

Tool Enables One-Trip Completions in Multiple Deepwater Pay Intervals

Jed Landry and Stephanie Weiss, SPE, BJ Services

When designing deepwater wells with long or multiple pay zones, completion specialists face economic and technical problems whose solutions are often in conflict.

Typically, these long pay zones include variations in fracture pressures, permeability, or other reservoir parameters. In trying to stimulate the entire length as one zone, it can be difficult to manage the many stimulation requirements, such as volume, rate, and pressure factors. The result can be poor reservoir coverage and uneconomic production. On the other hand, traditional multizone sandface completions can impair well economics because of the rig time required.

The typical completion of a two- or three-zone conventional, 10,000-ft well takes 10 to 18 days, most of which is nonproductive time (NPT) spent tripping in and out of the well (Turner et al. 2007). For a typical five-zone well in Indonesia, the conventional completion cycle has been estimated at up to 30 days (Delattre et al. 2008).

To address the varied and frequently conflicting problems of completing long- or multiple-pay-zone wells, especially in deep water, a system has been designed by BJ Services for executing gravel- or frac-pack completions over long or multiple intervals in a single trip (**Fig 1**).

Stimulating Multiple Zones

A reservoir with a large gross pay zone and numerous stress layers is difficult to complete and stimulate effectively as a single interval. Frac packs, in particular, require careful planning to avoid overstimulation, which can breach water zones, or understimulation, which can fail to achieve optimal wellbore-to-reservoir connectivity. Even ordinary gravel packs can be difficult and expensive to execute successfully in multilayer formations.

In reservoirs such as these, the most effective treatment method is to isolate each zone being treated. This is traditionally done by perforating, stimulating, and isolating each zone individually, a time-consuming process with many trips in and out of the well to run and retrieve various tools.

To minimize this NPT for tripping, the single-trip long- and multiple-zone completion tool, called Complete MST, combines several traditional tools to enable full flexibility in sand-placement techniques. Thus, positive, selective isolation of all zones can be achieved during completion, stimulation, and production operations.

By this combination of several tools into one, completion time and cost can be reduced by 20 to 60%, depending on well depth, water depth, and the number of zones being completed. Eliminating one-third of a typical completion

schedule on a multizone well could save an operator from USD 750,000 to 2.5 million in total cost for this work, based on a USD 250,000 day-rate for the rig. That cost estimate is conservative. Deepwater rig rates have been running at approximately twice that figure in early 2009.

In addition, the system's capabilities for selective zonal treatment enable optimization of treatments for each zone and enhance the economics of completing marginal zones that might otherwise be bypassed.

The technology for each zone comprises isolated wire-wrapped or premium screens with integral production sliding sleeves, a frac-pack/gravel-pack sleeve for placing sand (gravel) or proppant, and an isolation packer.

The assemblies for all zones are made up on surface, and the entire assembly is run into the wellbore in one trip. A single gravel-pack service tool contains components that will open or close the production sliding sleeves selectively for live annulus monitoring or taking returns. The tool also manipulates each treating sleeve, allowing zones to be individually treated and then isolated.

After all zones are treated and isolated, the production string is run, and zones may be produced or commingled selectively by opening or closing the production sleeves. Up to five internal profiles are available with the current production sleeves to provide selectivity for production, from one zone to multiple intervals.

Operational benefits of the system include mechanical and hydraulic verification of squeeze and circulating positions, and a large, unrestricted bore equal to production tubing string and large-bore service tools.

The system is available for use in 7 through 10³/₄ in. casing sizes, with no restrictions on zone length or zone spacing. (A minimum of 40 ft between intervals is suggested to facilitate effective zonal isolation and service-tool operation.) To date, most field applications have used the 7- and 9⁵/₈-in. systems. The number of zones to be treated in a single trip is limited only by the erosional resistance of the service tool. As an example, the limit for the 7⁵/₈-in. system exceeds 1 million lbm of proppant pumped at 35 bbl/min treatment rates. Downhole assemblies longer than 3,000 ft have been run successfully—overcoming challenges related to pressure and temperature differentials, as well as tubing movement.

Field Results

To date, the system has been used in the field to complete 61 zones in 18 wells for seven operators in Indonesia, India, and the Gulf of Mexico. Completions have ranged from two

Deepwater: Horizontal Openhole Gravel-Pack Completions

First Successful Horizontal Openhole Gravel Pack in Deepwater Stybarrow Field

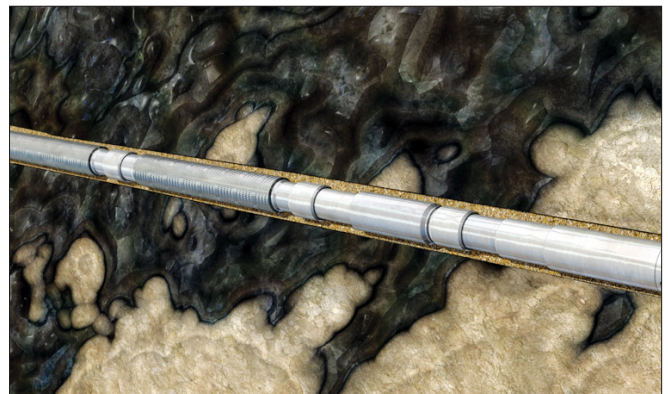
The Stybarrow Field consists of slope turbidite sandstones of the Macedon Formation in the Exmouth Sub-Basin offshore Western Australia. It is one of two fields in Australia's deepest water development, in more than 800 m of water, and was developed entirely by subsea wells connected to an FPSO.

