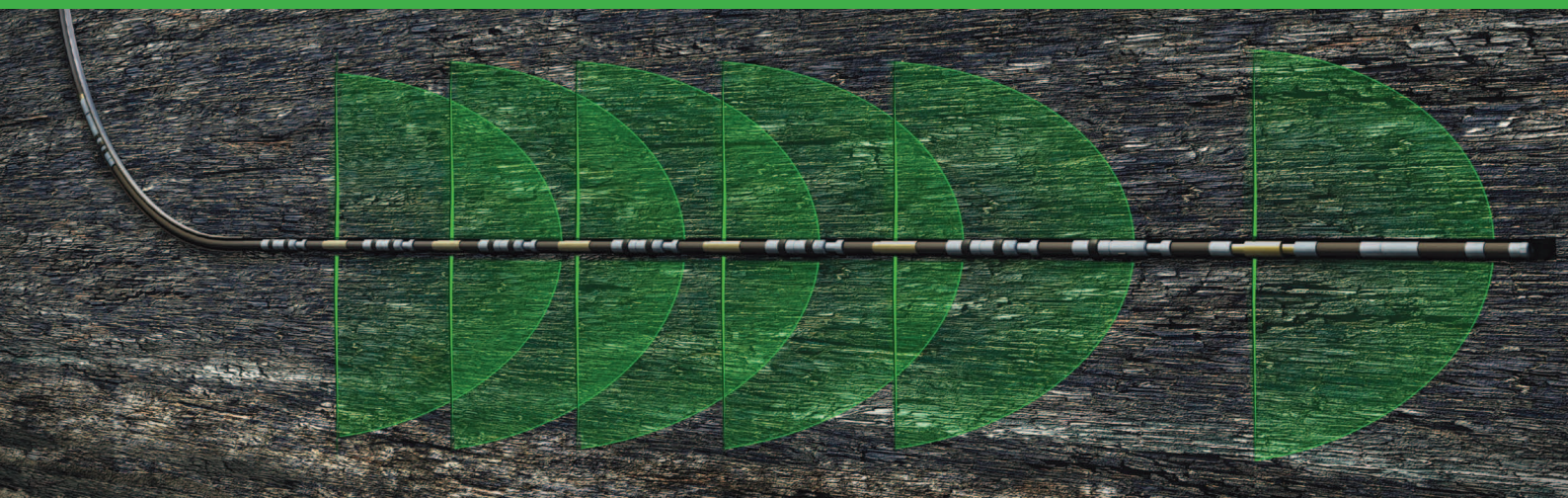


# COMPARING COMPLETIONS

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demonstrates the benefits of OHMS systems.



Since their introduction in 2001, many operators have chosen to complete their wells with open hole, multi-stage systems (OHMS), due to the time and cost savings compared to conventional multi-stage fracturing methods, such as cased hole or 'plug and perf' (CHPP). The operational efficiencies provided by OHMS have been documented in various unconventional (low permeability) formation types around the world.<sup>1</sup>

OHMS have also been applied to offshore completions in South America, West Africa, the Black Sea and the North Sea because of the even higher potential for cost savings. This article is a brief introduction and comparison of the OHMS and CHPP completion techniques as applied to multi-stage fracturing of offshore wells. Two case study examples are presented, highlighting the time and cost savings of OHMS in offshore Scotland and offshore Romania.

