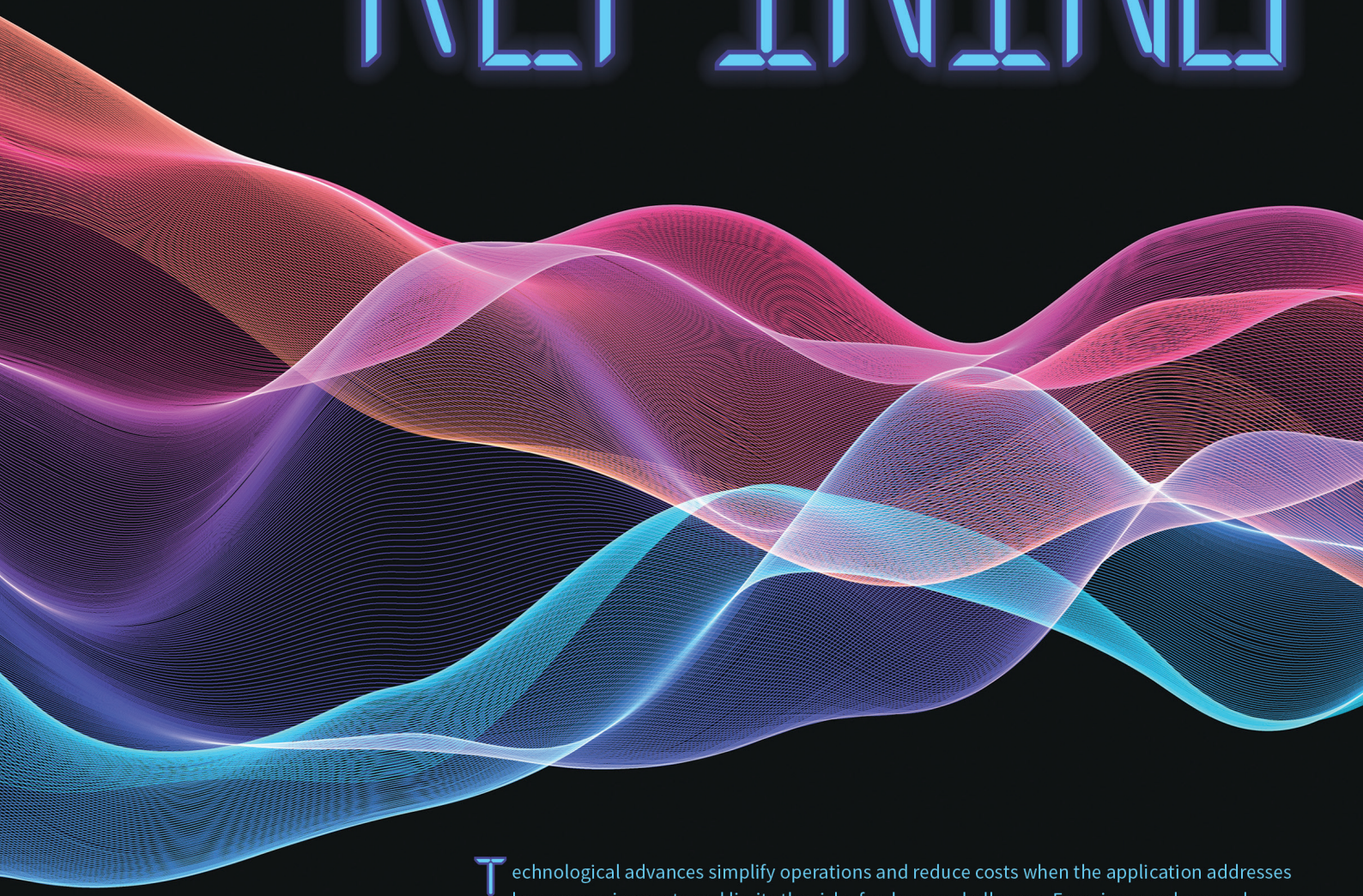
REFINING



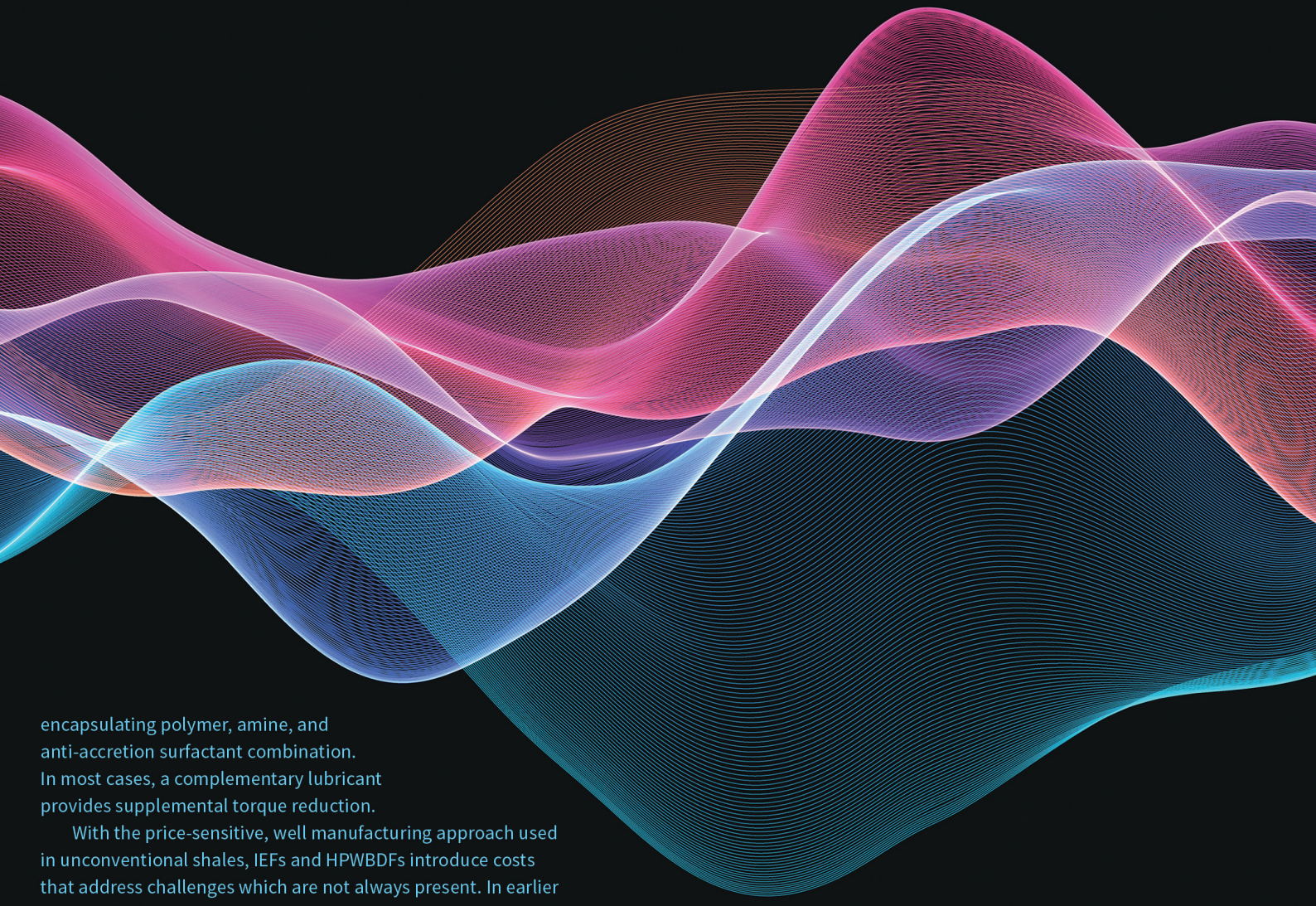
Technological advances simplify operations and reduce costs when the application addresses known requirements and limits the risk of unknown challenges. Experience reduces unknown risk, creating opportunities to reduce overall cost.