Lateral Reservoir Quality, Sand/Shale Heterogeneities

Lateral reservoir quality variations, difficult sand/shale heterogeneities, and limited in-country technical experience and infrastructure were only some of the obstacles to completing four, near-horizontal production wells in this field. Others included gravel packing across much longer non-reservoir sections, gravel packing out of a milled casing window, narrow pressure margin between circulating pressures and formation fracture pressure, large wellbore washouts, and gravel packing at wellbore inclinations of up to 94°.

Gravel-Pack Design With Ceramic Proppant

To solve these problems, Baker Hughes helped develop an optimized reservoir drilling fluid and gravel carrier fluid design. We also created a gravel pack pumping design that used a 16/20 US Mesh ceramic proppant. This combined with our EXCLUDER2000™ medium-weave premium screen to produce the optimal sandface completion. Baker Hughes engineers sized the screens to retain formation sand. This would ensure sand retention in case of incomplete gravel packs. Slurry and conformance tests with various screen types and a range of sand facies, along with various proppant sizes and types, concluded that inclusion of proppant drastically reduced pressure buildup across the screens as well as the mass of sand particles produced through the screens. The Baker Oil Tools



EXCLUDER2000™ screens like those used in the Stybarrow wells have compiled an outstanding performance record in the world's most extreme conditions.

gravel-pack design also contained contingencies specific to this design in case of poor installation outcomes. Another success factor in the project was continuity of key Baker Hughes personnel and essential equipment from concept through execution.

Near-Record Australian Production Rates

Gravel-pack efficiency factors between 108% and 118% were achieved despite several unforeseen geological and technical challenges. All four Stybarrow production wells achieved maximum sand-free rates per FPSO design capacity. Maximum production rates from all four wells have exceeded 80,000 BOPD, with one well producing at near-record Australian rates of 32,000 BOPD seven months after first oil.

