The key to connectivity

Kerry Daly, Global BD Manager, Tubing Conveyed Perforating (TCP)
First published by Oilfield Technology, November 2015

Connecting oil or gas-bearing formations with the wellbore is where the extraction process really begins. The foremost goal of any operator is to safely recover the most oil or gas in the shortest amount of time to maximise return on investment (ROI). Kerry Daly, from Expro's Tubing Conveyed Perforating (TCP) product line, explains how reservoir optimised perforation solutions can unlock hydrocarbon flow to produce vital revenue.

From an economic perspective, the decision to spend money - from securing exploration acreage through to drilling and completions - relates to recovering viable reserves. From a service company standpoint, our tools, equipment and service provision are focused on ultimately delivering hydrocarbons to the consumer.

The interface between the wellbore and the formation is key, and the completion will account for this, whether it's a trickle requiring artificial lift or a gusher requiring high pressure well containment.

With over 20,000 jobs run over 35 years and a 99% success rate, Expro's TCP technology aims to maximise oil flow in all phases of a well's life - from E&A to production and workover/intervention to abandonment.

Expro's TCP team will review reservoir conditions and model application options to propose and validate the most appropriate perforation system. Outcomes can then be verified and further analysis on well performance can be undertaken.

Cased hole versus open hole

Approximately one third of new wells globally are completed in open hole ($_1$); often referred to as a sandface completion. When operators complete a well this way and decide against running production liner (casing); allowing the formation fluids to flow without restriction into the well bore, perforating is not required.

The rock type is a key determining factor however many other considerations come into play such as completion cost, well maintenance and longevity, and production management. Stimulation services such as acidizing, fracturing, frac-packing or gravel-packing may still occur in open hole, however techniques may vary.

There are circumstances where open hole completions are not feasible. If the formation is weak causing the wellbore to collapse, then running casing may be preferred. Or if mud infiltrates the formation during drilling, causing damage near the wellbore which prohibits the flow of oil or gas; then perforating beyond this damaged zone may be required.

Running and cementing casing across the producing formation allows the operator to optimise perforating throughout the producing intervals; having the ability to segregate and isolate flow thereafter, particularly as water breakthrough occurs.

TCP and wireline

If a decision is made to case the wellbore across the reservoir, then the operator can consider TCP or electric wireline (E-line) perforating options. As always, this decision is based on many factors not least whether the well will be perforated underbalanced or overbalanced; prior to or after the upper completion has been installed.

In terms of E-line, this involves sending an electric current down the line to ignite a detonator which fires the perforating guns. This method also includes select-fire, which can be run with tractors, coiled tubing or slickline.

However, the inherent risk in running electric detonators is that they can pose a safety hazard to personnel on the surface due to potential accidental firing from miscommunication, stray voltage, lightning strike or static electricity. Furthermore, only a limited number of guns can be run due to surface lubricator length and the lack of formation control (underbalance/overbalance) after the first zone is fired (equalises afterwards).

In terms of TCP, this can be tubing, pipe or coiled tubing, and can also include slickline firing systems. The primary benefit is that the firing system does not rely on electricity, so surface safety is enhanced. There is still slight potential risk due to mechanical impact, shock or heat, however, this is normally mitigated within the design and/or running procedure.

A key benefit in using TCP is that extremely long intervals can be run. Expro recently completed a 5,000ft+ zone in a single firing which resulted in the beneficial cleanup of the formation for a major operator in Alaska. This was due to utilising pressure differentials from the formation to the wellbore which surges and carries potentially damaging debris out of the perforation tunnels.

In this example, as is often the case with horizontal well laterals, the depth exceeded 5,000ft and deploying a continuous length of TCP guns on tubing, as preferred by most operators, takes several hours. In turn, this can create risk and higher costs for both equipment and personnel.

By redesigning the deployment equipment, a combined clamp became the primary lifting mechanism with load- carrying capability. The rapid assembly and deployment of 5,000ft+ of guns saved 13 hours

of rig time,

estimated at $25,000 ($_2$) and would be significantly more in higher cost environments, such as offshore deepwater, where rig day-rates are much greater.

