PS Selecting Optimum Completion Designs in Deepwater Multilayered Tight Sand Applications*

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Abstract

Deepwater development in tight sands brings unique set of challenges. Tight sands are generally multilayered with gross pay thickness over 200 ft. Low permeability reservoirs require hydraulic fracture stimulation to improve production from tight formations and sand control completion to avoid formation sand fines production. The challenging deep targets are pushing the current capabilities of many technologies in both drilling and completion applications.

Multistage hydraulic fracturing technology commonly used in unconventional shale plays has recently started to be implemented in conventional low-permeability reservoirs to enhance hydrocarbon productivity.

This paper presents a completion selection workflow for deepwater tight sand application. The proposed workflow process includes fracture modeling, wellbore design including tubing stress and movement analysis for fracturing treatments and production systems analysis to estimate the initial production rates and flowing bottomhole pressure for sand-free production.

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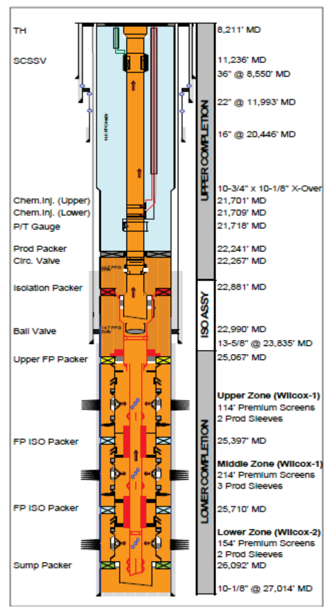
Objectives

- Completion selection and well performance analysis to design a new completion system for production enhancement in deepwater tight sand formations
- Design and selection of the lower completion system focused on multi-stage fracturing and potential sand control options, and their impact on production
- Study the completion systems to estimate and predict the initial production rates: Multi-Zone Single-Trip (MZST) completion, Large Bore Multi-Zone (LBMZ) completion system and Ball-Activated Fracturing Completion System (BAFCS)
- Develop a high-level workflow for completion design and selection, fracture modeling to generate 3D fracture geometry and fracturing pressures, wellbore design including tubing stress and movement analysis for fracturing treatments and production systems analysis to generate vertical lift performance/inflow performance relationships (VLP/IPR), and to estimate the initial production rates and flowing bottomhole pressure for sand-free production

Existing Common Applications in Deepwater Tight Sands

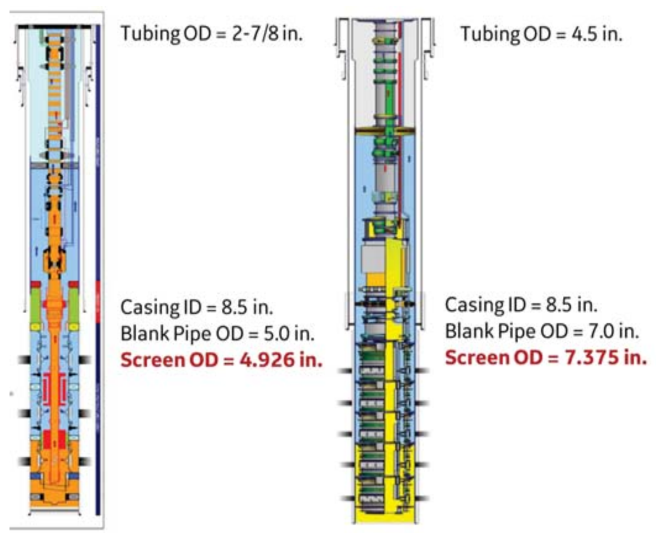
Multi-Zone Single Trip Completion in GOM:

- Water depth = 8200 – 8900 ft
- Reservoir depth = 25,600 ft
- Reservoir pressure = > 19,000 psi
- Reservoir Temperature = 256 °F
- Number of completed zone = 8
- Thickness of sand layer = 1200 ft
- Total proppant volume = 510,000 lbs. for 3 zones

