CUTTING COSTS IN WELL CONSTRUCTION

THOMAS ROESNER AND DIANE LANGLEY, CAMERON, USA, LOOKS AT WHAT SERVICE COMPANIES ARE DOING TO INNOVATE AND DRIVE EFFICIENCY AND COST SAVINGS IN WELL CONSTRUCTION.

The industry has shared many excellent articles and case studies on ways to enhance drilling and completion operations, to increase safety and decrease the overall cost per barrel of oil equivalent (boe). As the effects of low oil prices are experienced across the industry, one thing remains self-evident – oil companies generate revenue through oil and gas production. Therefore, service alignment and technology enables a sustainable future for both operators and service companies in today's oil price environment.

As the adage goes: necessity is the mother of all invention; service companies are taking on the challenge to address the 'other 20%.' What is the 'other 20%?' When one considers all of the players and procedures in the well construction

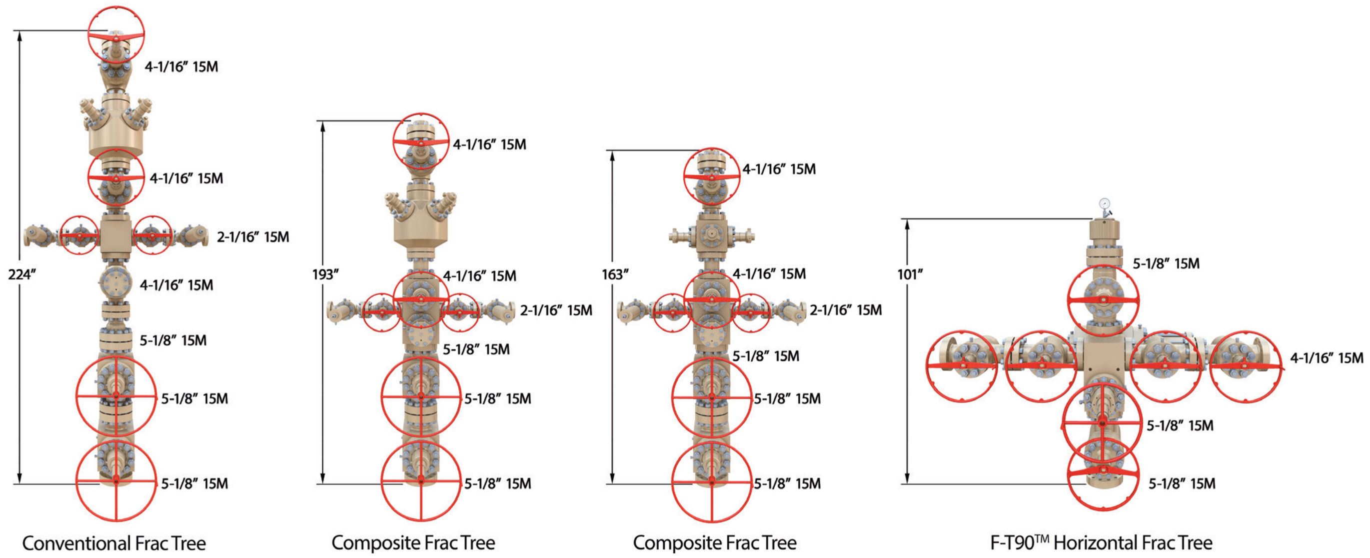

Figure 1. *Frack tree technological evolution and innovation.*

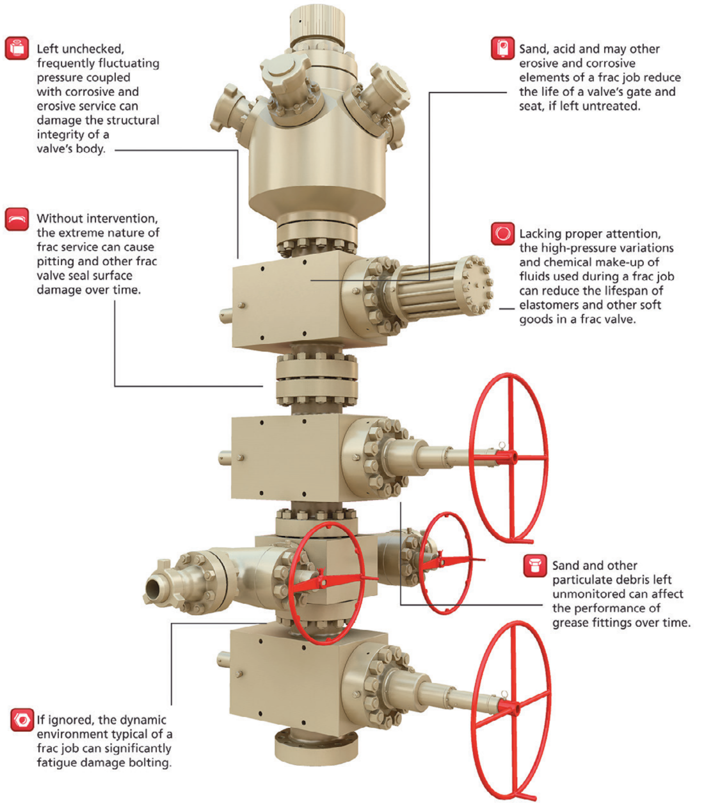

Figure 2. *Frack tree failure mechanisms.*

process, the industry has an excellent understanding of what needs to be done; this is the 80%. The 'other 20%' is discovering ways to further support the various aspects of well construction in detail in order to innovate new ways to drive efficiencies and cost savings.