Well control can be included in TCP string design, particularly in ‘shoot and pull’ applications; i.e. the well is perforated on a workstring on a separate trip prior to installing the completion. By incorporating certain Drill Stem Test (DST) tools (tester valve, circulating valves, packers etc.) the well can be perforated underbalanced and subsequently killed in a controlled manner before pulling the guns out of the hole on the workstring.

Similarly, TCP is often chosen by operators in exploration/appraisal wells, attached below the DST tools, again allowing underbalanced perforating on a single trip. This also allows larger (OD) and longer guns to be utilised; otherwise smaller, thus lower performing wireline guns would have to be deployed through tubing on multiple trips to allow the well to be perforated underbalanced; even then only the first gun run would perforate under static underbalanced conditions, as the formation would then be in communication with the wellbore.

Firing heads

Expro’s TCP solutions feature an innovative firing head portfolio and have been utilised by super-major operators in global deepwater fields, with support from in-house reservoir engineering professionals in pre-job modeling and rapid special modification services.

With many different types of firing heads including drop bar, pressure activated, time delay, differential pressure, and annular or tubing pressure fired; their use is dependent on the operators’ wellbore and desired completion method. The prime consideration of any firing head should be safety – Expro’s inherent design criteria is proven by risk analysis and qualification testing.

If in a vertical or deviated well up to 60 degrees, running a drop bar firing head or combination drop bar/pressure activated firing head (Top Dual Redundant) may be chosen. Adding a pressure component to this firing head allows for safe handling on the surface as the firing pin is locked until a certain amount of hydrostatic pressure, present only at depth in the wellbore, surrounds the assembly. Running this firing head on the top gun with a pressure activated firing head at the bottom provides a truly redundant firing option.

Ancillary equipment – vents and releases

Run in conjunction with TCP equipment as part of the bottom hole assembly, vents open or close at selected hydrostatic pressures to allow the circulation of wellbore fluids or production of hydrocarbons

after perforating. Automatic or mechanical releases allow guns to drop off after perforating to remove flow restrictions and allow full-bore access across the perforated interval(s) for future well intervention operations.

Gun and specialty systems

It is important to select the best available technology for specific formation and wellbore parameters. The critical parameters of gun systems are the temperature rating of explosives used, pressure ratings of carriers and tensile and load ratings of threads. Expro systems ensure all parameters are carefully designed and checked with pre-job models to ensure compliance to industry and client requirements.

As TCP services can be used in many stages of a well lifecycle, in different formation types and geographic locations, various perforating solutions exist.

DST operations, particularly in costly operating environments, benefit greatly from having real-time visibility of downhole data. Expro's Wireless Well Solutions provides this service, which enables downhole pressure/temperature gauge data to be accessed and transmitted to surface in realtime, thereby allowing the operator to make informed decisions on the length of flow (pressure drawdown) and shut in (pressure build-up) periods. This ensures that well test objectives are met yielding valid results in an optimised timeframe. As this is done through wireless telemetry this two-way communications platform can be utilised further.

Expro has also developed an 'intervention-less' safety impact mechanical firing head which operates acoustically to fire the TCP guns. No drop bar is needed, making the system safer and multiple firing heads can be run when several zones require to be perforated independently and tested sequentially on the same test string.

Actively providing solutions in extended reach horizontal wells, Expro TCP combines technology with coiled tubing, clean-out tools (mills and motors) and agitators/ vibrators/ water hammers, which are necessary because the total depth of these wells commonly exceeds coiled tubing running capacity (due to friction and buckling). Using bespoke patented technology, Expro combines these tools in a single assembly, ultimately eliminating one or more coiled tubing trips thus saving time and cost.

Conclusions

Expro's mission is to provide operators with a holistic well flow management solution throughout the well's life cycle. By providing flexible and engineered systems, TCP can enable operators to achieve their goal of maximising the recovery of reserves by matching particular reservoir parameters with the best available perforating technology. From shallow land wells to deepwater HP/HT environments offshore, Expro has safe, field proven systems in place to optimise wellbore connectivity with the

reservoir.

References:

1 Rystad Energy, 2014

2 Expro, “Expro Excellence / TCP”, 2015