |
| pH: | | 5.0 to 7.0 | 5.0 to 8.0 (0.5% sol.) |
| Product Viscosity (Cp): | | 70 to 200 | 1,100 to 1,200 |
| Solution Viscosity (Cp): | | <100 | 800 to 1,000 |
| Shelf Life (Months): | | 12 | 12 |
| Dissolution (Minutes): | | 1 | 10 |
| Freeze Point (°C): | | -3 | -3 |
| Function: | <ul style="list-style-type: none"> CLAY KATCH is a cationic liquid polymer used for electrostatic interaction of negatively charged inter-layers of surface of the sodium monmorillonite clay surface for shale inhibition. CLAY-KATCH can improve the yield values of drilling fluid with the additions of KEM-VIS HD. | <ul style="list-style-type: none"> Specially formulated flocculent applied after CLAY-KATCH to bridge destabilized colloidal solids and encapsulate with a polymeric film to withstand centrifugal forces generated by hydrocyclones and decanter centrifuges. Molecular Weight is high enough to be absorbed onto particles without causing flocculation and low enough to reduce screen blinding tendencies. | |
| Benefits: | <ul style="list-style-type: none"> Works across a broad pH range. Does not alter pH. Improves efficiency of liquid-solids separation when formulated with KEM-VIS in drilling fluids with low bentonite concentrations Increased yield values of drilling fluid with additions of KEM-VIS at low bentonite concentrations Coats metal surfaces to prevent bit balling | <ul style="list-style-type: none"> Improved separation of solids from hydrocyclones and decanter centrifuges. Provides drilling fluids with less solids content for improved bit penetration rates and dewatering capabilities. Used to “sweep” the hole of cuttings, while maintaining a low viscosity mud for greater lateral hole cleaning and separation of solids on the surface. Rapid hydration of polymer prevents “fish eyes” from occurring and creates polymeric film along borehole for improved lubricity. | |
| Dosage: | <ul style="list-style-type: none"> 1 gallon (3.8 liters) for each 1,000 gallons (3,785 liters) of water added and ½ gallon (1.9 liters) for each 250 feet of hole drilled. | <ul style="list-style-type: none"> 1 to 2 gallons (3.8 to 7.6 liters) per 500 gallons of mud, while drilling silt and coarse sand formations. 1½ to 3 gallons (5.7 to 11.3 liters) per 500 gallons (1,893 liters) of mud while drilling fine to coarse gravel. | |
| Packaging: | <ul style="list-style-type: none"> 5 gallon pail (45 lb.) / 18.9 liter (20.4 kgs) | <ul style="list-style-type: none"> 5 gallon pail (42 lb.) / 18.9 liter (19 kgs) | |

Table 1 - KEM-TRON Drilling Fluid Polymers

Thirty-one bags of bentonite were used on the first day only as a base fluid for drilling the first couple of rods. The concentration of bentonite was monitored using a MBT test. A bentonite weight, equivalent to approximately 15 to 25 pounds/barrel (43 to 71 kg/m³) is recommended in a drilling fluid with amphoteric chemistry and shear thinning capability. During high solids events, as experienced during mud transfers from the 100x120 rig, CLAY-KATCH™ additions were increased to maintain cationic exchange on both the 330x500 rig borehole and muds from the smaller rigs that were not using drilling fluid with an amphoteric chemistry.

Section 4 – The Mud Reclamation and Dewatering System

A triplex pump was used to circulate the drilling fluids from the clean mud pit to the 330x500 rig. The spent drilling fluid and cuttings would exit the hole into a 10,000 gallon (37,854 liter) earthen “rig-side exit” pit adjacent to the borehole (Illustrated in the top-center of Figure 7). Following completion of the pilot bore, the mud was then discharged to the pipe-side. This was the case until over 50% of the pipe was pulled in. Drilling fluid from the pipe-side pit was transported with a vacuum truck over to the rig-side earthen pit. A 6” (15.2 cm) trash pump was used to feed spent drilling fluid to the primary cleaning system.

