Low-density, lightweight cement tested as alternative to reduce lost circulation, achieve desired top of cement in long horizontal wells

Locally sourced materials and supply chain optimization can help to keep lightweight cements cost-effective

BY ANDY JORDAN, RODERICK PERNITES AND LUCAS ALBRIGHTON, BJ SERVICES

HORIZONTAL DRILLING AWOKE A new frontier in North America. This advanced drilling practice creates wells with mile-long horizontal sections, minimized hole diameters and maximized casing string diameters. Further, completion intensity has increased exponentially as longer horizontal wells are completed by fracturing with more stages and high-rate pumping. Casing programs have been optimized, often exposing weak formations to higher pressures for longer periods.

The combination of exposed formations, longer laterals and smaller annuli poses challenges in achieving a successful cement job. These cementing operations require lighter and more stable slurries and in larger volumes. They also require cements with sustainable resiliency to downhole changes in pressure and temperature, which help to contain the fractures and maintain annular hydraulic isolation.

At the same time, emerging cementing regulations, material supply shortages and a desire to decrease the time to completion and reduce the number of casing strings has stirred operators to seek alternative solutions. This is driving the need for reliable lightweight cements.

LOW-DENSITY CEMENT PORTFOLIO

BJ Services’ lightweight cement offering includes a comprehensive selection of engineered intergrind cements and a patented cement blend, as well as traditional foamed and beaded systems.

Normally, the density of the slurry is chosen so that the pressure exerted by the fluid column is between the pore pressure and fracturing pressure of the cemented zones.

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HIGH-DENSITY CEMENT PORTFOLIO

High-quality, low-density cements are lighter and have higher strength than conventional options.

Higher-density cement usually provides greater compressive strength. However, it will cause higher annular pressure and may exert excessive pressure on the formation, leading to lost circulation.

Lightweight cements will lower hydrostatic pressure during cement placement. They reduce the chances of lost circulation and can provide the desired top of cement. They can be engineered to have the necessary strength to overcome wellbore stresses induced by completion operations. They can also be designed so that setting times and gel transition prevent gas influx and improve overall well integrity.

Locally sourced materials and supply chain optimization can help to keep lightweight cements cost-effective.
SUPPLY CHAIN OPTIMIZATION

One of the major challenges with lightweight cements is cost-effective material sourcing. Bulk materials, such as cement and fly ash, are readily available. However, the cost to transport them can greatly impact the final material cost.

Lightweight cements typically contain fly ash, which is subject to seasonal supply variations that can impact its cost effectiveness. Because fly ash is produced as a byproduct from coal-fired power plants, availability can be disrupted by power plant shutdowns. This can occur when electricity demand is low, particularly in the spring and fall. An additional challenge imposed when using fly ash is product variability. As the low-density limits of fly ash blends are explored, issues related to product consistency become more acute. Increasingly, the availability and economics of these materials will be challenged.

As with bulk cementing materials, specific high-quality lightweight intergrinds and lightweight blends are restricted in their use by transportation expenses. For example, it is uneconomical to transport materials manufactured in South Texas to oilfields in North Dakota. For this reason, regional solutions are preferred.

BJ Services has locally sourced lightweight cement materials for the major North American operating basins. The company’s lightweight cement portfolio uses economically sourced raw materials.

LIGHTER BUT STRONGER

To further address supply and quality availability, the company has developed a proprietary, high-performing micromaterial cement blend. This low-density cement consistently provides superior tensile and early compressive strength and improves the integrity of the annular seal. The benefits of the patented, high-stability lightweight cement are wide-ranging.

The material is engineered to optimize set-cement properties – low density with high strength and low permeability – while providing slurry stability over a wide range of downhole temperatures.

The cement’s versatility is enhanced as a field blend, as densities and properties can be tuned to specific requirements by adjust-
ing the blend material ratio. The system also provides excellent slurry stability, free water control, particulate suspension, additional fluid-loss control and exhibits zero shrinkage, further promoting annular integrity.

LABORATORY TESTING

Research shows that the application of the unique cement blend can deliver multiple desirable properties in both a slurry state and hardened cement. The cement blend is pozzolanic in nature, and extensive testing found the new lightweight material demonstrates enhanced properties of the set cement superior to conventional cements.

In-house laboratory testing evaluated different densities of the proprietary lightweight cement for tensile and compressive strengths, water permeability, mechanical properties (Young’s modulus and Poisson’s ratio), shrinkage/expansion under pressure and temperature, and slurry properties like fluid loss, free water, mixability and pump time.

The evaluation began by examining the viscosity at surface and temperature, free water and fluid-loss properties in a slurry state. These examinations assessed dehydration level and slurry stability, which is important for long horizontal wells. Results showed that it provides free water control, extra suspension and facilitates in lowering fluid-loss value.

The second part of the performance evaluation tested the strength and permeability of the lightweight cement after setting. Testing was conducted over time intervals from 12 hours to 72 hours.

At each measurement, the cement blend delivered significantly higher compressive and tensile strengths with lower set cement permeability and better mechanical properties (relatively lower Young’s modulus and higher Poisson’s ratio) than conventional alternatives.

Having higher early compressive strength translates to faster time to drill to the next stage and faster time to complete the overall cementing process. The lower set cement permeability, resiliency and no shrinkage attest to wellbore integrity and better zonal isolation.

EMERGING REGULATIONS

In the United States, each state has its own cementing standards and regulations. Many states have detailed and specific regulations pertaining to the cementing practices of surface, intermediate and production casing strings. State requirements include specific cement compressive strengths to be attained before drilling operations can continue regardless of the cement density.

Lightweight cements have been demonstrated to perform at levels that meet stringent state regulations. Specifically, the new patented lightweight cement blend has proven to exceed the compressive strength requirement within a shorter time period than higher density cements, enabling operators to quickly continue drilling operations.

SUCCESS STORY

The use of lightweight cements in North American wells is proven to achieve a quality cement job, minimize complexity, leverage material supply options and meet emerging state standards.

In North Dakota, an operator required a cost-effective, low-density cement that could achieve high early compressive strength at low temperatures. BJ Services recommended a locally sourced, engineered lightweight intergrind cement. The cement had a density of 11.5 ppg that exceeded the strength required, providing a reliable annular seal, with no lost circulation and the required top of cement, thus enabling the operator to quickly continue drilling to the next stage.

CONCLUSION

Lightweight cements are demonstrating importance for achieving long-term well integrity while adhering to regulatory requirements and overcoming challenges posed by horizontal well operations. 

TOP: In-house lab testing showed that these lightweight cements demonstrated good slurry properties, such as lower fluid loss and free water values, compared with conventional (100% cement) and fly ash blend lightweight cements at both 11.5 and 14.2 ppg density.

BOTTOM: Compressive strengths help to compare the performance of new lightweight cement versus fly ash blend cement for time intervals from 12 hours to 72 hours.