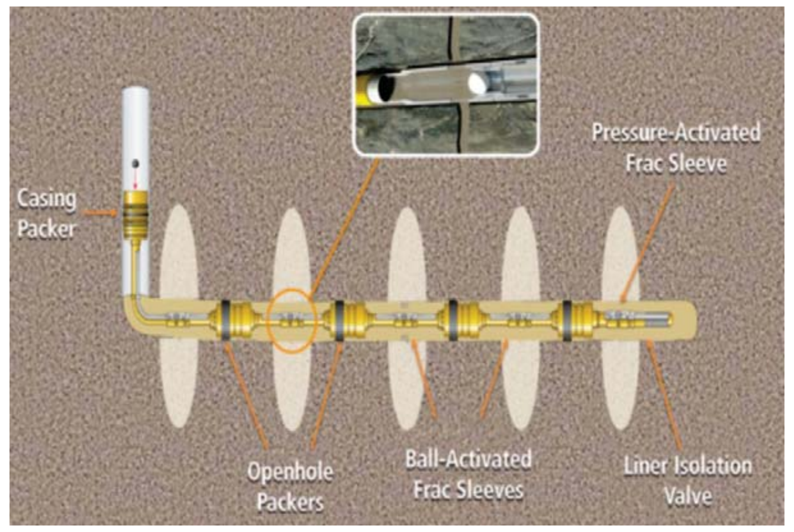


Multi-Zone Single Trip (MZST) Completion vs. Large-Bore Multi-Zone (LB-MZST) Completion Systems

- Main difference is sizes of screens used in the system to prevent sand production and the area between screen and the production casing.
- LB-MZST completion enables the use of large internal multi-zone work strings and reduce friction loss at high fracture treatments rates.
- With LB-MZST completion, fracture geometries can be improved (such as increasing fracture conductivity, placement of fracture across the perforations in cased hole completions) and higher production rates can be obtained over MZST completion.



Multi-Stage Fracturing System (Ball-Activated Fracturing Completion System)



Benefits:

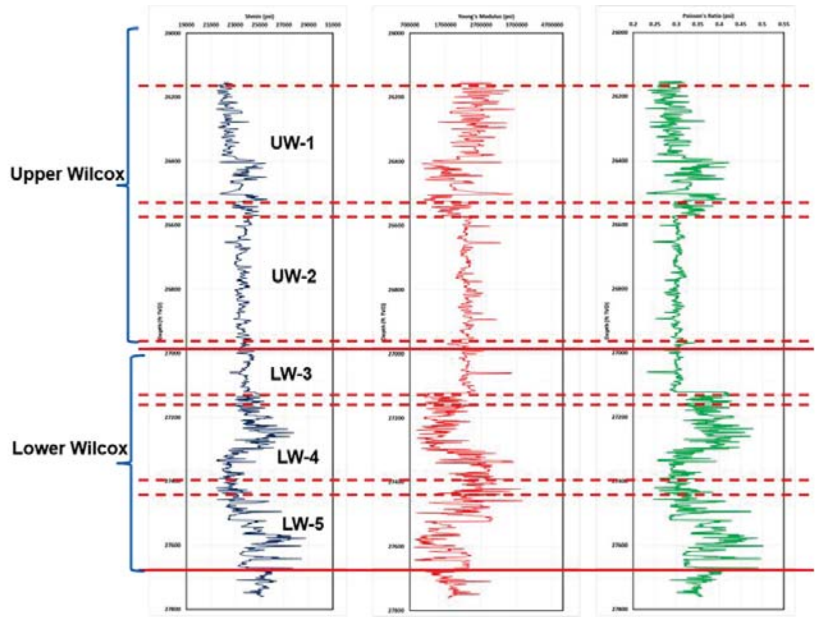
- Increased number of stages with only one trip into the well
- Reduced time to complete each treatment interval
- Reduced downtime between treatment interval
- Stage placement designed for each individual fracture, rather than a large treatment interval
- Optimized stimulation fluid system, pressure and rate for every fracture
- Optimized proppant type and concentration delivery to every fracture
- Reduced near-wellbore (NWB) tortuosity attributed to larger erosion area from ball-activated fracturing system
- Reduced HHP necessary for the treatment (only one fracture is being treated at a time)

Completion Selection Workflow in Deepwater Tight Sand Reservoirs

- Development of rock mechanical properties – Geomechanical modeling using available logs
- Optimization of stage spacing based on completion type
  - Stages and Perforation interval placement using sand body distribution in target layers and based on stress profiles)
- Optimized Fracture Modeling and Design
  - Fracture geometry (frac half-length, height, width, conductivity)
  - Proppant types, quantities and distribution
  - Fluid types, volume
  - Pumping treatment schedule
- Production rate prediction for each completion type
  - Well modeling using reservoir fluid and rock properties, and fracture geometry parameters
- Completion selection and recommendation

