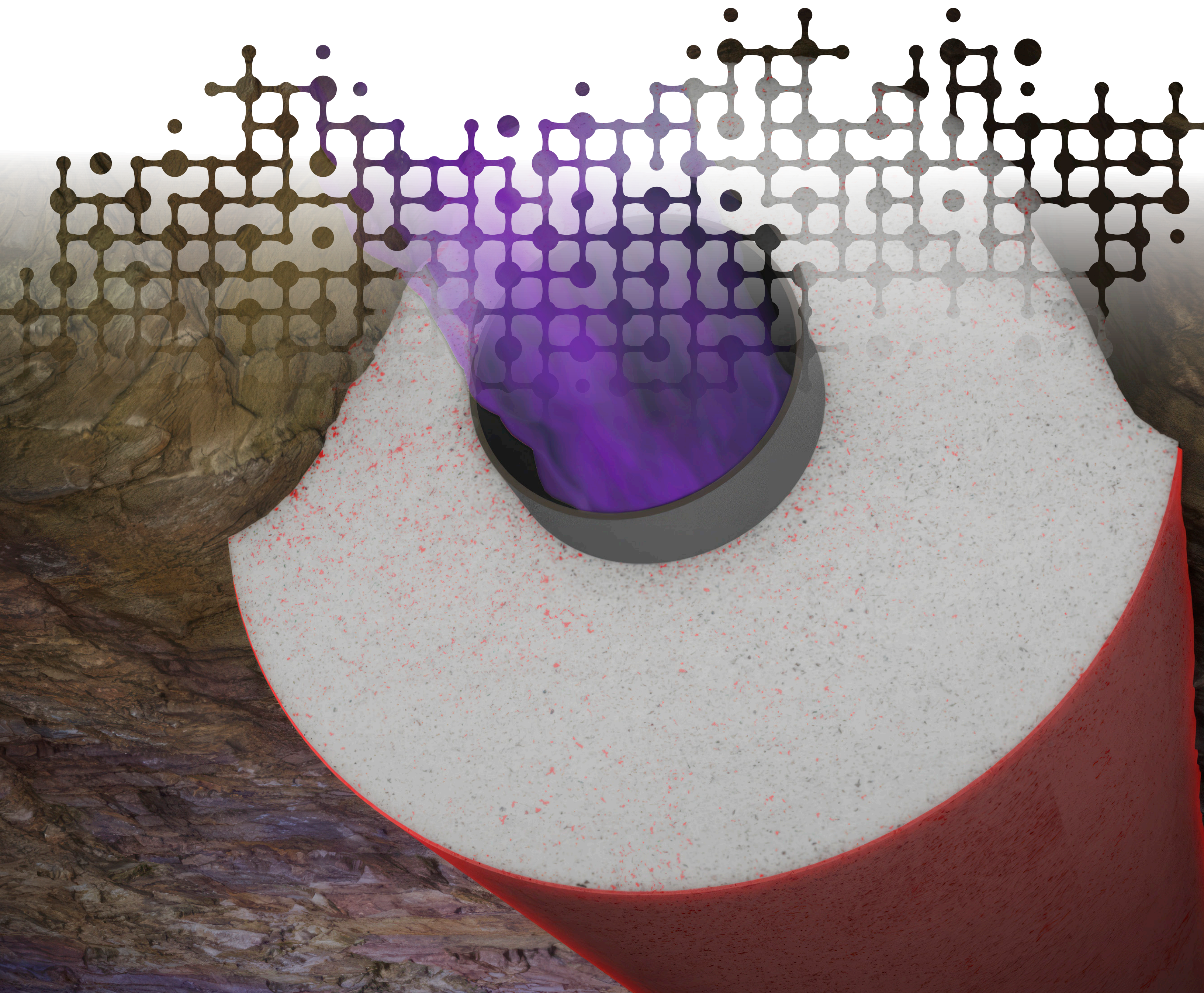
Cementing solutions

Carbon Capture, Utilization, and Storage (CCUS)



Halliburton engineers custom CCUS solutions

Cement barriers in carbon capture, utilization, and storage (CCUS) operations face unique challenges attributed to the corrosive environment, harsh injection cycles, and length of storage requirements. To facilitate permanent CO_2 storage, Halliburton designs cement barriers that can prevent CO_2 leakage, withstand dynamic injection stress, and minimize the opportunity for carbonation reactions.