Therefore, the 80/20 rule is applied to the unconventional shale plays, innovation with respect to holistic reliability in the space of the 'other 20%' is critical in today's low oil price environment.

Innovation of the wellhead

One key component on every well drilled is the wellhead. It is a vital pressure-containing component at surface that can often make operational processes more efficient and flexible. By nature, horizontal wellbores are deviated, causing fluids and cement to migrate to the low side of the hole, resulting in a less than optimal distribution downhole.

Internal components, such as a rotating mandrel hanger, will allow the casing to be rotated through the heel of the lateral as well as ensure the production casing runs the full length of the lateral and achieves a proper cement job. Once the casing mandrel is landed in the wellhead, slotted mandrel shoulders permit cement circulation, removing the necessity to wait on cement as with casing slips.

Other options that can drive operational efficiency are back pressure valves (BPVs) and wellhead packoff systems. These can be installed into the rotating mandrel to provide a barrier for both the bore and the annulus to secure the well at surface. This is especially important to help increase operational efficiency, as walking drilling rigs often are planned to move off the current well and onto the next as soon as possible.

Another important wellhead component in the completion and production process is the tubing hanger. Frequently after a well has been hydraulically fractured and the well flowed back and cleaned up, production will naturally flow for a period of approximately six months. After this time period, production often requires installing artificial lift and setting a packer downhole. A tension hanger is one easy way of achieving this, allowing completions to set the packer and keep the tubing string in tension. This will help prevent rod wear and provide a standardised solution to the completions team, who is also likely focused on boosting operational efficiency.

An example of advances made in the area of wellhead reliability and functionality for unconventionals is Cameron's advanced multi-bowl nested diverter snap ring (MN-DS) wellhead system. In this wellhead, the production casing/tubing hanger is nested within the lower casing pack-off. It features a nested internally locked upper hanger that reduces the overall height of the system for easier use with skidded rigs. This hanger can be either a production casing hanger or a tubing hanger, providing the option to complete as a one-stage system if intermediate casing is not required.

Innovation of the frack tree

As operators have adopted the factory approach to drive efficiencies in batch drilling and completions, frack tree designs have evolved, moving away from tall vertical conventional frack trees to more compact designs.

A recent move in forward-thinking innovation for unconventional shale plays is Cameron's F-T90™ frack tree. It is the industry's first horizontal frack tree specifically suited for today's factory approach to multiwell pad drilling, batch completions, and simultaneous operations (SIMOPS) applications. The F-T90 is engineered 50% smaller and 25%

lighter than conventional frack trees while preserving the rigorous durability and reliability required by the industry (Figure 1).

By taking the tall vertical configuration of the frack tree and turning it horizontally, the industry is able to take advantage of this configuration to reduce vibrational effects of fluctuating pressure caused by the introduction of solids flowing through frack equipment, enhancing the integrity of overall frack operations. The 90˚ goat head is located at the end of the horizontal section, resulting in the distance across which the bending loads act being less than half of that of a conventional stack-valve frack tree. Overall, its ultra-compact footprint makes installation easier and reduces bending stress at the wellhead connection.

Frack service is just about as harsh as it gets, and with the adoption of zipper fracking, frack trees and manifolds are being exposed to nearly continuous service, flowing and controlling high-pressure, high-volume, abrasive/corrosive frack fluid for days and weeks. To address these issues for continuous reliability, the frack trees incorporate metal-to-metal seals, feature CRA inlay in seat pockets and ring grooves, and use zero-chamfer flowbores to mitigate turbulence that is known to exaggerate erosion.

These features have proved beneficial in field application; there will no doubt be more developments as the mission toward increased reliability continues.

Innovation of frack fluid delivery

One factor in the evolution to multiwell pad drilling and batch completions is the increased time that pressure pumping crews are spending on the wellsite. Not long ago, service providers often spent five to seven days fracking a single well with 20 stages per well, on average. Nowadays, pressure pumping crews are spending 20 to 30 days on a multiwell pad and are completing over 50 stages per well; or over 200 stages per multiwell pad.

Meanwhile, demand is rising as operators push lateral lengths, the number of frack stages, and drill wells more closely together, while greatly increasing proppant and frack fluid volumes. Operators in some shale plays are injecting the equivalent of two trainloads of sand (more than 200 hopper cars) into each four-well pad. Doing all of this requires sustained use of pressure pumping equipment at high performance thresholds, prompting faster wear and tear on frack service equipment.

