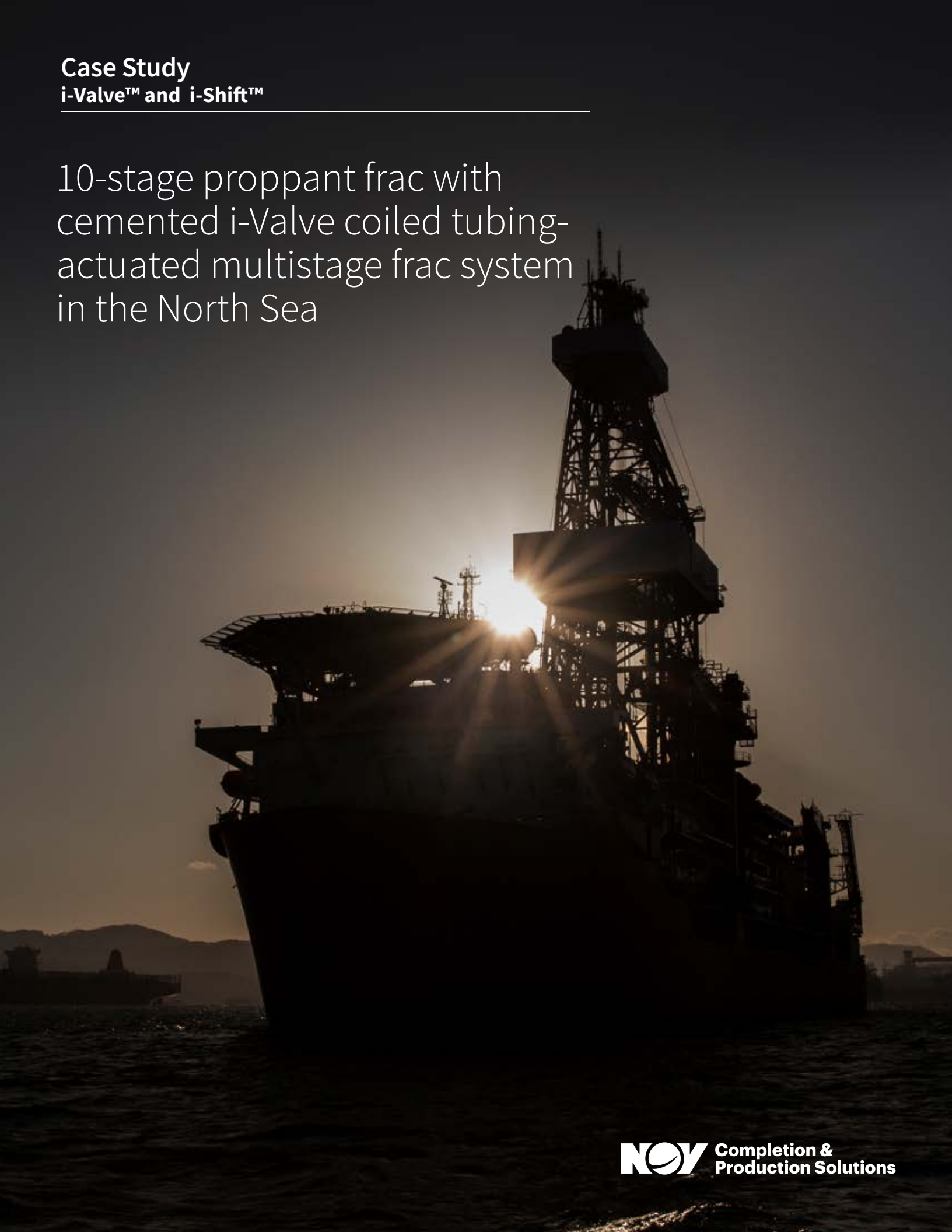
Case Study
i-Valve™ and i-Shift™

10-stage proppant frac with cemented i-Valve coiled tubing-actuated multistage frac system in the North Sea