The mud recycling system made its first cut using a scalping shaker equipped with API 50 mesh screens (275 to 327 microns - Rated per the American Petroleum Institute’s 13C Recommended Practice). The underflow from beneath the scalping shaker, containing 324 micron-sized solids, is picked up by the desander’s centrifugal feed pump to supply a manifold with two 10” (25.4cm) hydrocyclones. These desanders discharged solids greater than 40 microns over a linear motion shaker equipped with API 120 mesh screens (116 to 137 microns), while the overflow containing solids less than 40 microns discharged to the next compartment. The overflow from the desander was then picked up by the desilter’s centrifugal feed pump used to supply the desilter manifold with ten 5” (12.7 cm) hydrocyclones discharging solids greater than 25 microns over a linear motion shaker with API 170 mesh screens (82 to 98 microns), while the overflow (containing solids less than 25 micron material) discharged into the third compartment called the “clean” tank. Typical drilling fluid reclamation systems, with this solids control configuration, would be complete at this stage.



Figure 6 - Dried Solids Discharge from KEM-TRON'S KT-1448 Decanter Centrifuge

Consequently, based on the PSD analysis previously conducted, minimal solids removal would have occurred. This would have allowed a constant build-up of solids, ultimately resulting in whole mud dumping, or haul-off, and preparation of new drilling fluid. As such, KEM-TRON’s KT-1448 decanter centrifuge, coupled with a progressive cavity (“PC”) pump, was installed to draw fluids from the clean tank. The effluent from the decanter centrifuge had a mud weight between 8.4 to 8.6 lbs/gal (1.0 g/cm³) and was discharged into a small earthen pit and transferred to the process tank with a trash pump. A 10” (25.4 cm) screw conveyor was used to discharge dry cake solids at a rate of 1,900 to 5,100 lbs/hour (861.8 to 2313 kgs/hour), depending upon the rate of penetration and borehole diameter.

Section 5 – Dewatering Chemistry

Though the sole use of the KEM-TRON KT-1448 decanter centrifuge would have provided better results than conventional solids control equipment, its efficiency would have been significantly hampered due to the nature of the reactive clays. To achieve optimum solid/liquid separation, and to ensure that the centrifuge operated at its maximum efficiency, KEM-TRON utilized two specialized dewatering polymers to flocculate the colloidal solids prior to the centrifuge.

These two dewatering polymers were used in tandem with the drilling fluid polymers outlined in Table 1. The primary flocculant was KAN-FLOC E50™ and was introduced into the centrifuge’s PC pump suction to allow sufficient time for a chemical reaction to occur before being subjected to the high-G centrifuge (Illustrated in the right-middle of Figure 7). KAN-FLOC E50 was used throughout the bore at varying flow-rates pending on the volume of solids present. During the pullback, COLOR-KATCH 7™ was used as a coagulant³ to give the centrifuge the ability to handle the incredible volume of solids exiting the hole. The specifications of each of these dewatering polymers have been highlighted in Table 2.

Although KAN-FLOC E50™ was used through-out the hole, several days exhibited conditions in which flocculant was not required to maintain the mud weight. This is due to the beneficial side-effects created by using amphoteric drilling fluid. Consequently, it was generally required once reaming began. The centrifuge operated on a continuous basis, even when the rig was not circulating. This allowed for the removal of fine solids without the added cost of flocculant.