One of the standard responses to these conditions has been to put more fluid through more lines. But, that only adds to an already tangled maze of lines on the well pad. One answer is the Monoline™ frack fluid delivery system. This system replaces the need to rig-up four separate flow lines to the frack tree with a single line featuring a large inner diameter bore to accommodate the large frack fluid volumes required in today's hydraulic fracturing programmes.

The single-line frack fluid delivery system adheres to API standards and uses bolted connections to promote a higher level of system integrity and safety. The system uses a series of 5 in. inner diameter high-pressure pipe segments that are bolted together with 90˚ elbows and swivel flanges. This configuration allows the full range needed for alignment between the frack tree and the frack manifold. It also eliminates the potential to mismatch equipment and simplifies the rig-up procedure. Installation time is reduced by more than 60% over conventional frack-iron piping systems.

During field application in the Eagle Ford Shale, this system was shown to reduce potential leak paths, eliminate mismatched connections, remove temporary pipework, and resist erosion during a 23 frack stages per leg operation. The operator saved over 15 hours in installation time and 84 man-hours needed to install typical frack-iron pipework.

In a Canadian application, the Monoline frack fluid delivery system was also shown to improve operational efficiencies during an operation with more than 14 frack stages per leg. A four-person crew and one crane

Figure 3. *An example of advances made in the area of wellhead reliability and functionality for unconventionals is Cameron's advanced multi-bowl nested diverter snap ring (MN-DS) wellhead system.*

Figure 4. *The F-T90 is engineered 50% smaller and 25% lighter than conventional frack trees while preserving the rigorous durability and reliability required by the industry.*

Figure 5. *One of the standard responses to these conditions has been to put more fluid through more lines. But, that only adds to an already tangled maze of lines on the well pad.*

Figure 6. *One answer is Cameron's Monoline™ Frac Fluid Delivery System. This system replaces the need to rig-up four separate flow lines to the frack tree with a single line featuring a large inner diameter bore to accommodate the large frack fluid volumes required in today's hydraulic fracturing programmes.*

Figure 7. *FracServ™ valve integrity protection plan establishes a sequence of activities and inspections designed to ensure that any degradation of frack equipment is identified and corrected before the equipment is reassigned to another frack job.*

were used to install the pre-assembled system in 3 hours per leg. The rig-up time was seen at about half of that time, or around 1.5 hours per leg. In addition to reducing the wellsite footprint, the system achieved a 50% reduction in the number of needed hammer union connections.

As the number of needed connections is decreased, reliability of the connections is increased and the drastically reduced maze of flowlines and restraints will have a positive impact on safety. It is the collaboration of the operator with the service companies in exploring new ways of delivering today's high-volume hydraulic fracturing programmes that ensures reliability in operational performance.

Innovation for holistic reliability

To drive reliability into the frack programme is to understand the erosion effects on service equipment used in today's hydraulic fracturing operations.

The primary type of erosion encountered with surface frack equipment is erosion due to solid particle impingement. Frequently, fluctuating pressure coupled with sand loaded frack fluid can damage the structural integrity of a frack tree. Sand, acid, and many other erosive and corrosive elements of a frack job reduce the life of the frack tree's valve gate and seat. Lacking proper attention, the high pressure variations and chemical makeup of fluids used during a frack job can reduce the lifespan of elastomers and other soft goods in the valves of the frack tree (Figure 2).

In order to fully understand operating conditions and erosive effects on equipment used in hydraulic fracturing, specifically frack trees and manifolds, Cameron has conducted extensive erosion studies. From these efforts, Cameron has developed engineering standards to address erosion effects and maintenance procedures to ensure reliability of the frack equipment. These procedures, known as FracServ™ valve integrity protection plan, establish a sequence of activities and inspections designed to ensure that any degradation of frack equipment is identified and corrected before the equipment is reassigned to another frack job. An example of this diligence helped one Bakken operator achieve more than 99% uptime in fracturing operations.

Another example of increased frack tree uptime is the experience of one operator starting up development in the Fayetteville Shale. Faced with the daunting challenge of entry into a new type of exploration combined with concerns about finding quality equipment and personnel to reach the company's ultimate goals through adherence to strict operating standards, the operator needed to keep fracturing operations continuous without unexpected shutdowns for frack tree repairs. Use of special valves and methodology significantly heightened confidence in frack tree integrity. Time lost to have a new valve brought to the wellsite, set a plug, and replace the faulty valve is about the time it takes to complete a frack stage. For this operator, savings from not having to replace a faulty valve on the frack tree was valued at approximately US$1.5 million.

In the Eagle Ford, an operator achieved performance gains through the use of comprehensive maintenance procedures. The operator previously had been experiencing three to four failures per week that had cost on average about US$2.7 million per month. Since instituting specially designed frack trees and frack manifolds and a comprehensive maintenance programme, this operator achieved a valve integrity success rate of 100% on 189 frack stacks and 72 zipper manifolds.

The onus of success in exploitation and production in today's unconventionals is on the reliability of necessary technology to keep the industry moving forward. Therefore, as the gap in the 'other 20%' is closed, both operators and service companies will be able to thrive in a low oil price environment.