Fracture Modeling – Rock Mechanical Properties

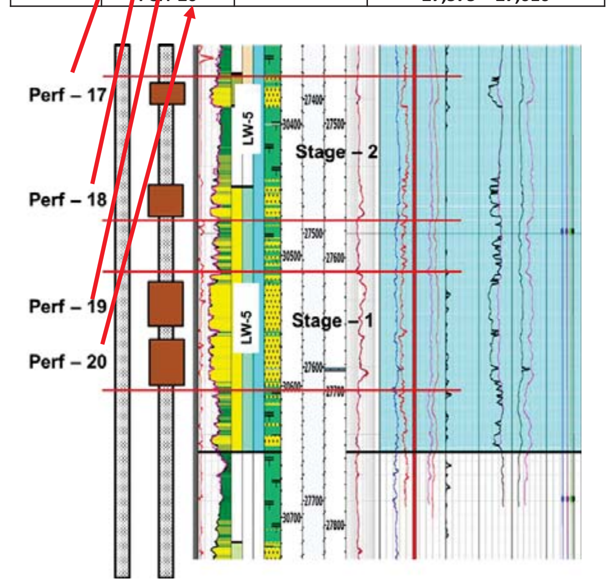
- Develop rock mechanical properties (minimum horizontal stress, Young's Modulus, Poisson's Ratio)
- Use rock mechanical properties in 3-D hydraulic fracture simulator to predict the fracture growth and fracture dimensions which are affecting performance of the well



Stage Spacing – MZST and LB-MZST Completion Systems

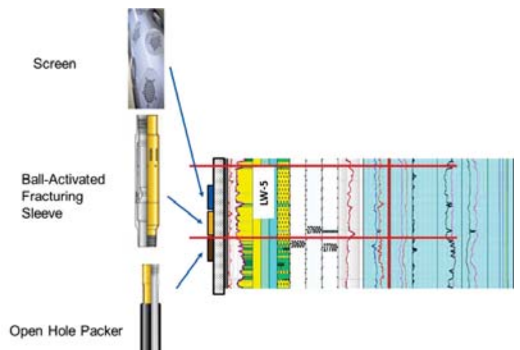
- Selected 8 individual stages and 20 perforation intervals for MZST and LB-MZST completion systems for fracture modeling in order to increase the productivity

Stages	Perforations	Number of Perforations	Perforation Intervals (ft. MD)
8	Perf-1 Perf-2	2	26,170 – 26,195 26,215 – 26,275
7	Perf-3 Perf-4 Perf-5	3	26,325 – 26,370 26,390 – 26,420 26,430 – 26,500
6	Perf-6 Perf-7 Perf-8 Perf-9	4	26,615 – 26,645 26,655 – 26,675 26,695 – 26,740 26,745 – 26,865
5	Perf-10 Perf-11 Perf-12	3	26,970 – 26,990 26,995 – 27,100 27,105 – 27,125
4	Perf-13 Perf-14	2	27,155 – 27,190 27,195 – 27,255
3	Perf-15 Perf-16	2	27,265 – 27,305 27,310 – 27,330
2	Perf-17 Perf-18	2	27,390 – 27,405 27,470 – 27,490
1	Perf-19 Perf-20	2	27,540 – 27,570 27,575 – 27,610