| Table 1 | CLAY-KATCH™ | KAN-FLOC E50™ |
|---------------------------------|--|--|
| Description: | Quaternary Polyamine Water Soluble Cationic Polymer Coagulant | Anionic Polyacrylamide Water Soluble Anionic Polymer Flocculant |
| Form: | Liquid | Emulsion |
| Molecular Weight: | Low | Medium |
| Charge Density: | High | Low |
| Specific Gravity: | 1.01 to 1.05 | 0.80 |
| pH: | 5.0 to 7.0 | 5.0 to 8.0 (0.5% sol.) |
| Product Viscosity (Cp): | 150 to 700 | 1,100 to 1,200 |
| Solution Viscosity (Cp): | <100 | 800 to 1,000 |
| Shelf Life (Months): | 24 | 12 |
| Dissolution (Minutes): | 1 | 10 |
| Freeze Point (°C): | -3 | -3 |
| Function: | <ul style="list-style-type: none"> COLOR-KATCH is a high cationic structured liquid polymer used for primary colloidal particle neutralization and also creates molecular bridging to enmesh the destabilized particles. COLOR-KATCH is the building block when developing a “Hard Flocc” before the addition of KEM-TRON’s KAN-FLOC flocculents for dewatering sludge with high suspended solids and drilling | <ul style="list-style-type: none"> Specially formulated flocculant applied after COLOR-KATCH coagulant dosing to enmesh destabilized colloidal solids and encapsulate with a polymeric film to withstand high G-forces generated by a decanter centrifuge dewatering. The phenomenon of the “Hard Flocc” produced by the dosing of COLOR-KATCH coagulants and KEM-TRON’s KAN-FLOC products stems from the configuration of |
| Benefits: | <ul style="list-style-type: none"> Works across a broad pH range. Does not alter pH of treated water or add soluble metals to treated water. Increases the rate of solid-liquid separation. Non-Hazardous and unregulated by DOT. | <ul style="list-style-type: none"> Works across a broad pH range. Maintains “Hard Flocc” in water with high salinity and hardness values when exposed to decanter centrifuge separation. Reduces hydraulic head losses through lowered “flow friction”. |
| Dosage: | <ul style="list-style-type: none"> Low Solids/Density Freshwater Drilling Muds (<8.9 lb./gal.): 1,000 to 3,000 mg/l. High Solids/Density Freshwater Drilling Muds (<10.0 lb./gal.): 3,000 to 7,000 mg/l. | <ul style="list-style-type: none"> Low Solids/Density Freshwater Drilling Muds (<8.9 lb./gal.): 100 to 300 mg/l. High Solids/Density Freshwater Drilling Muds (<10.0 lb./gal.): 300 to 600 mg/l. |
| Packaging: | <ul style="list-style-type: none"> 5 gallon pail (45 lb.) / 18.9 liter (20.4 kgs) 55 gallon drum (500 lb.) / 208 liter (94.3 kgs) 275 gallon tote (2,500 lb.) / 1,041 liter (1,134 kgs) | <ul style="list-style-type: none"> 55 gallon drum (450 lb. net wt.) / 208 liter (94.3 kgs) 275 gallon tote (2,300 lb. net wt.) / 1,041 liter (1,134 kgs) |

Table 2 - KEM-TRON Drilling Fluid Polymers

³These polymers are used to enhance the solids control capabilities of the dewatering system in comparison to the drilling fluid polymers that were used to enhance the down-hole properties of the drilling fluids. When done correctly, the dewatering polymers (KAN-FLOC E50™ and COLOR-KATCH 7™) will leave the system with the solids, where the drilling fluid polymers (CLAY-KATCH™ and KEM-VIS HD™) will remain in the drilling fluids.

The KAN-FLOC E50™ working solution was prepared in a truck-mounted 1,260 gallon (4,770 liter) steel mixing tank circulated by a centrifugal pump. Approximately 10 gallons (38 liters) of “neat” KAN-FLOC E50™ was added to water to “make-down” the polymer contained in the mixing tank using a 1:125 polymer to water ratio working solution. During low solids situations, weak concentrations were added to assist in the flocculation and to keep a steady feed of water into the mud system. This was done as an alternative to charging large volumes of water at one time.

Section 6 – Job-Site Dewatering

The PC pump provided for an adjustable mud feed rate to the decanter centrifuge when changes occurred in mud density, viscosity, and solids concentration, or for improving water clarity and dry cake solids while dewatering. Based on the data collected during the field trial, it was determined that the PC pump operated on a range of 26 to 58 gal/min (1.6 to 3.7 l/sec) depending on solids loading. The average pumping rate was 43 gal/min (2.7 l/sec). The higher end of the operating range was reserved for those periods in which the mud weight needed to

