GOM COMPLETIONS: INNOVATION FILLING GAPS AT NEARLY SIX MILES UNDER

By Katie Mazerov, contributing editor
WITH ITS WEALTH of resources, the Gulf of Mexico holds great promise for oil and gas operators as they push the envelope to tap deeply buried hydrocarbons. But those deep resources are now ultra-deep, approaching six miles under. And venturing into unknown territory opens up many challenges for an industry that has already overcome daunting barriers to new frontiers.

Deep fields are being developed in the Gulf’s geologic Miocene and shelf regions, characterized by well depths approaching 30,000 ft and extremely high pressures that challenge existing technology. High temperature is also an issue, particularly in the coastal shelf region where bottomhole temperatures often reach 400° F or above. The focus is now shifting to the Lower Tertiary, which, in addition to ultra-deep and high-pressure conditions, presents the added challenges of low-permeability rock formations and long intervals.

In the completions sector, technologies that have been proven at 20,000 ft are being scrutinized to determine if and how they will work in this new environment. For example, gravel-pack and frac pack systems combined with pumping are required in the deepwater Gulf because of unconsolidated sands, said Arthur Loginov, technology integration manager for Weatherford, which is developing those systems to eventually enter the GOM completions market.

“We are gaining track record in other areas before entering the Gulf of Mexico,” Mr. Loginov said. “Our focus right now is to establish ourselves as a provider of gravel-pack solutions focused on overlooked, neglected and price-sensitive markets. Once we have a solid track record, we will enter the GOM market.”

Technology gaps, combined with high development costs of up to $1 million per day, are making risk management procedures, contingency planning and offline strategies routine for operators.

“The Lower Tertiary has sparked a revival in multi-zone technology for the GOM because the intervals are so long,” said Tommy Grigsby, product line manager for sand control tools, Halliburton. The company’s Enhanced Single-Trip Multizone (ESTMZ) system allows multiple frac pack intervals to be completed in a single trip of the work string.
“Everything we are finding and developing these days is ultra-deep and highly overpressured,” said Lee Hardin, completions team leader, deepwater Gulf of Mexico, for Chevron. “Most of our reservoirs are 20,000-plus psi. When you combine 30,000 ft with 20,000 psi, the risk increases significantly.”

The Tahiti and Blind Faith developments, both in the Miocene region, proved good learning experiences for Chevron as they necessitated considerable technology development, Mr Hardin said. “We needed to know if our service providers had the logging tools, perforating guns and gravel-pack tools rated for 25,000 psi, and, in most cases, the answer was no,” he explained. “That meant there was some amount of technology development required to at least increase equipment capacity to withstand the hydrostatic pressures. In the worst case, we had to work with our suppliers to totally redesign equipment, for example, the tubing-conveyed perforation system and the subsea test tree system.”

Chevron has since completed the Jack well and is developing St Malo, both in the Lower Tertiary. “The rock in the Lower Tertiary is much different than anything we’ve developed in the deepwater GOM,” Mr Hardin said. “The tight, low-permeability formations make it more difficult to complete the wells in a way that we get the rates we need to make these projects commercially viable. A key enabling technology for the long intervals is the single-trip, multi-zone frac pack system, which can complete and stimulate multiple zones on a single trip, resulting in significant cost savings relative to conventional techniques.”

Chevron has a detailed process of risk management that assesses risk for every installation operation and every piece of equipment. “We assess the probability and consequence of every risk, and require that contingency plans are put in place for all high risks on our risk matrix,” he explained. “It might be as simple as having a fallback operation, or as complex having to redesign tools.”

While risk management is costly, operators agree that the stakes are too high to go into the deepwater without a plan.

“Contingency planning is a significant issue in the deepwater/ultra-deep completion environment,” said Sam Brown, engineering and performance manager, global drilling and completions group for Hess Corp. “We need to identify and understand the key risks to enable mitigation measures and contingency plans to be developed to reduce risk to an acceptable level. Given the costs associated with operating in this environment, the contingency plans have to be fully engineered and ready to deploy.”

“As recently as a few years ago, 1,000-3,000 ft water depth and completions over 20,000 ft were considered challenging,” Mr Brown continued. “Now we are working in water depths up to 6,000 ft and looking to complete wells with measured depths in excess of 30,000 ft. With the increase in depth, new technological and operational challenges arise. Not only does new technology have to be
developed, but we also need to evaluate if existing technology and equipment can be used reliably in this challenging ‘new’ environment,” he said.