In the drilling fluids domain, invert emulsion and high-performance water-based drilling fluid systems mitigate a broad set of drilling risks – many of which do not exist in today's unconventional wells. A new drilling fluid system, paired with experience and a robust set of well data, is tailored to focus on the true risks of these applications to eliminate unnecessary costs.

Invert emulsion drilling fluids (IEFs) provide operational simplicity, tolerate many contaminants, and maximise rate of penetration through lubricity and inhibition. Considered an environmentally-friendly alternative, high performance water-based drilling fluids (HPWBDF) maximise shale inhibition using an

Matthew Offenbacher and Richard Toomes, AES Drilling Fluids, USA, explain how data analytics can lead to simpler, more cost-effective drilling solutions.

THE RISKS



encapsulating polymer, amine, and anti-accretion surfactant combination. In most cases, a complementary lubricant provides supplemental torque reduction.

With the price-sensitive, well manufacturing approach used in unconventional shales, IEFs and HPWBDFs introduce costs that address challenges which are not always present. In earlier development phases, many wells were drilled with brine and water. As unconventional shale transitioned to a boom, fluid technology was needed to overcome rig limitations and personnel shortages. IEFs provided supplemental

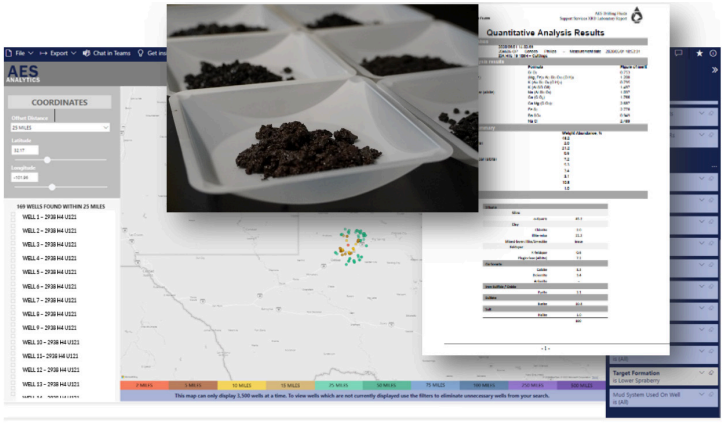


Figure 1. *AES ANALYTICS map tool feature allows users to quickly filter data to a target formation, where dozens of XRD/mineralogy lab results can provide further understanding of location-specific drilling risks.*

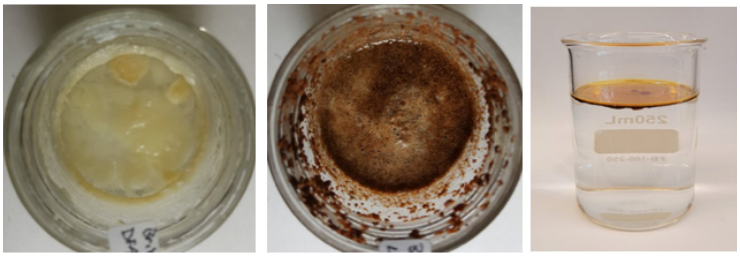


Figure 2. *Cheesing (left) and greasing (middle) are the result of many lubricant incompatibilities during the screening process, whereas a compatible lubricant (right) will have little-to-no evidence of cheesing/greasing.*

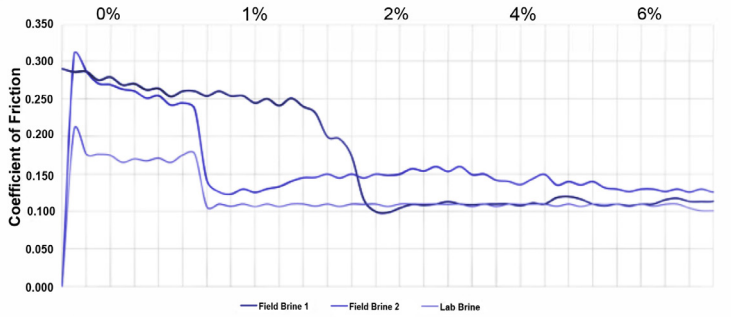


Figure 3. *Lubricity performance of BRINEX as measured on the LEM in various brine samples.*

Table 1. Lab screening of various experimental additives used to reduce fluid loss and generate thin, lubricious filter cake.