Cement placement best practices, design for elasticity, and proper material selection help deliver an annular barrier that can withstand decades of injection cycles and meet long-term CO_2 storage requirements. The Halliburton CCUS solutions portfolio includes non-Portland, modified Portland, and reduced Portland products. Each annular barrier properly placed over an area of interest can help reduce potential pathways for CO_2 to infiltrate the cement sheath. Material selection depends on the temperature and pressure cycles and the chemical harshness of the CO_2 environment in the wellbore.

To learn more, contact your Halliburton cementing representative for a risk management discussion or visit Halliburton.com/CCUScement.

CCUS barrier design approach and selection

Reduce pathways for gas flow

Cement barriers must effectively prevent CO_2 leakage and minimize pathways through the cement. Cement placement best practices can help achieve full radial coverage to avoid the creation of channels in unset cement.

Intermittent CO_2 injection causes repeated temperature and pressure changes within the wellbore. These fluctuations can make the casing and cement expand and contract, which can lead to cracks, fractures, or seal failure over time. This can result in CO_2 migration.

To help prevent plume migration, operators should enhance the elasticity of a cement barrier to withstand dynamic injection stress. Pure resin, cement-resin composites, or the addition of elastomers to the cement blend can improve elasticity and absorb injection stresses to reduce the risk of long-term mechanical damage.

Minimize opportunity for carbonation reactions

CO_2 forms carbonic acid (H_2CO_3) in the presence of water. Portland cement reacts with H_2CO_3 during a process called carbonation. This process alters the cement sheath and can affect wellbore integrity. As carbonation progresses, the cement becomes more brittle and prone to crack under mechanical stress. Microcracks can form because of volume changes from the carbonation reaction. This can increase permeability and allow CO_2 to migrate through the cement sheath and compromise the well's seal. Over time, carbonation can degrade the cement sheath.

To mitigate this, operators should reduce or eliminate Portland cement and design barriers with low permeability to minimize CO_2 corrosion.

Evaluate barrier integrity

To help predict long-term CO_2 resistance, Halliburton offers lab-scale CO_2 immersion testing capabilities in Houston; Tananger, Norway; and Pune, India. Samples are tested in dry gas, wet super-critical CO_2, and CO_2 saturated in water in static and dynamic flow environments. WellLife® computer software uses post-exposure mechanical property test results to evaluate the system's long-term integrity under CO_2 injection cycles. The results are used to optimize the cement design to help prevent mechanical failure.

Non-Portland barrier

WellLock® resin system is a non-Portland system that does not react with CO_2, has ultralow permeability, and offers excellent CO_2 corrosion resistance. This resin system enhances performance with superior mechanical properties. Its high elasticity allows it to better withstand stresses from cyclic injection operations to prevent mechanical failure. Improved shear bond strength helps anchor the system to the casing and formation. This reduces the risk of debonding and potential CO_2 pathways to the surface.

ThermaLock™ cement system is a non-Portland calcium aluminate phosphate cement with low permeability. It is tailored with mechanical property modifiers to enhance elasticity. It does not react with CO_2 and provides excellent corrosion resistance.

Modified Portland barrier

CorrosaLock™ cement system is a resin and cement composite system tailored to provide excellent chemical resistance to CO_2. Lower in permeability than conventional systems, it has enhanced mechanical properties that minimize the impact of cyclic loading on the mechanical integrity of the cement barrier.

Reduced Portland barrier

CorrosaCem™ cement system is a reduced Portland-based cement system designed to lessen chemical alteration effects caused by CO_2. The system is modified with materials to help reduce permeability and enhance elasticity.

> Every CCUS project is unique with its own barriers to success.

Why Halliburton?

Halliburton advantages

Choosing Halliburton to help engineer your CCUS projects provides many advantages that help ensure safe, compliant CO_2 storage:

- 40 years of CO_2 project experience
- Successful execution of CCUS projects globally
- Industry-leading people, products, services, and technology for comprehensive CCUS project planning and execution
- Strategic collaboration with leading CCUS partners worldwide
- Integrated, full-cycle solutions for greater efficiencies and commercial viability of CCUS projects
- Onsite research and technology center to develop new and enhance existing CCUS technology and solutions

At Halliburton, we collaborate and engineer solutions to help maximize asset value for our customers. All products and service solutions are available as integrated offerings or as discrete services, based on customer requirements.

For more information on Halliburton CCUS services, please visit halliburton.com/ccus.

To learn more about our comprehensive portfolio of Low Carbon Solutions, visit halliburton.com/LCS