DATA SHEET

HALLIBURTON

Cementing software

WellLife® software

A life-of-the-well design approach

FEATURES

- Life-of the-well production and abandonment phase sealant integrity assessment
- Poro-mechanical and thermo-mechanical analysis
- Multi-casing and openhole simulations
- Failure mode prediction
- Salt and shale creep
- Hydration volume change (shrinkage/expansion)
- Probability of failure or remaining capacity analysis

BENEFITS

- Life-of-the-well tailored cement design for conventional, CCUS, geothermal, lithium, and P&A operations
- Helps prevent remediation and reduces expensive interventions
- Enhances operational efficiency
- Helps prevent sustained casing pressure (SCP)
- Evaluates fluid influx during abandonment phase

Overview

As the landscape of oil and gas operations, geothermal energy, mining, and carbon capture, utilization, and storage (CCUS) projects evolves, wellbore integrity during both production and abandonment phases is crucial. During typical well construction operations, only short-term cement mechanical properties and safe placement are considered. WellLife® software, a well integrity digital twin, uses advanced finite element analysis (FEA) models to evaluate the cement system or sealant's performance under various operational and environmental stresses. Applications include conventional oil and gas production, geothermal resources, CCUS, lithium extraction, H_2 storage, and plug and abandonment (P&A). This technology can mitigate risks, such as thermo-mechanical failure and fluid migration, to help ensure long-term well stability.

End-to-end well lifecycle analysis to maximize wellbore integrity

WellLife software uses advanced FEA to analyze the casing, cement sheath, and formation information to determine the cement mechanical properties necessary for long-term integrity. During the analysis, the cement sheath integrity is modeled as it is subjected to planned well operations. These operations, such as drilling, injection, production, fracturing, and abandonment, can impart temperature and/or pressure loads that result in stress on the cement sheath, which can lead to potential cement failure.

The software evaluates the failure risk in multiple modes that might occur throughout the life of the well. Modes of failure for the wellbore components (i.e., cement sheath, casing, and formation) include compression, tension, debonding, casing plasticity, and formation shear. When the most likely failure mode is understood, Halliburton engineers can tailor the exact mechanical properties for the unique operations the annular barrier will experience throughout the productive and abandonment phases of the well.

Modeling features

Conventional well construction

- **Thermo-mechanical analysis:** Simulates stress conditions caused by cyclic loads during drilling, stimulation, injection, and/or production operations to reduce failure risks and sustained casing pressure (SCP).
- **Failure mode prediction:** Identifies risks related to tensile, compressive, and debonding failure to ensure optimized barrier performance for long-term integrity.
- **Tailored cement design:** Adjusts mechanical properties, such as Young's modulus and compressive strength, to mitigate operational risks and maintain wellbore integrity during production.

Geothermal operations

- **High-temperature stress simulation:** Models the extreme thermal cycling conditions typical of geothermal wells to help ensure cement or barrier systems can withstand temperature fluctuations over time.
- **Thermal expansion analysis:** Tailors cement properties to manage the high thermal loads to prevent failure modes, such as cracks or debonding, in geothermal environments.

CCUS operations

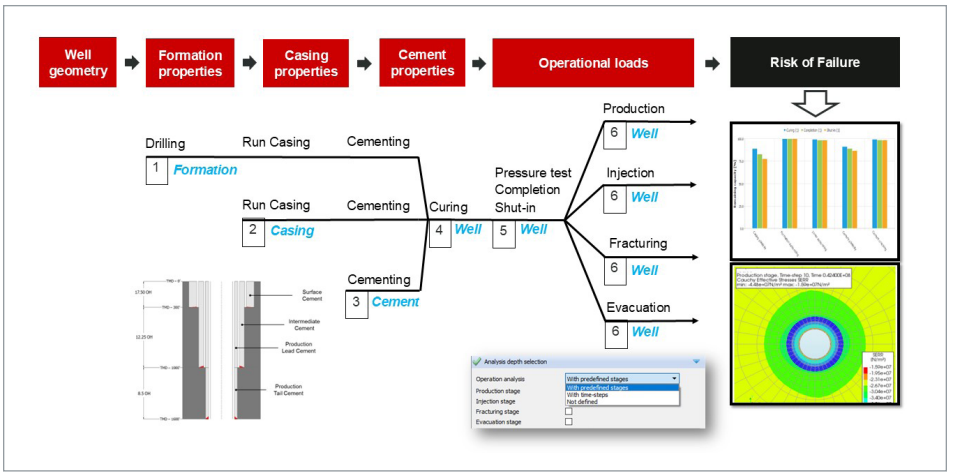
- **CO_2 exposure:** Simulates long-term exposure of cement systems to CO_2 and accounts for the chemical interaction and optimized seal integrity of CO_2 storage wells.
- **Injection cycle analysis:** Evaluates cement performance under CO_2 injection cycles where frequent pressure, temperature, and fluid dynamics can impact the long-term stability of storage wells.
- **Isolation and containment:** Models cement performance to prevent CO_2 leaks and maximize permanent isolation of carbon storage formations with a focus on long-term environmental safety.