Experimental blend no.	#1	#2	#3	#4 (WALLPLEX)
Exp additive #1, % wt.	29%	29%	33%	29%
Exp additive #2, % wt.	-	-	9%	13%
Exp additive #3, % wt.	29%	-	-	33%
Exp additive #4, % wt.	42%	42%	58%	25%
Exp additive #5, % wt.	-	29%	-	-
API fluid loss, cc/30 min	11.3	No control	7.5	6.1

*Base test fluid consisted of 9.2 lb/gal NaCl brine, 0.25 lb/bbl soda ash, 0.25 lb/bbl caustic soda, and 0.5 lb/bbl xanthan gum.

lubricity, low maintenance, and simplicity – particularly as operators entered new areas with limited knowledge of formation compositions and drilling challenges.

Years of experience show that many, but not all, formations in unconventional basins do not require IEFs or HPWBDFs. Savings are available through leveraging data analytics to select and optimise fluids technology for lower risk wells. AQUA-FLEX is a new, optimised water-based drilling fluid system (OWBDF) designed to reduce costs by pairing data and system components with actual well risks. In the case of losses, a lower per-barrel cost generates immediate savings.

Well identification

Over time, large volumes of well data and formation properties accumulate to align well risk with fluid requirements. In the data analytics dashboard (Figure 1), risk events are filtered by the target reservoir, geographical location, and likelihood of a fluids-related drilling issue. Paired with laboratory analysis, including x-ray diffraction data, it becomes clear that shale inhibition is not a significant factor to well risk. This information eliminates many cost-intensive HPWBDF components.

Pipe life and torque management

A key limiter for long laterals is torque. Friction reduces weight applied at the bit, limiting rate of penetration. Sustained high torque limits pipe life, increasing overall cost. In some cases, the benefits of an aqueous fluid were completely offset by the cost of an entirely new drill string due to damage from excess torque. Since that time, pipe costs have increased more than 90%. Any transition to lower-cost aqueous fluids requires a low coefficient of friction to extend pipe life.

BRINEX, the first lubricant offering in the AQUA-FLEX system, demonstrates effective torque reduction while remaining compatible with base fluids ranging from freshwater to saturated sodium chloride brine. The broad application scenarios of BRINEX maintain simplicity while delivering sustained torque reduction.

Lubricant development begins with compatibility screening in common base fluids at expected drilling conditions. The lubricant is added to the base fluid and stressed by contaminants to identify cheesing and greasing tendencies. Cheesing or greasing compromises torque reduction and creates issues with the circulating system, such as blinding screens.

Cheesing occurs when the lubricant forms an emulsion, creating chunks of material in the base fluid. Greasing occurs when solids in the fluid become oil-wet and agglomerate. Figure 2 shows cheesing, greasing, and a passing compatibility.

Lubricity is measured using a lubricity evaluation monitor (LEM). The LEM provides a baseline coefficient of friction readings to compare to treated fluid. The LEM was modified to capture different lubricant concentrations during the same test via a syringe pump. This helps to identify the optimal concentration to provide the largest torque reduction. Figure 3 details BRINEX's performance on the LEM in several brine sources, each with different properties.

Wellbore quality

While shale is generally impermeable, there is occasional need for filtration control to aid in mechanical shale stability

and to seal permeable streaks. WALLPLEX is a single-sack blend of materials that aid in developing a wall cake when necessary, via sweeps of material or, to quickly 'mud up' in a critical situation.

The optimised blend for WALLPLEX was developed by combining attributes of products known to enhance wellbore stability, improve lubricity, and reduce fluid loss. Blends of new and historically proven additives were tested using freshwater, produced water, and saturated field brine to establish the optimum blend for expected formation properties.

Table 1 shows the optimised fluid loss for the blend and Figure 4 shows the resulting lubricious filter cake.