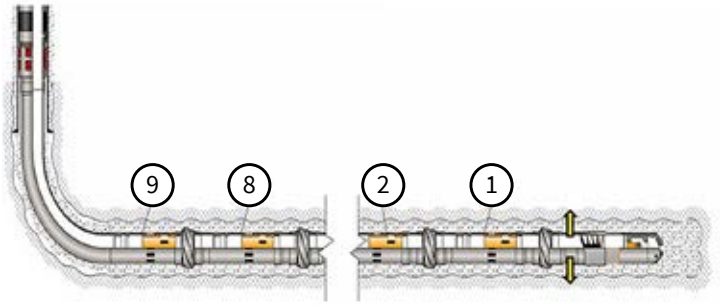


NOV Completion & Production Solutions

i-Valve and i-Shift

Background

A North Sea operator required a multistage frac completion system that allowed multiple high-concentration (16 ppa), resin-coated proppant fracs with planned tip screenouts to be placed along the horizontal cemented reservoir liner. To ensure good near-wellbore conductivity, all fracs were under-displaced during the stimulation phase, preventing any pumpdown system from being used. Due to high spread rates (offshore rig and stimulation vessel), a system that minimized the required number of coiled tubing trips in the well had to be developed.



First proppant frac with cementable sleeves in liner in the North Sea.

Solution

Working together with the client, our team proposed a completion and stimulation methodology based around the i-Valve CEM frac sleeve technology and a tailored coiled tubing intervention tool package that would minimize the time required to stimulate the well. The i-Valve CEM sleeve is a robust full bore, coiled tubing-activated frac sleeve that can be opened and closed multiple times during the life of the well. During stimulation, a single coiled tubing run with a high-flow shifting tool would be required to clean out a possible screenout from the previous stage, pressure test the proppant plug, and open the i-Valve CEM sleeve in the next stage. Additional benefits of the cemented i-Valve solution included the ability to add additional stages between sleeves by running TCP, or opening and closing sleeves in the future for production management or re-stimulation of individual zones.

The 1600-m (5,249-ft) long reservoir liner consisted of nine i-Valve CEM sleeves for stimulation and production. The i-Valve nozzle number and sizing was designed in order to minimize friction losses during stimulation and production. An additional stage in the toe of the well was added using TCP perforating. Installation of the reservoir liner went according to schedule with the liner being run through a dogleg of 10 degrees. The i-Valve CEM design incorporates special cement-protection features to allow regular cement to be pumped through the sleeve without compromising sleeve functionality during manipulation after the cement job. At depth, liner rotation was established and cement pumped. The cement dart bumped according to calculated volume.

After stimulating the first stage and screening out to surface, the high-flow i-Shift tool was run in hole (RIH) on coiled tubing. The high-flow i-Shift tool BHA enabled circulating at rates up to 5 bpm through the BHA without activating the shifting keys. This allowed proppant cleanout at RIH speeds up to 8 m/minute (26 ft/min). When the well had been cleaned to 10 m (33 ft) below the sleeve in the next stage to be stimulated, the remaining proppant plug was pressure tested to confirm isolation from the previous stage. The i-Shift tool was activated for operation of sleeves, and the i-Valve in the next stage was opened. Coiled tubing was retrieved from the well, and the stage was fracked. The process was repeated for all stages that were stimulated. Nine out of 10 zones were stimulated with the planned treatment pumped successfully. Stage 8 was not stimulated due to the proximity of water. Finally, a cleanup run to total depth was done to remove the proppant plugs between stages to prepare the well for production.

During the job a total of approximately 236 000 kg (520,000 lb) of proppant was removed from the wellbore using the high-flow i-Shift BHA, with accumulated RIH length of the BHA being approximately 100 000 m (328,000 ft). Approximately 1.4 million kg (3.1 million lb) of proppant was pumped in the well. However, the robust i-Valve CEM functioned as designed with no shifting issues experienced during operation of the sleeve.

Solution summary

- i-Valve CEM system with high torque and pressure capabilities and cement protection features
- Robust high-flow i-Shift BHA allowed cleanout of significant proppant volumes
- Proppant plugs between stages

Results

- Liner run and cemented successfully in place
- All stages fracked according to planned stimulation design
- No issues with i-Valve CEM or high-flow i-Shift BHA experienced during stimulation