P&A and kickoff-plug operations

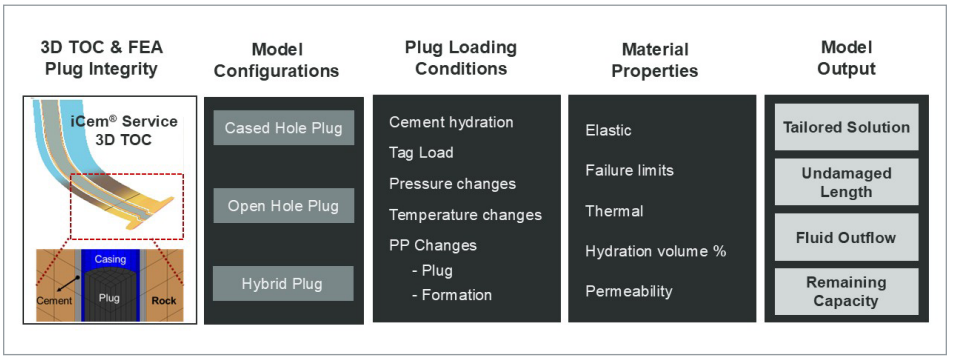
During the abandonment phase, WellLife software assesses cement system integrity under thermal, mechanical, and hydraulic stresses to ensure plugs provide reliable long-term isolation and resist fluid flow. It also analyzes risks, such as cement plug failure, fluid influx, and SCP, which are critical to decommission a well and/or achieve optimum kickoff-plug integrity.

- **Poro-mechanical analysis:** Examines how formation fluid, abandonment plugs, and wellbore materials interact to impact long-term integrity. The permeability of materials is key to assess the risk of fluid flow from the formation into the abandonment plug and potentially to the surface.
- **Cement plug integrity:** Evaluates cement plug performance under abandonment conditions to assess potential for pore pressure changes, fluid influx, thermal cycles, and SCP.
- **Long-term stability:** Ensures abandonment plugs provide reliable isolation for decommissioned wells or kickoff well sections to prevent post-abandonment issues, such as fluid migration or well leaks.

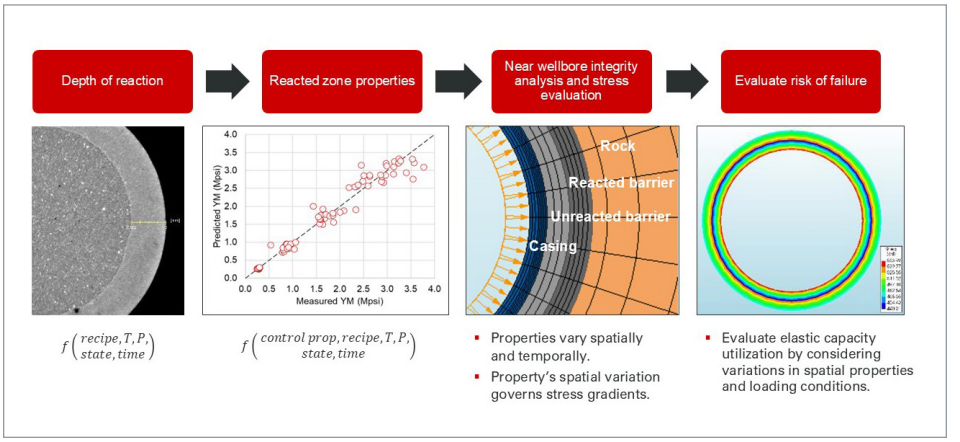
WellLife software analyzes cement systems to optimize their design, increasing the likelihood of withstanding stresses throughout the well's lifecycle. It models wellbore conditions and operational and environmental stresses to enable Halliburton engineers to tailor cement properties for long-term integrity. In the event of a failed well, WellLife software can identify the root cause and enable more effective remediation and future cement operational improvements. This feature can minimize recurrence and help ensure subsequent improved well performance.



Life-of-the-well integrity workflow illustrates how WellLife® software, a well integrity digital twin, enables the construction and evaluation of the well's potential for failure (i.e., remaining capacity) during its productive life.



Abandonment integrity workflow indicates how WellLife® software helps analyze a plug's potential for mechanical or poro-mechanical failure as a wellbore is decommissioned.



CO_2 exposure kinetics and integrity impact indicate how WellLife® software helps analyze chemical interaction and potential seal integrity failure in CO_2 storage wells.

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