The simplicity of the mixture reduces the requirements for the rig crew to maintain appropriate ratios of multiple products. A single-sack solution also limits the amount of material shipped to location, simplifying logistics and reducing trucking costs.

Rate of penetration

Clear, high-spurt loss fluids maximise rate of penetration as cuttings at the bit rapidly reach equilibrium pressure with the wellbore. When fine solids accumulate in the fluid system, they can form a seal that slows this equilibrium, reducing the rate of penetration.

To maintain clear fluids, a flocculant was introduced to improve solids separation through solids control equipment. The liquid polymer additive is injected prior to the centrifuge where it adsorbs on to solids, agglomerating them into larger particles that more readily separate in the equipment.

While dewatering is a very common concept, the simplicity of a liquid additive performing across a range of base fluids is essential to the AQUA-FLEX concept. AES FLOC 4003 minimises solids, effectively reducing water usage through lower dilution rates.

Case history

The key to cost and technology optimisation is matching the drilling fluid components to well demand. The engineering team utilised the in-house data analytics platform to match well risk to an application in the Midland Basin. Offset performance indicators and clay characterisation data confirmed torque – not reactive shale – was the primary well challenge.

A 7.88 in. lateral section was planned using water as the base fluid with a standard corrosion control programme. After drilling out the intermediate casing shoe, drilling commenced, monitoring torque. As torque reached programmed limits, sweeps of BRINEX were introduced, ultimately treating the whole system at 1.5% v/v. This allowed for a 50% increase in weight on bit and 50% increase in rate of penetration.

2 – 4 lb/bbl WALLPLEX sweeps were pumped every stand to provide supplemental torque reduction and to seal any permeable zones. Sweep returns were diverted to limit the introduction of solids. To maintain rate of penetration gains, solids were controlled through dewatering using AES FLOC 4003, limiting dilution requirements and water usage.

At total depth of the ~14 000 ft interval, a BRINEX pill was spotted before running casing. Casing was run to bottom with no issues and cemented.

Results

The well, and many more, have drilled as effectively as IEFs or HPWBDFs, at a much lower cost. Base oil savings alone exceed US$100 000 while reducing the environmental impact and carbon intensity of the drilling operation. AQUA-FLEX is now used across many fields, with future improvements in torque reduction promising to displace even more traditional applications in the future.

Figure 4. *Filter cake generated by WALLPLEX on an aloxite disk.*

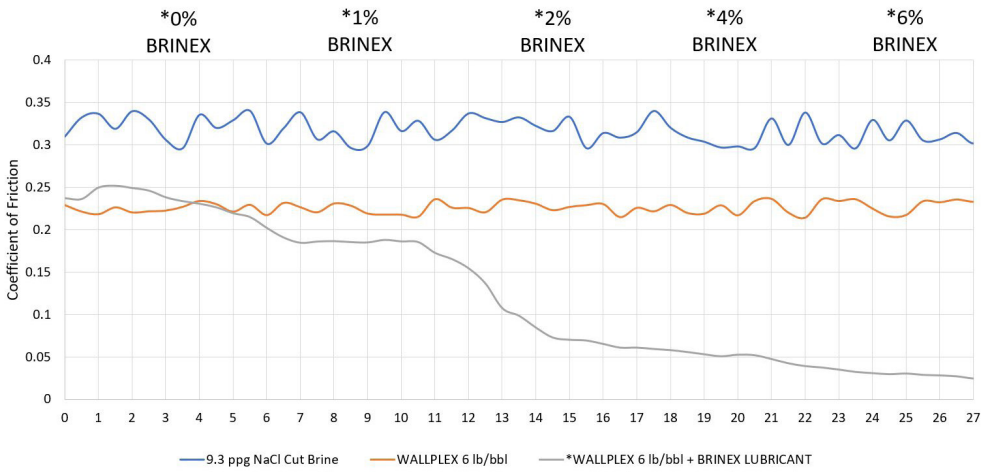


Figure 5. *WALLPLEX enhances lubricity in the AQUA-FLEX system.*