Hess currently operates a number of fields in the Gulf of Mexico in water depths of 1,100-1,700 ft and well depths of 18,000-20,000 ft. The company is assessing the development of the Pony field, where the water depth is around 3,500 ft, with well depths up to 33,000 ft.

“The reality is that very few wells have been completed at depths in excess of 30,000 ft, and as a result, the technology and equipment required have a limited track record at these depths,” Mr Brown said. “For example, when performing frac-packs, it may not be possible to achieve the desired treatment rates using existing tools, equipment and fluids due to, among other things, the higher treatment pressures required as a result of well depth and pressure, etc. From a completion perspective, getting the desired ID to complete the well optimally is a significant challenge due to the number of casing strings required to get the well to these depths with casing.”

The depth of these completions is either pushing or exceeding the “current operating envelope” for existing technologies such as coiled tubing, slickline and electric line, he added. “Because of the depth impact, every aspect of the technology and operating procedures we have used historically has to be re-evaluated, even well-developed practices and procedures that have been optimized over the years,” he explained.

“There are well-developed equipment and technologies, and we’re continuing to develop them, but at 30,000 ft there are gaps in technology.”

Real-time downhole data is another challenge. “As we move into these significantly deeper operating environments, tools and equipment that allow us to see at the surface what is actually happening downhole would be extremely useful,” Mr Brown said. “At the moment, we mostly have to work off surface parameters, and usually only get downhole data after the operation.”

Completions are expensive in the ultra-deep environment and can take as long as 100 days. “We have to use technology and optimize our procedures and work processes to reduce completion duration,” Mr Brown emphasized. “We should do as much preparation work as possible off critical path, and perform system integration and function testing onshore to reduce nonproductive time.”

“It’s cost effective to invest in QAQC and equipment testing onshore to ensure that the equipment is properly manufactured, qualified and tested to reduce the risk of failure either during or after completion installation. “In addition, we need to ensure that all the people involved fully understand their role in the operation and the plan for it, then adhere to it so we don’t have any mistakes,” he noted. “Failures in any environment, but the deepwater environment in particular, can be extremely expensive.”
Devon Energy is involved in several deepwater operations targeting the Lower Tertiary, including Kaskida, Jack, St Malo and Cascade. "The deepwater is where we see the most growth potential in the Gulf," said Roy Hathcock, completions manager for well engineering, Gulf of Mexico. "In most cases, we are taking proven technology and evolving it to develop these reserves."

But in some areas of the Lower Tertiary, the problems posed by the high pressures are pushing the need for new equipment. "It depends on where you are in the Lower Tertiary," Mr Hathcock said. "We're involved in a 32,000-ft Lower Tertiary discovery for which we're having to develop new equipment."

Because rig costs are so high in the deepwater environment, operators are putting a lot of emphasis on the design of the wells. "There is a lot of focus on reducing trips and time optimization," Mr Hathcock said. He agrees that a key innovation in deepwater completions technology is the single trip, multi-zone completion technology, which enables operators to perforate a large interval at one time, then make a clean-out trip and run all of the screens and packers at one time. Zones can be stimulated back-to-back by manipulating the service tools to where the correct valves are open, allowing for stimulation through those valves.

"We're looking at breaking up the Lower Tertiary at anywhere from three to five different stages that we would effectively stimulate one zone after another," Mr Hathcock said. "We believe we can save in the realm of $20 million per well by using this technology."

For the oilfield service companies, single-trip multi-zone technologies along with new designs and innovations in casing, stimulation fluids, flow control devices, subsurface safety valves, elastomers, metallurgy, packer systems and electronics are becoming essential for viable reservoir production, and for reducing the duration of completions and expensive well interventions in the deep and ultra-deep regions of the Gulf.

"The drilling going on today in the ultra-deep Lower Tertiary and ultra-deep shelf regions of the Gulf of Mexico represent the latest challenges facing our industry," said Tommy Grigsby, product line manager for sand control tools, Halliburton. "Completion technology that works in the 15,000- to 20,000-ft wells is not really viable in deeper wells due to the number of work string trips required," he explained.