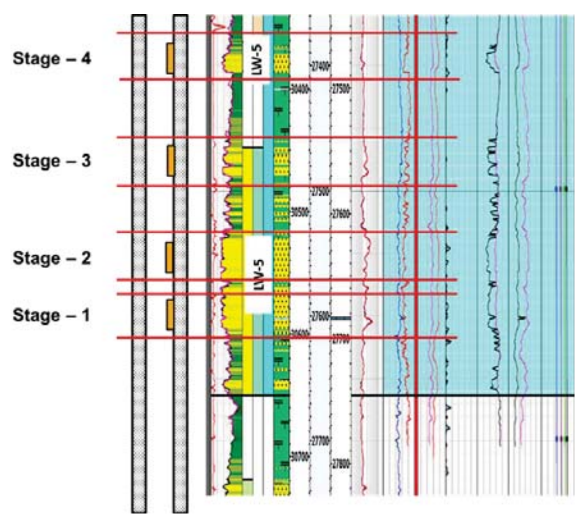


Multi-Stage Fracturing System Design – Stage Spacing

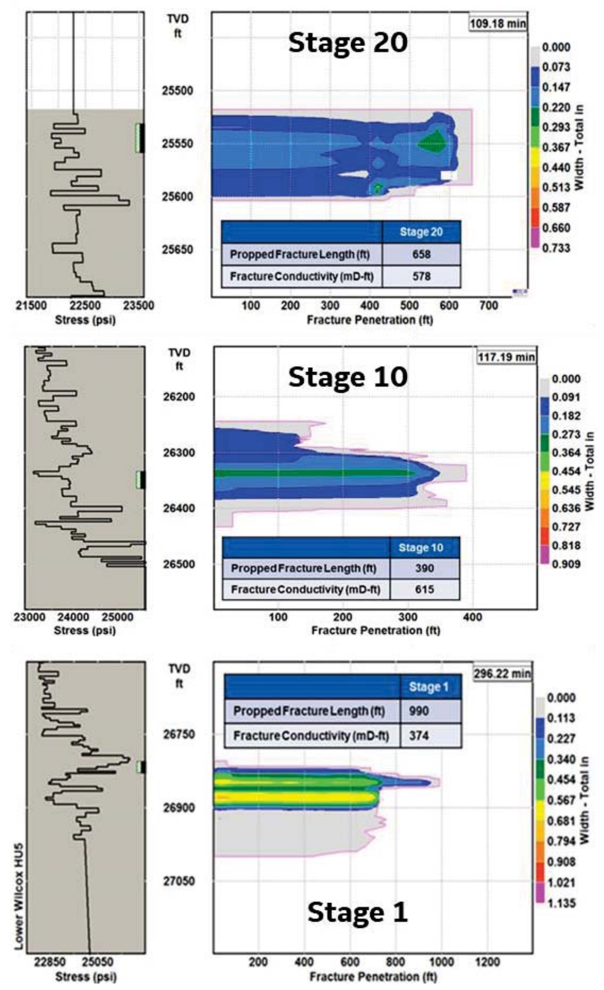
- Identify the fracture initiation points
- Locate fracturing sleeves to accommodate geological complexities by considering sand bodies)
- Provide fracture propagations in sand layers which is essential for long term productivity



Ball-Activated Fracturing Completion System (BAFCS)



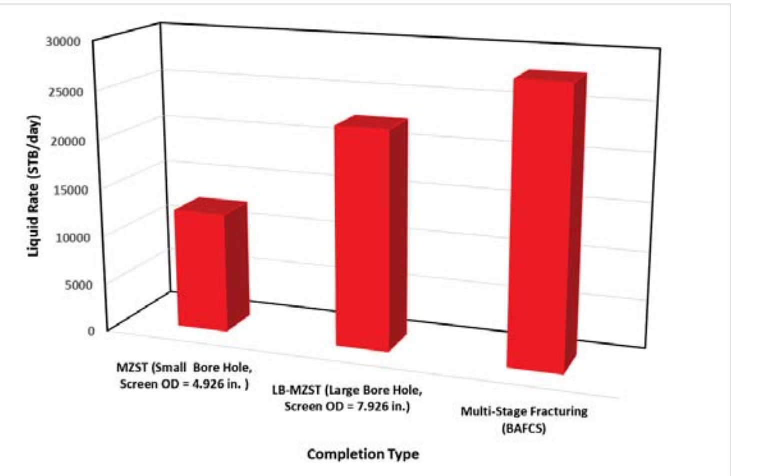
Fracture Geometries (Multi-Stage Fracturing Completion System)



Effect of Completion Options on Operating Conditions

	MZST (small bore hole)	MZST (large bore hole)	BAFCS
# of stages	8	8	20
Proppant Mass (lbs/stage)	380,000	380,000	170,000
Total Proppant (lbs)	3,040,000	3,040,000	3,400,000
Liquid Volume (gal/stage)	127,500	127,500	98,700
Total Liquid Volume (gal)	1,020,000	1,020,000	1,974,000
Pump Rate (BPM)	35	35	25
Pump Time (min/stage)	135	160	106
Surface Treating Pressure (psi)	14850	14285	13890
Frac Pressure (psi)	25750	25250	24750

- Multi-Stage Fracturing System (BAFCS) enabled lower frac rates, lower surface treating pressure and frac pressure as well as shorter pumping times thus speeding the completion process.
- Multi-Stage Fracturing System (BAFCS) can be the key to increase the well productivity and improve the economics of these cost-intensive completion projects in deepwater formations.



- Multi-Stage fracturing completion system brings a production uplift in comparison to MZST and LB-MZST completion systems
- Specifically, by using BAFCS production has increased by 25% over LB-MZST and 125% over MZST completion system