Abstract

The FracRight DHP Liner Hanger has been specifically designed for use with open-hole multi-zone completions focusing on the leading edge operations in the Bakken. This paper describes the design and qualification process through the three core functionalities: DEPLOY – HANG – PACK.

Introduction

It is the combination of hydraulic fracturing and horizontal drilling techniques that has made the Bakken one of the most important sources of new oil production in the U.S. With an estimated 400 billion barrels in place the prize for increasing recovery is great and operators here have led the way: extending lateral lengths and increasing fracture stages. The combination of shale and dolomite in the Bakken and Three Forks formations, and the presence of vertical to sub-vertical natural fractures make open-hole multi-zone completions the most effective solution. An average well drilled in the Bakken today is 10,000ft long with over 60 frac stages delivering 3% - 6% recovery rates.

Reliable performance of the completion is a prerequisite for economic operations and while most frac sleeves do deliver, the liner hangers have not always met this requirement. Many hangers have been adapted from use in conventional cemented applications or were designed with shorter, lighter open-hole systems. Combining local experience with our innovative completion design capability Tendeka has developed a robust and reliable liner hanger system that is effective and economical in these unconventional plays.

DHP Liner Hanger Design

The FracRight DHP liner hanger has simple functionality combined with fail-safe features to make it a reliable deployment system for multi-stage frac completions. The key functionalities are defined by the three main areas of operation:

Deploy:
- 200,000lbs tensile and compressive load capability for deployment of up to 100 sleeves in a 10,000ft lateral
- Rotational lock to allow for high torque to be applied in tight wellbores
- Built in anti-preset feature combining pressure activated shear pins and dogs eliminates the risk of premature setting or release from the hanger

Hang:
- Hydraulic setting mechanism with double grip slips to safeguard hanging system against potential overload
- Efficient hydraulic release features initiated during the setting procedure allows the setting tool to be released by straight pull
- Secondary mechanical rotational release to ensure successful operation

Pack:
- Utilizes hydraulic and compression forces to create an effective 10,000psi seal
- Anti-Extrusion back-up rings on element the DHP meets the standards of ISO 14310 V3
Design Qualification

Tendeka’s New Product Development (NPD) process establishes internal controls for the rigorous qualification of any new equipment prior to field deployment. For the FracRight DHP packer the designed qualification program simulated the deployment and setting of the hanger in field conditions and established its performance to a standard exceeding ISO 14310 V3.

The testing program was performed using a temperature controlled chamber with annulus and tubing pressure regulation. A load compensator was used to simulate tubing loads. Testing was 3rd party witnessed for both minimum and maximum casing ID ranges for 7” 23 – 32 lb/ft

Liner Hanger Setting

<table>
<thead>
<tr>
<th>Test Objectives</th>
<th>To qualify the DHP hanger setting mechanism at simulated field conditions</th>
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</thead>
</table>
| Outline Procedure | 1. Deploy running tool and hanger into test casing  
2. Heat chamber to 275°F and apply 1,000psi system pressure  
3. Increase tubing pressure in 500psi increments to 4500psi differential pressure to set hanger  
4. Hold pressure and apply a compressive load of 35,000lbs. to simulate hanging weight of string  
5. Hold load and bleed off tubing pressure to system pressure  
6. Increase tubing pressure to 5,500psi to release the torque lock  
7. Bleed off pressure and pull the running tool clear of the hanger |

Outcome

Successfully passed with all tool operations occurring at the designed conditions
Hanging Capacity

Test Objectives

<table>
<thead>
<tr>
<th>Outcome</th>
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<tbody>
<tr>
<td>1. Stab test locator seal assembly into hanger PBR and apply 35,000 lbs. compression</td>
</tr>
<tr>
<td>2. Heat system to 275degF with 1,000 psi system pressure.</td>
</tr>
<tr>
<td>3. Apply 200,000 lbs. simulated tensile load to the hanger and return to neutral load conditions</td>
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</tbody>
</table>

Pressure and Load Conditions

Test Objectives

- To qualify the DHP hanger for pressures and loads encountered during fracturing operations
- To meet the requirement of ISO 14310 V3

Outline Procedure

1. With 35,000 lbs. compression on hanger and 1,000psi system pressure, test upper annulus to 2000psi/ 5,000psi/ 10,000psi differential pressure at 275°F
2. Repeat pressure test from lower annulus and tubing
3. Repeat steps 1. and 2. twice for a total of three pressure cycles at 275°F
4. Reduce temperature to 175°F and repeat three pressure cycles at 2000psi/ 5,000psi/ 10,000psi maximum differential pressure
5. Increase temperature to 275°F and repeat three pressure cycles at 2000psi/ 5,000psi/ 10,000psi maximum differential pressure
6. Return fixture to ambient temperature, bleed off pressure and remove hanger from casing for inspection
Pressure and Load Conditions continued

Outcome

Successfully passed with full load held and no hanger slippage

Conclusion

The FracRight DHP has been purpose built and tested for application in unconventional plays and open-hole completions. It combines functionality and simplicity to deliver a reliable and economic liner hanger for horizontal multi-zone completions.