To reduce the number of costly work string trips into ultra-deep wells, Halliburton is utilizing its Enhanced Single-Trip Multizone (ESTMZ) system, a multi-zone gravel pack system that allows multiple frac pack intervals to be completed in a single trip of the work string. "The Lower Tertiary has sparked a revival in multi-zone technology for the GOM because the intervals are so long," Mr Grigsby said. "This system allows us to go in and do a very aggressive frac pack with rates up to 45 barrels per minute with a proppant volume of 400,000 lb of 16/30 HSP per interval for up to five intervals, providing a total cumulative proppant volume of two million lb per well."

Halliburton is also developing a new line of expandable liners, VersaFlex, for ultra-deep wells that require many large casing strings. The hangers are designed for large diameter liners (18 5/8-in. to 13 5/8-in.) to improve reliability and reduce risk in the subsea environment. "This is a new place for us," said VersaFlex product line manager Ron Nida. "These expandable liner hangers have a very smooth transition coming into them, so it makes re-entry into the liner tops much easier than what we saw with conventional liner hangers."

Fracture stimulation required in low-permeable Lower Tertiary formations is further complicated by the large intervals, which require high pumping pressures and a lot of proppant volume. Halliburton’s high-density fracturing fluid, DeepQuest, has been used successfully with proven conventional pumping equipment in the area to reduce the surface treating pressure.

"Because of the high bottomhole pressures and fracturing gradients of these wells, the surface treating pressures start to approach the safe working limits of the conventional pumping equipment and surface treating lines," explained Bart Waltman, product line manager, sand control fluids. "The DeepQuest fluid is designed to go from specific gravities of 1.14 to 1.49, or up to over 12 lb/gal. It
allows us to use our conventional pumping and surface equipment, saving the customer time and money.”

In terms of intelligent well technology, Halliburton’s WellDynamics group is expanding its SmartWell product offering to include a suite of tools that will allow operators to remotely monitor and selectively control multiple deep reservoir intervals in a single well without any physical intervention. “The real challenge in ultra-deep environments is the high differential pressure requirement (up to 15,000 psi), which is a function of high reservoir pressures and extreme pressure draw downs,” said Colin McKay, product manager for WellDynamics.

“The real driver for our customers in deploying intelligent completions is increased ultimate recovery,” Mr McKay said. “Other benefits include reduced well intervention costs, accelerated production, reduced average well costs and reduced subsurface facilities.”

Keeping pace with current market interest in all-electric subsea trees, WellDynamics is also investing in the development of all-electric SmartWell systems to reduce the number of required control lines, thus increasing operating efficiency and reducing installation time.

In foreseeing the need for technology development for ultra-deep waters and extreme pressures and temperatures, Baker Hughes in December 2008 opened their Center for Technology Innovation in Houston where tools and technologies are being tested up to 40,000 psi and 750°F. “We anticipated the need for these products well over five years ago, and about three years ago, we started planning this facility,” said Michael Naquin, director of cased hole completion systems.

The center, located on a 14-acre campus, provides a setting for collaboration among Baker Oil Tools, ProductionQuest, Baker Petrolite, Centrilift and the Reservoir Technology Group, with some 600 scientists, engineers and technicians engaged in research and testing.

“The ultra-deep GOM is a challenging environment because the majority of the portfolios that will be required to complete the Lower Tertiary are currently under development,” Mr Naquin said. “The higher temperatures and, predominantly, the higher pressures involve a change in design of the casings required. Operators are requesting we do everything we can to advance their reservoir performance and mitigate their risks in the products we’re developing, as well as eliminate the need for remediation because the cost is almost prohibitive.”

GOM HPHT wells push tubing, fluids needs

By Katie Mazerov, contributing editor

Among the host of challenges facing operators in the Gulf of Mexico are HPHT wells that pose completion issues requiring new technologies in tubing, fluids and intelligent well monitoring.

Most often seen in the Gulf’s ultra-deep shelf region along the coast, HPHT wells can have bottomhole temperatures in excess of 400°F. “Because of the hostile environment in HPHT wells, including the presence of H₂S [sour gas] and the pressures that are required, we use exotic materials such as high nickel alloys,” said Arthur Loginov, technology integration manager, Weatherford.

