Globally, more than 800,000 wells are currently active. Of those, 90 percent lack sufficient energy to flow to the surface and require some form of artificial lift. In addition to energy loss, major production challenges from the formation include solids, gas breakout, scaling and corrosion, which can both compromise the wellbore and cause dramatic production decline.

In the U.S., unconventional shale liquids production is focused in the Eagle Ford Shale, Bakken Shale, Mississippi Lime and Permian Basin. Operators in these areas use fracturing and horizontal drilling to release oil and gas from the unconventional reservoirs at higher-than-traditional rates. The use of water and sand for hydraulic fracturing can create additional production challenges because these materials tend to migrate up the wellbore and mix with the natural formation fluids. After the initial natural flow in unconventional shale wells, both pressure and production usually decrease, requiring artificial lift to sustain production.

Challenges
The challenges associated with sand, gas, scaling and corrosion can reduce pumping efficiency and must be managed for the well to be continuously produced.

Sand
Proppant that is used during hydraulic fracturing operations migrates up the wellbore during pressure drop created by the pump and enters the pump intake. High solids concentration can plug pump stages. The aggressive nature of silicates at high speeds can cause the erosion of internal metal components.

Gas
Gas in the reservoir is released as the wellbore pressure is reduced by pump drawdown. Normally, gas flow is not homogeneous. It comes in slugs, which can be problematic to centrifugal pumps designed for liquids that contain a modest amount of gas. The gas consumes valuable space inside the pump impeller vanes, which can restrict and ultimately stop all liquid flow. This gas can cause the erosive effects of cavitation or liquid starvation because of gas lock. These conditions may cause reduced pump efficiency and premature wear or failure.

Production Decline
Centrifugal pumps are designed for a limited production range, so rapid decline can cause premature pump wear, increased interventions and extended payback of investment.
**Scale & Corrosion**

Pressure and temperature changes cause carbonates and other salts in the formation and fracturing fluid to precipitate onto the internal components of the pump, which can lead to premature pump wear, efficiency loss and intervention costs. The high water content also encourages the formation of acids that contribute to metal erosion. These conditions must be treated with chemicals to maintain an economical run life.

**The Solution**

Operators address unconventional drilling and production challenges with innovative and highly engineered complete artificial lift solutions. The three most popular artificial lift methods for shale production are electrical submersible pumps (ESPs), surface rod pumps and progressive cavity pumps. ESPs, in combination with a traditional rod lift during a well’s life cycle, are increasingly an economical choice.

A provider of ESP systems offers several technologies to address the key artificial lift challenges faced by operators. The solution is most effective when the selected technologies are employed across product service lines.

**Sand**

Abrasion resistance is designed throughout most ESP provider’s unconventional systems. Inside the pump, tungsten carbide inserts protect stages from the effects of high speed erosion by providing radial support for improved sand management. For the harshest environments, 100 percent coated staging—usually of a nickel boron type—is available. Gas separators can use flame-sprayed coatings and hardened liners to allow for continuous operation in sandy environments.

The most effective way to handle sand is to prevent the proppant from leaving the formation. Some proppants use resin consolidation for sand control. De-sanders and pump screens are also options for capturing sand after it migrates from the formation but before it reaches the pump intake.

**Gas**

Operators use different tools to handle and separate free gas in the wellbore fluid. Initially, a charger pump allows the passage of gas-filled fluid and repressurizes. Then a rotary separator removes a high percentage of gas before the fluid enters the production pump. Handling and separating gas helps prevent cavitation and gas lock. Some ESP providers’ remote monitoring systems allow a technology tool to automate data gathering, monitor operations and control well operation. Alerts are created, and the software can be viewed and managed easily with a mobile or desktop device.

**Production Decline**

Pump downthrust is a hydraulic condition in which the head over the pump is greater than the pump discharge pressure. It is often caused by low production. To help prevent this condition’s destructive effects, most pumps are configured in compression. This allows for a wider hydraulic operating range. A suite of wide-range pumps that can be used within a broad range of unconventional wells is essential. Wide-range pumps extend flow ranges, redraw the medium-term production curve, accommodate the changing inflow of unconventional wells and remain in the well longer.

Production decline can be managed through careful, intelligent operation combined with monitoring and automation technologies. Realization of the full expanded production
range potential depends on the use of a variable speed drive (VSD) with gas mitigation software that allows a system to continue normal operation when encountering gas slugs by sensing and responding to fluid levels. Continuously monitoring the pump performance helps optimize operation under dynamic conditions and lets operators know when a change in artificial lift method may be required.

**Scale & Corrosion**

Chemical providers analyze water chemistry in an injection system for scaling tendencies and examine any deposits that form to identify scale type. From this analysis, a customized scale-control program and chemical application is developed. This helps maintain production and reduce the potential for pump failure and costly replacement.

Chemical providers also evaluate the fluid properties and field conditions to customize a corrosion-treatment program. In addition to chemical treatment, they can recommend a corrosion-monitoring program to address the corrosion risk profile. Through regular monitoring of corrosion rates and chemical performance, an optimized corrosion-mitigation program can be implemented, extending the effective life of the pump.

**Two Case Studies**

An operator in North Dakota’s Bakken Shale drilled and completed two nearly identical wells in close proximity and at approximately the same time. Each well was completed using an ESP with the principal difference being an artificial lift company that used the shale production approach of wide-range pumps, gas separation technology, VSD gas mitigation, and remote monitoring and control. The well conditions were as follows:

- Total vertical depth (TVD): 9,623 feet (ft)
- Total measured depth: 20,691 ft
- Gas liquid ratio (GLR): 500 to 900
- Wellhead pressure: 200 to 300 psi

By using this approach, the run life of the ESP system was extended by five months and had an additional drawdown of 300 to 500 psi.

An operating company in Northern Oklahoma’s Mississippi Lime play experienced consistent artificial lift system underperformance in its most challenging well. This operator asked an artificial lift service company to provide its unconventional system that used wide-range pumps, an abrasion resistant system configuration, charger pump and gas separation, and 24/7 remote monitoring and control. The well conditions were:

- TVD: 9,336 ft
- GLR: 1,444
- Gas oil ratio: 3,250
- Static bottomhole pressure: 2,000 psi

The result of this system was an additional drawdown of 200 psi and an increment in oil and gas production of 160 barrels per day and 1.8 million cubic feet per day, respectively.

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Matt Wisnewski is downhole ESP product champion for Halliburton Artificial Lift. He has one patent and has co-authored two technical papers presented at conferences on artificial lift alternative deployment. He has a Bachelor of Business Administration from Texas Tech University and a Master of Energy Business from the University of Tulsa. He may be reached at matthew.wisnewski@halliburton.com.

Kelsey Gonzalez is business development manager for Halliburton Artificial Lift. He has 25 years of experience in the artificial lift segment of the oil and gas industry and has authored three SPE papers related to artificial lift applications. He holds a BS degree from Brigham Young University and an MBA from Northwestern University. He may be reached at kelsey.gonzalez@halliburton.com.