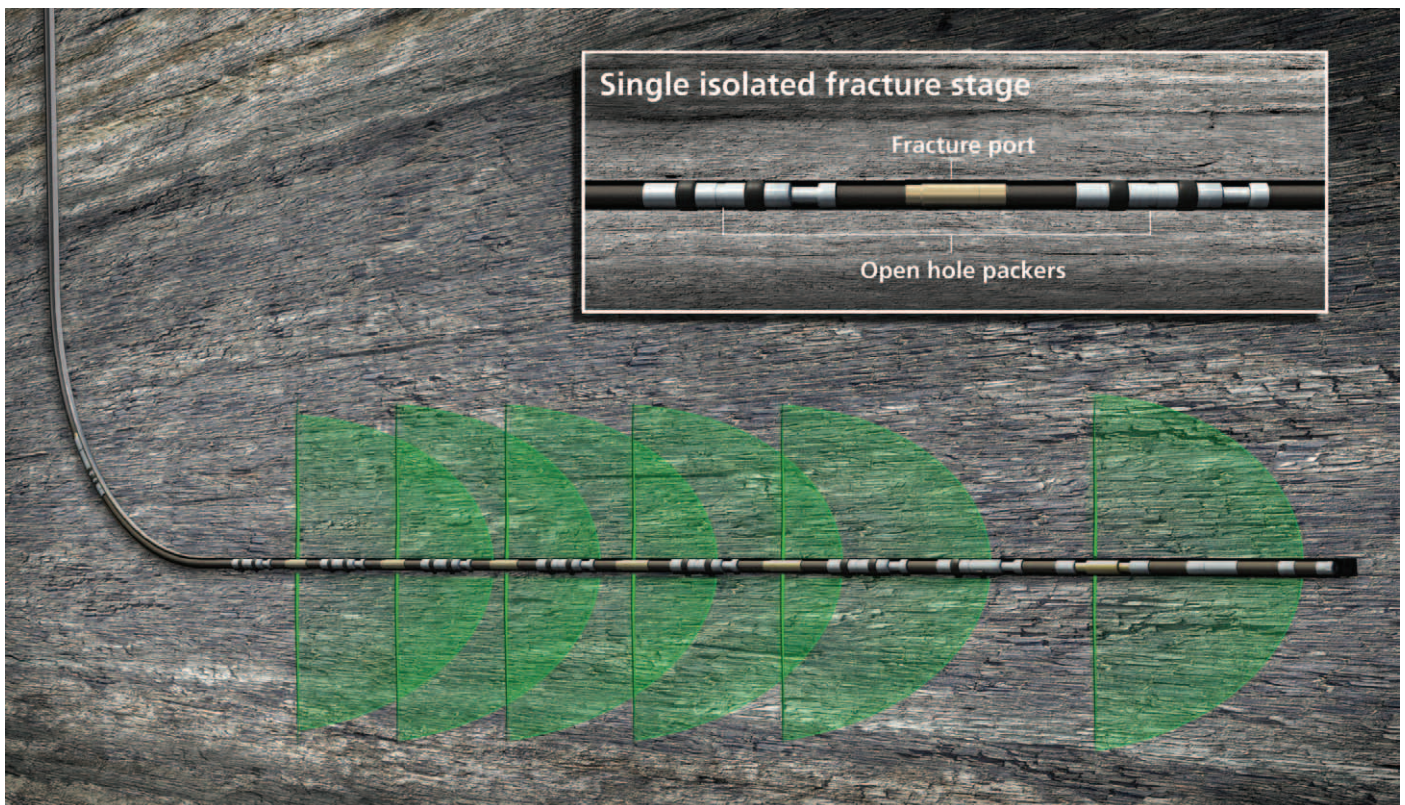


Figure 1. Open hole, multi-stage fracturing system.

### Offshore CHPP completion method

The specific CHPP method adopted in the North Sea and Europe is slightly different to the method used in North America, which employs pump down bridge plugs and is performed at aggressive rates, often leading to significant over displacement – bad practice for any fracture treatment.<sup>2</sup>

The method used in the North Sea involves running into a cleaned out, cased and cemented well with perforating guns on coiled tubing (CT) to regain access to the reservoir. After shooting the first set of perforations, the CT is tripped out. The stimulation treatment is then pumped with fracture fluid and proppant, which is left significantly under-displaced above the first set of perforations. At this point, pressure squeezes are applied to the tubing in order to compact the proppant until a high pressure plug is formed.

The CT is then run in hole with a clean-up bottom hole assembly (BHA) to dress the top of the sand plug to a certain distance above the first set of perforations. The CT is then tripped out in order to change back over to perforation guns, and the whole process is repeated for the remaining stages. After all the stages are treated, the lower completion is left full of proppant. The final operation is to trip in a clean-up BHA with CT to remove all of the excess proppant, at which time the well is ready to be put onto production or well test.

### Offshore OHMS completion method

Although they can also be run in cased hole applications, OHMS are typically run in open hole, taking the place of the cemented liner described in the previous section. Cementing and perforating are not required and CT intervention is only required as a contingency, not as an integral part of the planned operations. The OHMS liner consists of a liner

hanger, open hole mechanical packers, fracture ports, an open hole anchor and a toe circulation assembly (Figure 1).

