Multistage Perforation Enables 300% Production Increase in an Ultradeep HPHT Gas Well

PetroChina uses through-tubing perforating technique verified with laboratory testing to effectively stimulate an onshore gas well in China

Multiple factors impede effective production
An HPHT gas field in the northern portion of China’s onshore Tarim basin lies in a tight sand reservoir at a depth of 6,000–7,500 m [19,685–24,606 ft] with pressures from 15,229 to 20,305 psi and temperatures up to 170 degC. With high compressive strength (17,405 psi), low porosity (5%–8%), and low permeability (<10 mD), most wells in the reservoir require stimulation to improve productivity.

Stimulation concept verified by laboratory modeling
To overcome challenging reservoir conditions PetroChina and Schlumberger used the SRV concept. In this new method multiple short clusters are perforated throughout the entire reservoir section and large volumes of slickwater (low-proppant concentrations) are pumped at a high rate with fibers for diversion. A wireline-conveyed 2.25-in perforator using 15,000-psi pressure control equipment was selected to accommodate a 68-mm [2.68-in] restriction in the downhole safety valve and operate in the completion of 4½-in tubing and a packer set above the pay zone, which is lined with 5½-in high-strength TP140V casing (12.09-mm [0.48-in] wall thickness).

Because perforation entrance hole size and penetration depth are critical, particularly with the relatively small perforating gun for the casing size, a two-step laboratory program was designed and executed. First, screening tests assessed perforation hole diameter in the casing at ambient surface conditions. Then, two laboratory tests were conducted at downhole pressure and temperature to confirm perforation casing hole diameter and penetration depth into a stressed sandstone core. The results indicated that perforation performance at downhole conditions would enable successful stimulation operations and confirmed predictions made with SPAN Rock analysis.

Production increased threefold following perforation
The perforation operation was conducted successfully in a total of three runs made using an addressable-switch firing system with 12 guns (six stages total). The multistage stimulation was then executed and resulted in a 300% production rate increase for the well compared with PetroChina’s nearby wells.
CASE STUDY: PetroChina uses laboratory-verified perforating technique to increase gas production, China

Test 1 (0° phased) split core and casing assembly.

Test 2 (180° phased) split core and casing assembly.