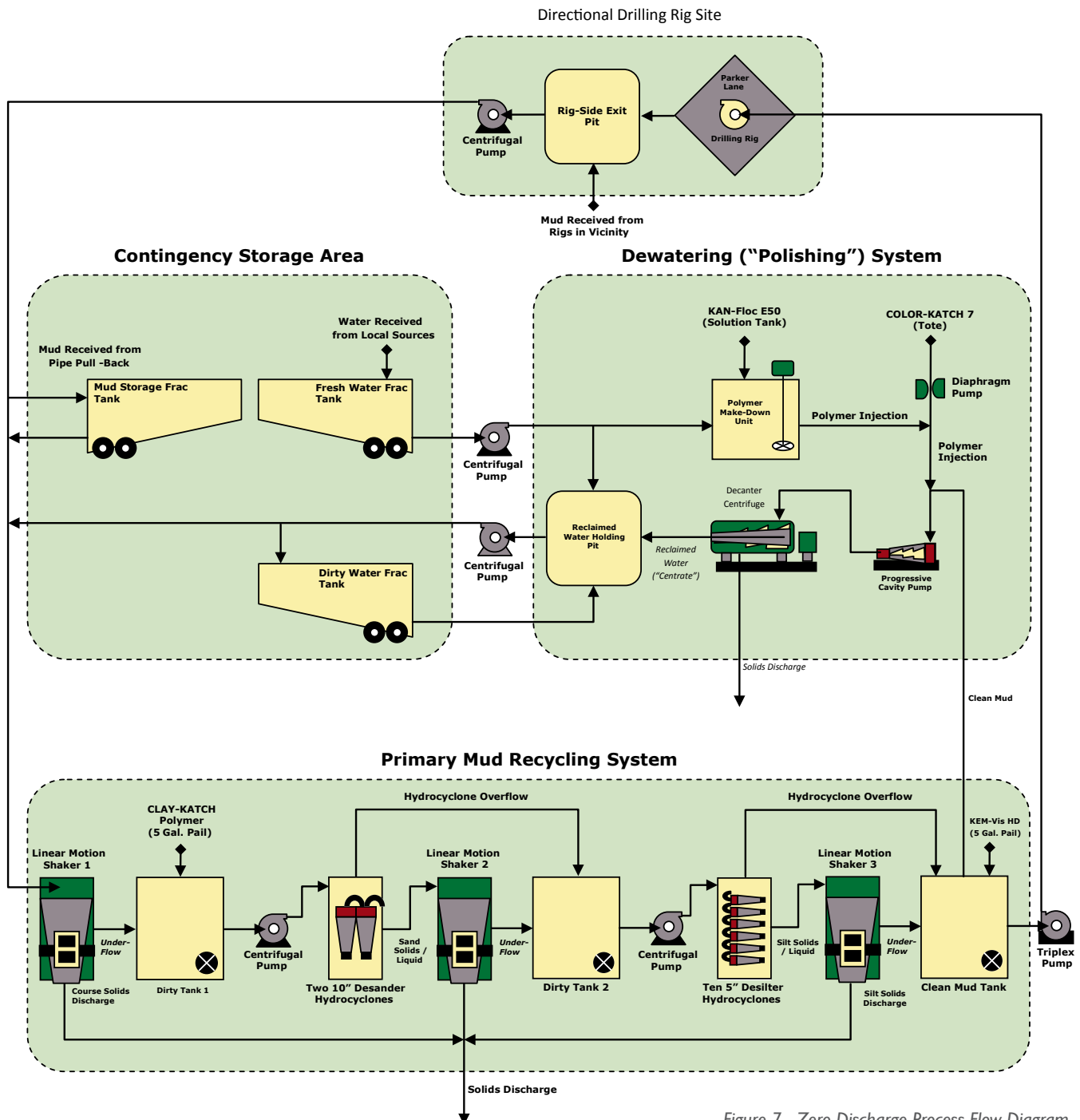


Figure 7 - Zero Discharge Process Flow Diagram

be quickly reduced. Of notable mention was the fact that while the triplex pump was operating at approximately 325 gal/min (20.5 l/sec), the decanter centrifuge was exposed to only 13% of the down-hole flow rate.

As the characteristics of the returned drilling fluid varied, so too did the characteristics of the centrifuge effluent. As such, adjustments were periodically made to accommodate the variations, therefore resulting in an average centrifuge discharge of approximately 8.4 lbs/gal (1.0 g/cm³). Even though there were intermittent events in which the actual cut was adversely affected by changes in the solids loading, the goal weight of 9.0 lbs/gal (1.1 g/cm³) was easily maintained. Prior to the pipe pullback, the PC pump flow rates were reduced to approximately 26 gal/min (1.6 l/sec) and COLOR-KATCH 7™ was then introduced ahead of the KAN-FLOC E50™ solution. The combination of COLOR-KATCH 7™ and KAN-FLOC E50™ provided the necessary conditions allowing the centrifuge to produce clear, reclaimed water.