Prior to running the OHMS liner, a reamer run is performed to ensure the hole is in suitable condition. The OHMS liner is RIH in approximately the same time as a cemented liner would be, and can be circulated through while it is RIH and once installed to total depth (TD). After the final displacement is complete, a ball is pumped to the toe circulation assembly to close off the circulation path. This allows the tubing to be pressured up to set the liner hanger and subsequently the open hole mechanical packers and anchor.

At this point the running string is tripped out and the upper completion is run. The tree is in place and the stimulation equipment is rigged on top of it. The first stage is opened by pressuring up the tubing beyond the setting pressure of the open hole mechanical packers. Once opened, a step rate test and/or mini frac can be performed prior to pumping the first stimulation. The remaining stages are opened using balls of increasing size that land on correspondingly sized fracture port ball seats, allowing pressure to build and open the port sleeves.

### CHPP versus OHMS comparison

The OHMS method is significantly more efficient than CHPP, as shown by the time comparison in Figure 2. OHMS are designed so that all stimulation stages can be performed continuously without stopping. However, stopping between stimulation jobs is not an issue and in offshore applications this may be required in order to reload the stimulation boat.

In many offshore locations, such as in the North Sea, other factors come into play, such as logistics of frac boats and proppant/fluid capacity. The timeline in Figure 2 takes into account a typical five-stage treatment in the North Sea with typical proppant/fluid volumes and average frac boat capacity.

The decrease in operational time with OHMS not only results in cost savings, but also lowers risks to health and safety, as less time is spent performing high risk operations, such as the use of perforating guns.

After OHMS stimulation is complete, the well can be turned over to production or well test. As the well can be immediately flowed back, stimulation fluids are in contact with the reservoir for significantly less time, thus mitigating induced damage to the reservoir. The speed at which the stimulation treatments can be placed, the reduction of fluid loading on the reservoir and under displacement are key benefits of OHMS and inherently follow good simulation practices that have been developed over decades of hydraulic fracturing.

An unexpected benefit that operators have experienced using OHMS completions in unconventional reservoirs, is a dramatic reduction of excessive fracture initiation pressure.<sup>3</sup> Using CHPP, it was common that some hydraulic fracture treatments could not be initiated simply due to excessively high breakdown pressure.<sup>4</sup> Since fractures are able to initiate anywhere within the open hole stage section, the fracture will take the path of least resistance – where the breakdown pressure is the lowest. This in turn reduces the potential for fracture tortuosity.

Over the last three years, several papers have been written comparing offset wells completed using CHPP or OHMS.<sup>3, 5-8</sup> These papers show that in addition to the operational efficiencies, better production is gained from OHMS as compared to CHPP. From a theoretical, modelling perspective this makes intuitive sense, as OHMS completions would allow production from the open hole wellbore, including natural fractures.<sup>9</sup>

## Offshore OHMS applications

### North Sea: offshore Scotland

The Eastern Area Trough Project (ETAP) is a network of nine oil and gas fields in the central North Sea that has been in

development since the late 1990s. One of the reservoirs consists of a naturally fractured chalk reservoir at a depth of 1250 – 2800 m with low matrix permeability, requiring stimulation for economic production. Historically, wells were cased and cemented with limited entry perforation clusters at each natural fracture location and then stimulated with large acid treatments using ball sealer diversion.

A sidetrack well presented a number of unique challenges because the density of natural fractures could not be determined prior to drilling. The operator wanted to segment the lateral into isolated sections to allow for sequential, high-rate acid stimulations. A seven-stage open hole StageFRAC system from Packers Plus Energy Services Inc. was chosen because it provided focused fracturing, allowed production contribution from the matrix and eliminated the cost and risk of cementing and perforating.

The installation and subsequent stimulation treatment were performed for the first time from a semi-submersible rig and was completed 11 days ahead of schedule compared to the previous plug and perf operations. Not only were time and cost savings realised through the completion and stimulation operation, but the well came in significantly higher than expected.

### Black Sea: offshore Romania

The Lebada Vest Field is situated in the Black Sea approximately 95 km offshore from Constanta, Romania. The zone of interest is limestone laminated with streaks of permeability ranging from 0.1 – 2 mD and porosity between 15 – 22%. This oil reservoir is situated close to an undesirable gas cap.