“Other specific challenges include the need for heavy-weight casing materials or liner materials. We try to maximize flow areas as much as we can, while maintaining the pressure rating that the customer requires,” he said. “And even with less overall thickness on the material, we still need to be able to maintain those high pressures.”

A wide range of metallurgy is used for tubing, casing, packers and other completion “jewelry” to withstand the effects of high pressure and high temperature, said Roy Hathcock, completion manager for well engineering, Gulf of Mexico, for Devon Energy.

“The deeper you go, the higher the temperatures,” Mr Hathcock explained. “There are also areas in the shelf that have a high geothermal rating, which pose a huge challenge for elastomers, especially when temperatures exceed 320°. And we’re finding that when bottomhole temperatures go beyond 275°, we start seeing the presence of H₂S.”

With regard to equipment characteristics, high temperature and high pressure work against each other in that regard. “High pressures require the use of higher-strength steels for tubulars, casing, packers and other equipment. But those higher-strength metals are also particularly susceptible to high temperatures and H₂S conditions, said Trey Lowe, completion engineer for Devon’s corporate office. “Special alloys are available, which include a high nickel content with chrome, to provide the necessary strength to combat corrosion and stress cracking, and also help prevent hydrogen from penetrating through the pipe and breaking the steel,” he said.

Ultra-high temperatures also present many challenges to conventional fracturing fluid chemistry, said Bart Waltman, product manager, sand control fluids, Halliburton. “So we are working on developing chemicals and other technologies to handle and sustain fluid properties to carry proppant to stimulate wells over 400°F.”

HPHT environments dictate that modeling be utilized to reduce the chance of failure. “Pressure and temperature affect the tubing and cause it to expand and contract,” said Bruce Techentien, Halliburton’s senior technical advisor, completion tools and sand control. “It is important to settle on our best completion option for the reliability and long life of the well, and then model that so we can determine what we’re going to do for the life of the well and what happens as the well is produced and as pressures and temperatures change.”

Intelligent well completion technology also is being pushed to handle ultra-high temperatures. “Our latest generation electronic monitoring systems offer high levels of reliability at temperatures up to 400°F,” said Collin McKay, product line manager, WellDynamics for Halliburton. “We’re now developing fiber optic technology that will withstand temperatures in excess of 400°, enabling our customers to reliably monitor wells in even the most stringent environments.”

Tom Swan, product manager for subsurface safety valves and flow controls, Halliburton, commented that the company is also developing HPHT subsurface tubing-retrievable safety valves with psi that exceeds 20,000 lb.
Among the products Baker Hughes is developing are Premier Packers for intelligent well and non-intelligent well completed formations; intervention-less setting devices that will allow the use of hydraulic systems without the use of wireline, coiled tubing or jointed pipe interventions; mechanical and hydraulic flow control devices, such as the ORBIT valve and a line of REALM subsurface safety valves for deepwater and HPHT environments.

“In these deep environments, the rate of return in the flow is absolutely crucial, so our clients are requesting we stay within the constraints of standard product offerings normally used in 9 5/8-in. through 10 3/4-in. casings, but get the ID as big as we possibly can to achieve appreciable flow rates,” Mr Naquin said. “A typical field that normally would have 20 to 30 wells is now going to be developed with 10 or 15 wells.

“We’re developing completion systems that will allow us to complete wells at these greater temperatures and ratings,” he added. “We’re also developing products that will allow us to do flow control at those temperatures and ratings, as well as safety devices that will allow us to control the flow if a catastrophic event were to happen.”

In intelligent well technology, Baker Hughes is developing products to eliminate interventions and tools to provide real-time pressure temperatures and downhole flow measurements.

“There’s been a certain level of market acceptance for IW in 7,500 to 10,000 psi applications,” said Jesse Constantine, product line manager for intelligent well completions. “Now, the obvious step change is to go to 15,000-psi working pressures and 350°F and above applications. A huge driver in this is eliminating the need to move a rig back on location and the risk of having to do an intervention.”

“Much of the sensing technology, whether electric or fiber optic, is already developed and usable in the ultra-deep environments,” he continued. “We can achieve very high resolution and can actually measure .001 psi, which gives us much better insight into the reservoir performance. We can see sooner, and with greater accuracy, water or gas breakthroughs while they are happening.”

An animation demonstrating a new line of expandable liners for ultra-deep wells is available online at DrillingContractor.org.