

Permanent Monitoring System Reveals Dominance of Lower-Zone Fractures Even Before Start of Production

WellWatcher Flux multizonal reservoir monitoring system provides alternative to mandatory production logging in well with high H₂S levels, Caspian Sea

CHALLENGE

Eliminate the need for periodic production logging in a deep, high-pressure, sour well with a three-stage completion and challenging S-shaped trajectory, without impeding flow.

SOLUTION

Deploy the WellWatcher Flux* multizonal reservoir monitoring system—which includes PT gauges and digital temperature arrays—across the sandface.

RESULTS

- Successfully installed the system using standard drilling and completion processes.
- Transmitted real-time stimulation data, providing zonal-specific flow projections even before production started.
- Enabled operator to update and optimize reservoir management plans with new information about relative zonal permeabilities.
- Provided an alternative to the high-risk mandatory production logging and the consequent deferred production.



Periodic production logging presented multiple challenges

Regulatory requirements in the Caspian Sea mandate production logging at least once per year per well. High pressure and H₂S levels up to 15% in an operator's wells pose significant HSE risk, necessitating use of specialized equipment during logging and increasing operating time. Moreover, production must be suspended on all adjacent wells on the platform each time a well is logged, resulting in deferred production and the inherent risk of shutting in a well.

An alternative monitoring system with the following characteristics was required:

- deployment compatible with the planned three-trip completion
- distribution along multiple zones (up to five) without impeding flow
- robust construction to withstand deployment on the outside of a liner in an S-shaped wellbore and subsequent cementing and perforation of the liner
- real-time communication of zonal data from the lower to the upper completion
- data interpretation capability to maximize the value of the sensors.

“This program, involving many disciplines, was delivered by a Schlumberger team with phenomenal commitment, tenacity, integration, and professionalism. It was just another demonstration of why we come back again and again to Schlumberger when we need a technologically complex or novel solution.”

Caspian Subsurface Lead

WellWatcher Flux system provided permanent monitoring across sandface

WellWatcher Flux multizonal reservoir monitoring system addresses the challenge of acquiring reservoir data in real time across the sandface of wells with multistage completions. Large-bore inductive couplers provide wireless power and data transmission between upper, intermediate, and lower completions. The system requires no modification to the rest of the completion architecture.

This first installation in a three-stage completion was carefully planned. A significant amount of engineering effort contributed to the development of new coupler sizes, higher shock ratings for the sensors with added fault-tolerant wiring configuration, new packer sizes with very aggressive work envelopes, ancillary components, and data transmission hardware and software. A new visualization and analysis software package was also developed. Close cooperation between the operator and Schlumberger led to innovative solutions and timely execution of the project.



The WellWatcher Flux system includes arrays of miniaturized, hermetically sealed digital temperature sensors connected to a single electric cable.

CASE STUDY: Real-time multizonal monitoring helps operator enhance reservoir management, Caspian Sea

Arrays of miniaturized digital temperature sensors were installed on the exterior of the lower completion liner and cemented in place. With a resolution of 0.003 degC at a 1-min sample rate, these sensors can detect extremely small changes in temperature, which are interpreted using thermal modeling and analysis software.

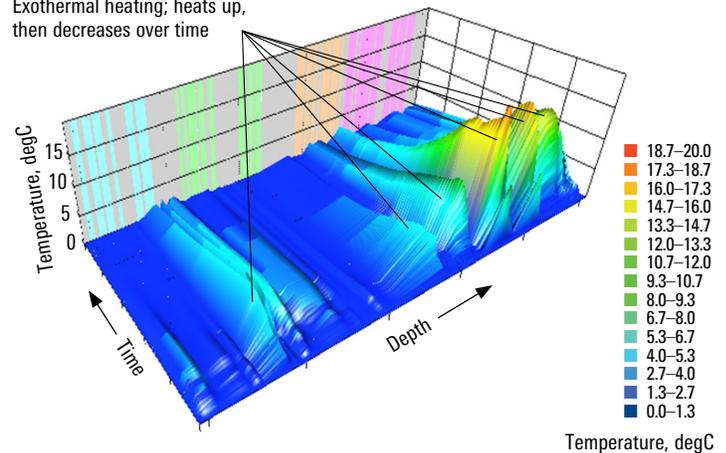
To minimize the likelihood of damage to the temperature sensor arrays during perforation, index casing couplings (ICCs) were incorporated in the liner along the target zones. These couplings featured orientation grooves unique to each zone, which mated with matching key profiles on the perforating gun BHA, orienting the perforations away from the sensors and minimizing the risk to system integrity.

System proved its value even before production commenced

Although the goal was to replace production logging, the benefits of the new system became apparent even before the well was placed on production. The WellWatcher Flux system was powered and data were successfully transmitted to surface in real time during the injection test and subsequent acid stimulation via CT and bullheading. The robust inductive couplers performed effectively despite heavy solids settling and the stimulation pumping.

The high-resolution data enabled identification of the zones that were successfully stimulated. The acid produced an exothermic reaction with the formation. More acid could penetrate the higher-permeability zones for more effective stimulation, resulting in higher temperatures. The data revealed exactly which zones had the best permeability distribution. The operator was extremely pleased with the insights provided by the system and plans to review previously completed perforated and stimulated wells to determine if re-perforating or just target-specific restimulation is needed to optimize reservoir drainage.

Exothermal heating; heats up, then decreases over time



The exothermic reaction between the acid and formation caused a rise in temperature, which gradually decayed. The effect was more pronounced in the deeper intervals, indicating higher permeability and causing the operator to revise its completion plans.

Once data transmission to the operator's onshore office begins, the WellWatcher Flux system will be used for monitoring temperature to establish the flow allocation from each zone and determine reservoir depletion and connectivity with other wells. This will eliminate the need for production logs in this well while remaining compliant with government regulations.

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