The operator wanted to multi-stage stimulate the well without fracturing into the gas cap. Previously, the wells had been completed with cemented perforated liners and polymer-based, conventional fracture fluids prepared with fresh water. The latter required that the treatment boat return to port after each stimulation because the fracture fluid had to be

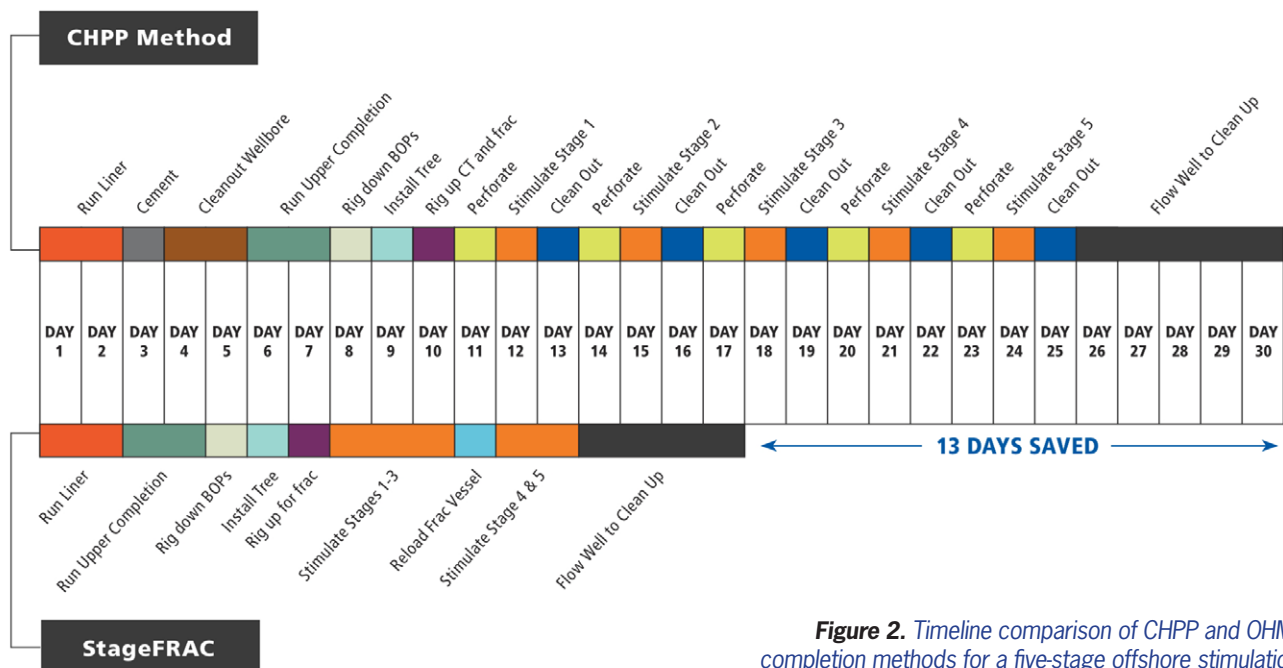


Figure 2. Timeline comparison of CHPP and OHMS completion methods for a five-stage offshore stimulation.


batch-mixed into the boat tanks at the dock. This process required an average of three days for each fracture treatment.

After evaluating all completion options, the operator chose to run a three-stage open hole StageFRAC system. Due to the lack of a dedicated treatment boat, a supply boat was modified to hold land-based fracture equipment. The three-stage stimulation was executed in one day with eight hours of pump time versus an estimated nine days for a conventional cemented liner, plug and perf completion.

After treatment, the well became the record producer in the Black Sea and its stabilised production rate was 2.5 times the best offset well in Lebada Vest completed with conventional methods.<sup>10</sup>

## Conclusion

The time savings realised through OHMS completions illustrated in Figure 2 and demonstrated by the case study examples translate into significant cost savings. Typical rig spread rates for the North Sea range from US\$ 150 000 to US\$ 500 000+/day, translating into US\$ 6.5 million for 13 days saved on a five-stage job. Additionally, stimulation costs are reduced by requiring a shorter working window for the stimulation vessel. Availability of stimulation vessels can be an issue in certain areas, so adopting more efficient methods can also increase the chances of obtaining these services.

As of March this year, over 6200 StageFRAC systems have been run worldwide in a variety of formations, both on and offshore. Combined with significant time savings, this demonstrates that OHMS systems provide multiple benefits for operators looking to reduce risk, increase productivity and improve well economics in an offshore setting. 

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