Figure 8 - Treated Mud discharge from KEM-TRON's KT-1448 Decanter Centrifuge

In anticipation of the heavy solids loading expected from the pullback, all the surface volume was reduced to approximately 8.4 lbs/gal (1.01 g/cm³) mud weight⁴. Additionally, 200 barrels of clear water was reclaimed and stored in the fresh water frac tank. Two additional frac tanks were brought in to accommodate the large volume of fluids expected to be displaced by the pipeline. The configuration and use of the frac tanks is highlighted in the middle-left of Figure 7.

As the pipe was pulled into the hole, KEM-TRON began to draw from the primary mud system and restored the mud back to clear water. This water was fed into the clean tank and intermittently back to the primary mud system to dilute the down-hole mud, as well as make-down KAN-FLOC E50™ working solutions. As a result, KEM-TRON maintained the primary mud system tank and earthen pit volumes for 5.5 hours. This was accomplished through the selective use of the on-site frac tanks used to collect treated volume on an as-needed basis. Following this period, KEM-TRON began to eliminate volume exclusively into the dirty water tanks.

The second frac tank was to be used to store mud processed by the centrifuge, but lacking clarity. The third frac tank was to be used to collect mud directly pulled from the earthen pit. KEM-TRON was able to avoid discharge to the third frac tank for approximately 15 hours. Since the centrifuge was sized to easily process the heavy mud, the limiting factor was the trash pump. The trash pump was unable to efficiently extract the heavy mud from the earthen pit and transfer it to the primary mud system. Ultimately, as the mud weight and viscosity increased, the trash pump flow rate would inversely decrease.

| Table 3 - Time <i>(Hours)</i> | Clean Tank Mud Weight <i>lbs/gal (g/cm³)</i> | Return Mud Weight <i>lbs/gal (g/cm³)</i> |
|---|---|---|
| 0 | 8.5 (1.02) | 9.1 (1.09) |
| 6 | 8.9 (1.07) | 9.3 (1.11) |
| 8 | 9.4 (1.13) | 9.8 (1.17) |
| 16 | 9.8 (1.17) | 10.2 (1.22) |

⁴ With a target of <9.0 lbs/gal, KEM-TRON had been successfully maintaining a fluid discharge from the dewatering system with a mud weight of 8.4 lbs/gal. Since the rig was preparing for pullback on this particular day, it provided enough time for the surface volume to be treated down to 8.4 lbs/gal. This would not have normally been possible while drilling.

As the job progressed, volume was eliminated into either the clean water frac tank or the dirty water frac tank at an approximate rate of 44 gal/min (2.8 l/sec). Approximately 12,000 gallons (45,425 liters) was pumped directly from the hole into the third, dirty-mud frac tank due to the trash pump.

As the pipe was initially being pulled into the hole, the clean tank contained 8.5 lbs/gal (1.02 g/cm³) fluid, while the returns were 9.1 lbs/gal (1.09 g/cm³). Over the course of approximately 6 hours, the clean tank mud weight increased to 8.9 pounds/gallon (1.07 g/cm³), with returns running 9.3 lbs/gal (1.11 g/cm³). Since centrifuge-processed fluids were no longer being discharged to the mud system (therefore no longer diluting the circulating volume) an increase in circulating mud weight was anticipated. Within two additional hours, the clean tank mud exhibited a weight of 9.4 lbs/gal (1.13 g/cm³), with returns at 9.8 lbs/gal (1.17 g/cm³). This rate (mud weight increase) slowed over the next 8 hours. Table 3 highlights the changes in mud weight density over time.

The pipeline was staged in seven welded sections. Once a section was pulled into the hole, the next section would be welded in place. Approximately 8 hours after the first section of pipe was pulled into the hole, efforts were recommenced to control circulating volume mud weight and to reduce the collected volume within the frac tanks. Approximately 16 hours after the first section of pipe was pulled into the hole, the clean tank mud weight and returns had increased to 9.8 and 10.2 lbs/gal, respectfully (1.17 and 1.22 g/cm³). It was at this time that KEM-TRON's activities were solely focused on eliminating volume into the frac tanks.