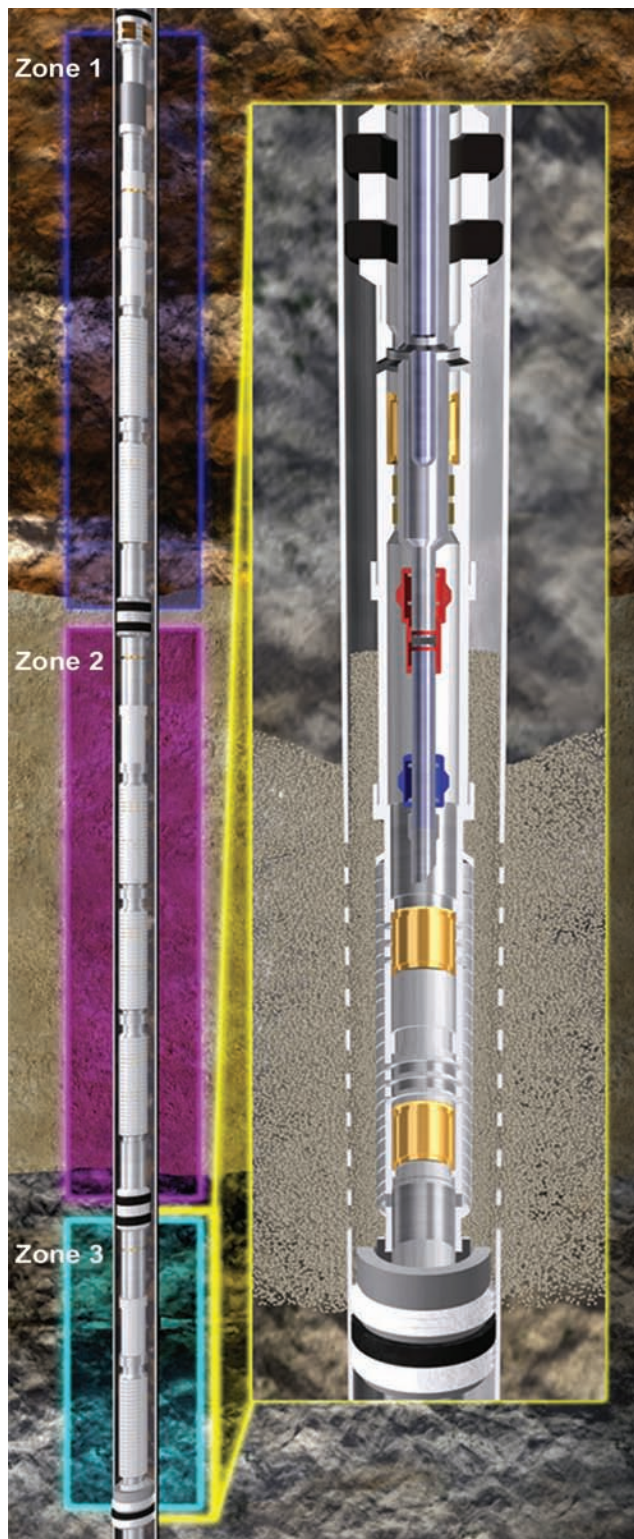


Fig. 1—The system combines several traditional tools into one that enables multizone completions in a single trip. From the top, the yellow components are the frac sleeve and sleeves for valves that isolate the production interval and allow selective production. The blue tool opens the sleeves. The red tool closes the sleeves and establishes circulating or squeeze position.

to six zones per well. Several shallow-water implementations have been previously described (Walker and Daulton, 2007; Delattre et al., 2008; Walker et al., 2008).

More recently, the system has been installed in three deepwater wells, allowing two operators to improve economics vs. conventional multitrip completion technology.

The first two deepwater wells were completed in August and September 2008 offshore India in 2,300 ft of water. Both wells are nearly vertical completions to 7,085 ft, with five clearly identified sands requiring separate, optimized frac packs.

For the first well, a total of 170,600 lbm of 16/20 mesh lightweight ceramic gravel was pumped in borate-crosslinked fluid through a 9⁵/₈-in. completion system. For the second well, a total of 262,700 lbm of the lightweight ceramic gravel was pumped.

The five-zone deepwater systems were estimated to have saved the operator 4 days of rig time on one job and 7 on the other, amounting to approximately USD 6 million in savings.

The third deepwater well was completed in the Gulf of Mexico's Mississippi Canyon area, in 2,400 ft of water. The deviated (55°) well was 13,400 ft deep, with two distinct sands to be frac-packed separately. During the stimulation operation, a total of 75,000 lbm of 30/50 mesh ceramic proppant was pumped in borate-crosslinked fluid through a 9⁵/₈-in. system.

According to the operator, the two-zone completion with frac packs took only 7 hours longer than a prior one-zone completion in the same area. On the basis of the water and well depths, the operator estimated that the single-trip multizone completion saved 3 days' rig time.

Ongoing Technology Development

Development efforts to improve the utility and versatility of the completion tool, especially for deepwater applications, are ongoing. Plans include achieving 12,500 to 15,000 psi downhole-tool ratings; increasing tool lengths to improve function at extreme depths; and increasing endurance for high-volume, high-rate applications of high-strength bauxite proppant for future development programs in Miocene and Lower Tertiary environments.

References

- Turner, D., Franklin, B., Walker, D., and Turick, D. 2007. Single- and Multi-Zone Sand Control Completions in Deep Water—The Approach and Advantages Offered. Paper 989 presented at the 7th International Petroleum Conference (Petrotech 2007), New Delhi, India, 15–19 January.
- Delattre, E., Sofyan, M., Suryadana, S., and Banman, M. 2008. Single-Trip Multi-Zone Gravel Packing—Case Study at Handil, Bekapai, and Sisi-Nubi Fields. Paper IPTC 12388 presented at the International Petroleum Technology Conference, Kuala Lumpur, 3–5 December.
- Walker, D. and Daulton, D. 2007. Complete Many Zones in One Trip. *E&P* **80** (11): 85–87.
- Walker, D., Delattre, E., Landry, J., Hansen, C., and Li, C. 2008. Implementing a New Single-Trip Multi-Zone Frac-Pack System With Integral Zone Isolation and Selective Production Capabilities. Paper IPTC 12711 presented at the International Petroleum Technology Conference, Kuala Lumpur, 3–5 December.

JPT

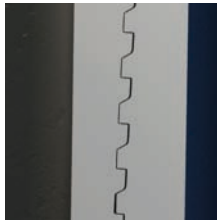
Blue™ Series

Key Features and Benefits

- Designed for high performance and versatility
- ISO 13679 CAL IV tested, and field proven
- Optimized geometry for trouble free installation

Dry Dopeless® option

- Improved operational performance through less pipe handling and makeup stability
- Avoids well contamination improving productivity
- Enhances environmental protection allowing zero discharge operations



Robust thread and deeper stabbing avoid cross-threading and installation problems



Toroidal seal makes sealability stable under any load case



Performance. Under Pressure.

Our Blue™ Series connections incorporate the most advanced premium connection technology available. Designed for the most complex and environmentally sensitive wells and for testing under ISO 13679 CAL IV, they are establishing new performance standards in HP/HT drilling operations all around the world. Including coupled and integral configurations plus our Dopeless® option, Blue™ Series connections reduce drilling risk by providing performance you can rely on when you most need it.

Tubular technologies. Innovative services.