

PetroChina Ensures Long-Term Well Integrity in Underground Gas Storage Wells

FlexSTONE cement technology and CemSTRESS software enable first underground storage facility in western China

CHALLENGE

Construct underground gas storage wells in a depleted reservoir and maintain well integrity in the face of dynamic downhole conditions.

SOLUTION

Apply FlexSTONE* advanced flexible cement technology and design cement properties using CemSTRESS* cement sheath stress analysis software.

RESULTS

Cemented wells with zero losses and excellent coupling between the cement and the formation, ensuring well integrity for decades and preventing costly remediation.

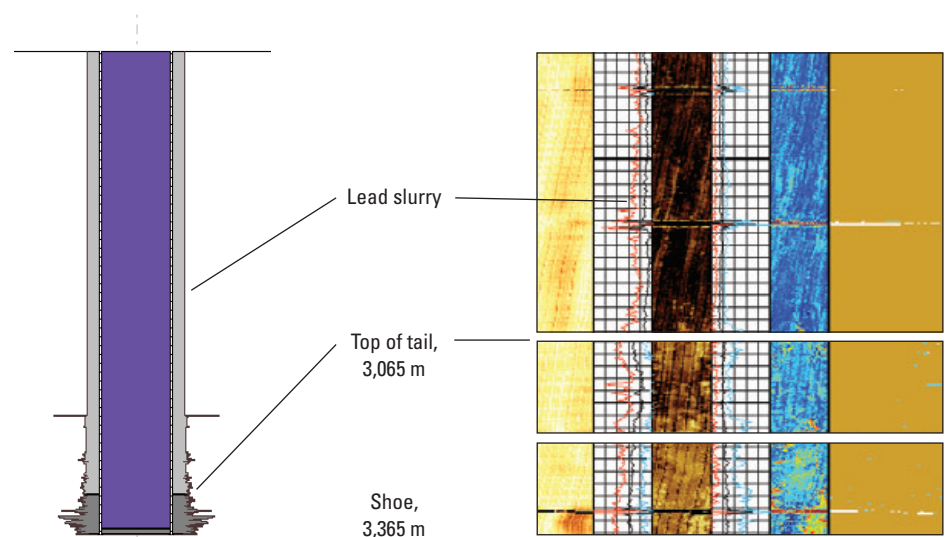


Storing natural gas for high demand

Supply and demand for natural gas in China is markedly imbalanced, making underground gas storage an important part of the country's economy. China's domestic natural gas production cannot match the sharply rising demand, so gas is made available only in peak winter months. Underground storage facilities serve a vital role, acting as a strategic reserve, helping counter demand fluctuations, optimizing gas-transport-pipeline capacity, and financially hedging changes in gas price.

PetroChina operations in Hutubi, Xinjiang, focus on underground gas storage wells within a depleted reservoir. The company invested more than USD 1.5 billion in the dry gas field and a storage capacity of $4.51 \times 10^9 \text{ m}^3$ in a total of 37 wells. PetroChina was concerned with well integrity and was unable to apply a conventional cement system because of tension failure. Fluctuations in pressure and temperature are caused by injecting and withdrawing natural gas over time, which induces different stresses on set cement in the annulus. Well integrity can be destroyed either by debonding or cracking.

