Case Study

15-Stage, 75 i-Frac Sleeve Completion; North Sea First for UK

Textbook opening of every sleeve helped operator perform extremely efficient stimulation resulting in higher than expected production rates.

Background

Chrysaor's primary completion design was to stimulate their chalk formation with acid via a limited entry multistage frac (MSF) design in an 8.5-in. open hole. Due to a challenging well trajectory and reservoir characteristics, several contingencies needed to be accommodated for. Any solution needed to be flexible enough to accommodate different acid treatments and capable of being cemented in place for contingency isolation.

Solution

Our Norwegian-based Completion Tools team was instrumental in designing a sleeve that exceeded Chrysaor's requirements. Our extensive experience in cemented limited-entry completions and deep understanding of North Sea challenges were critical in the product development process.

We designed a 4.5-in. 15-stage i-Frac™ CEM system. Each stage contained five sleeves per stage with specialized injection nozzles that allowed the stimulation to divert throughout each treatment properly. The i-Frac CEM was selected because of its cement-compatible design, featuring specialized coatings and design features to prevent cementing issues. The injection nozzles can be replaced to accommodate changes in the number of sleeves per stage, fluid type, and treatment schedules.

Case study facts

Location: North Sea, UK

Customer: Chrysaor

Products

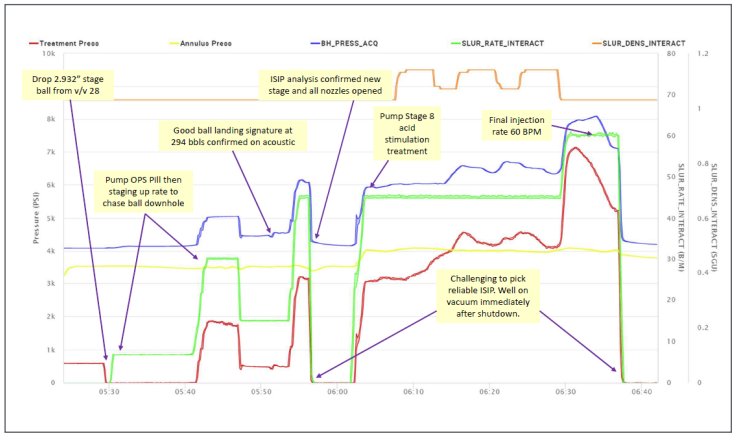
- i-Frac CEM 450 SS sleeves
- i-Seat 450 ball seats
- d-Solve 706 balls
- Flow Lock Sub
- BPS
- Reamer shoe and floats

General well information

- Liner size/weight/grade: 4.5 in. 15.1 ppf L-80 13Cr
- Open hole size: 8.5 in.
- Well TD: 23,522 ft (7,170 m)
- Open hole length: 5,506 ft (1,678 m)
- Temperature: 284°F (140°C)
- Deviation: 90°
- Max. surface treating pressure: 8,500 psi

To fully design this project, Chrysaor requested a test to confirm our in-house pressure drop calculations. We performed a full test using three different seat sizes, and a variety of rates and pressure drops were measured. The testing was then compared to our proprietary calculators and confirmed the accuracy of our estimates. Chrysaor accepted that our calculations should be used for stimulation calculations moving forward.

We performed an additional test to confirm that the proposed composite setting ball was fit-for-purpose on this installation. The composite setting ball is used to close the Flow Lock Sub at the toe of the well and must be circulated even in wells with uphill trajectories. A simulated 95° uphill scenario was set up, and the ball successfully passed the test at just one bpm.



Ball displacement, sleeve opening, and acid stimulation plot

The success of any ball drop activates system relies heavily on the selection of the balls. Chrysaor required a high strength ball that was resistant to acid and dissolved quickly and consistently after the stimulation treatment was completed. Our d-Solve™ 706 high-strength dissolvable balls with special acid inhibitive coating fit all these requirements.

Results

The well was drilled to TD successfully, and the primary completion design was then run to bottom without incident. After running the upper completion, a stimulation vessel then arrived on location to pump the treatments. The BPS™ toe initiation sub was opened as planned, and the well went on partial vacuum, meaning that the fluid level dropped between stimulations and the d-Solve balls had to free fall on average 1,130 ft and up to a maximum of 2,909 ft before a soft landing on fluid.

The operation required the coordination between Chrysaor, each service company, and the various consultants on the rig and stimulation vessel. A streamlined path was agreed upon and set in motion prior to beginning stimulation to ensure each party could contribute effectively to the stimulation treatment. Throughout the stimulation, familiarity with the signatures and the excellent communication led to fast stimulation stages and improvements in overall efficiency.

Each stage was treated at up to 60 bpm, with the d-Solve balls landing at a rate of 15 bpm. The i-Frac sleeves confirmed activation through a pressure signature at surface, which was backed up by specialized acoustic monitoring. The initial shut-in pressures and step rate analysis were also used to verify all sleeves had been successfully opened and were stimulating each stage as designed.

Initial well testing showed a gas and oil production rate that far exceeded the predicted values, and Chrysaor was very pleased with the system's performance.