Approximately 18 hours after the first section of pipe was pulled into the hole, the 12,000 gallon (4,542 liters) volume was pumped into the dirty mud frac tank to be treated at a later time. By adding dirty water back into the primary cleaning system, the mud weight was fully under control. Just two hours later, the rig had completed the pullback.

Section 7 – Dewatering Economics

Based on his own experience, Mr. Brent Lane, co-owner of Parker Lane, provided some key insight regarding historical disposal costs incurred when drilling without the use of a centrifuge-equipped solids control system. Historically, Parker Lane transported approximately 8 loads per day (20,000 gallons or 75,700 liters) of waste drilling fluid and spoils to a local disposal site, for a low cost of \$50 USD per load (\$400 USD per day). The 10-hour round trip would incur truck transport fees of approximately \$85 USD per hour or an additional \$850 USD per day. Approximately 8 loads of fresh water are required per day at \$10 USD per load for a total daily cost of \$80 USD. Finally, Parker Lane utilizes a specialized blend of additives to prolong drilling fluid life at an approximate cost of \$80 USD per day. Simply based on the costs identified above, the total daily waste disposal expense was \$1,410. Each of the typical

| Table 4 - Cost Description | Unit Cost \$ USD | Total Number of Units | Total Cost \$ USD |
|----------------------------|------------------|-----------------------|-------------------|
| Waste Disposal | \$50/load | 8 loads | \$400 |
| Waste Transport | \$85/hour | 10 hours | \$850 |
| Fresh Water | \$10/load | 8 loads | \$80 |
| Additives | \$80/mix | 1 mix | \$80 |
| Total Daily Cost: | | | \$1,410 |

daily costs are summarized in Table 4. Consequently, there are several intangible costs that must be considered, including increased downtime associated with the management of truck loading and unloading, accelerated tool wear, and accelerated wash-out of triplex pumps. It is estimated that just one hour of downtime could generate a loss of equal value to the known costs identified above.

During the course of the trial performed by KEM-TRON, the daily operating costs ranged from \$200 to \$900 USD, with an average operating cost of \$350 USD per day. This equated to an average daily savings of approximately \$1,060 USD (See Table 5).

As for the unknown costs mentioned above, each of these are significantly alleviated when operating with clean drilling fluids. Though these issues cannot be eliminated, history has proven that the hidden costs are materially reduced.

Even more important than the costs savings highlighted above, was the fact that Parker Lane was able to reuse the cleaned drilling fluid on their next job, creating even greater savings and environmental benefit. Based on this particular case study, the closed-loop treatment system reclaimed approximately 70% of the originally prepared drilling fluid.

As experienced during the case-study described above, by taking the time to match the right technology with the right chemistry and process, four bores were completed with no spoiled fluids being disposed. In addition, the customer was fully prepared to start the next job without preparation of a new batch of drilling mud. Though there are initial capital expenses required to create a closed-loop or zero haul off job, the savings generated will generally pay for those costs within the first

year of operation, even in the most inhospitable formations. Ultimately, Parker Lane achieved an improved rate of penetration and a 100% closed-loop waste management and recycling system, therefore saving time, money and the environment.

Consequently, simply adding a centrifuge to a solids control system does not guarantee success. There are countless installations incorporating this technology that do not garner the same results due to a lack of, or misapplication of, chemistry. Solids control equipment and closed-looped treatment systems are seldom a “one size fits all” technology. Matching the technology with the right chemistry and process is a key part of the planning process that all operators must consider before commencing any job. For more details regarding KEM-TRON’s capabilities, available solid/liquid separation technologies, and/or performance chemicals, please contact us at www.kemtron.com.

| Table 5 – Cost Savings Analysis | Unit Cost \$ USD |
|--|---------------------|
| Historical Daily Waste Disposal Costs | \$1,410 |
| Actual Average Daily Treatment System Operating Cost | \$350 |
| Average Daily Savings | \$1,060 |



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