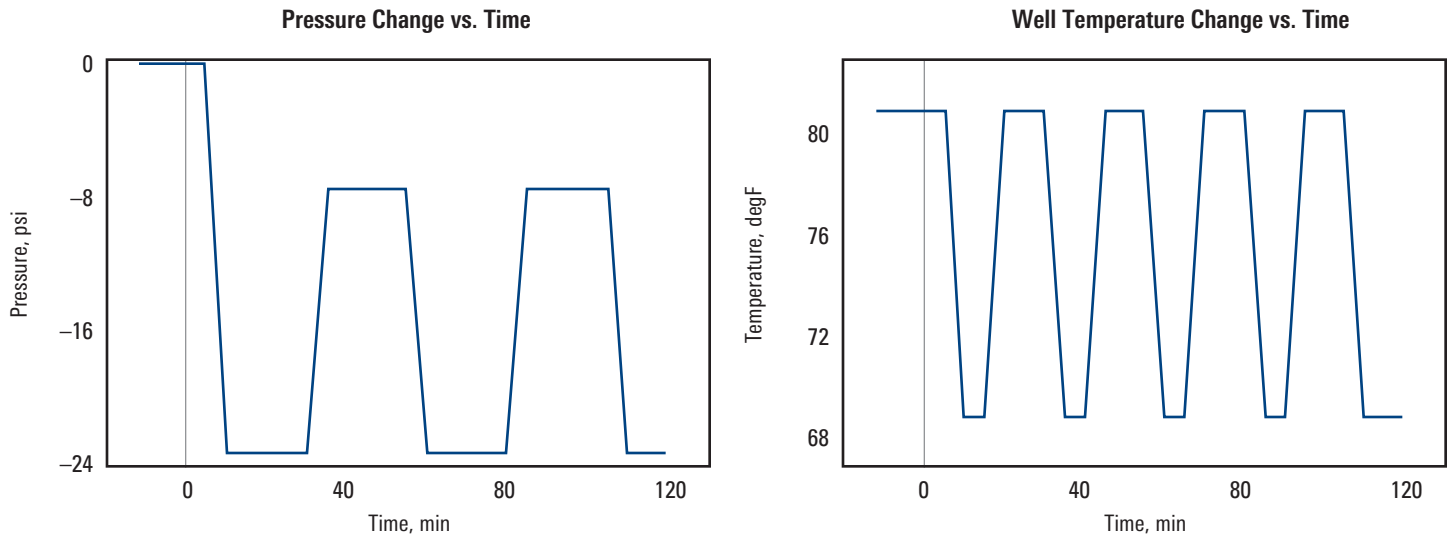
PetroChina needed a cement system that ensured long-term cement sheath integrity in the caprock and pay zone. And with the storage wells located within 15 km of Hutubi, operations needed to prioritize safety.



Cement evaluation showed excellent bonding and zero losses.

Cementing with custom design and flexible technology

PetroChina reached out to Schlumberger for this underground storage project (the first in western China) because of its reputation for leading technologies and superior service quality in the region. The team chose FlexSTONE advanced flexible cement technology for cementing the wells; the advanced flexible cement has mechanical properties matched to the downhole stress environment, enabling it to conform to changing conditions.



Hutubi wells faced dynamic downhole conditions.

Collaborating with PetroChina, Schlumberger designed the job using a specialized engineering workflow:

1. Collect formation and casing information (Young's modulus, Poisson's ratio, etc.).
2. Predict downhole temperature and pressure.
3. Simulate stress on the FlexSTONE cement technology using CemSTRESS software.
4. Identify a set of ideal cement properties for the project.
5. Design the FlexSTONE technology to target above the ideal properties.
6. Validate the slurry mix by measuring mechanical properties and adjusting to ensure long-term well integrity from the pumped FlexSTONE cement technology.

Once validated by simulation, the FlexSTONE flexible cement technology was pumped downhole, followed by formation integrity testing to evaluate the cement quality.

The UGS well is drilled in four stages, which include the surface casing, first intermediate casing, second intermediate casing, and production liner.

In the third stage, FlexSTONE technology is used as tail slurry in the second intermediate casing to cement and seal the caprock of the depleted reservoir and ensure a complete entrapment, while the normal slurry system is used as lead.

During the last stage, FlexSTONE technology is used in the production liner cementing. The liner is perforated and natural gas will be injected and withdrawn through the liner into the depleted gas reservoir.

Establishing long-term well integrity and preventing remedial jobs

A total of 32 wells were successfully drilled and cemented according to their individual stress requirements, giving PetroChina its first underground gas storage field in western China, which is capable of holding 4.51×10^9 m³. Formation integrity tests for the newly constructed wells showed no losses, excellent bonds, and good formation arrivals, proving the strong coupling between the cement and the formation.

The high quality and flexible nature of the FlexSTONE advanced cement technology gave wells integrity to last 30 years or more under high-intensity injection—preventing costly remedial jobs entirely. Furthermore, the careful and intentional design strategy employed by the Schlumberger team ensured safe operations close to the populated areas of Hutubi.

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