

A worker in a blue uniform and white hard hat is working on a complex blue industrial structure, likely part of a wellhead or valve assembly. The worker is wearing safety glasses and orange gloves, and is focused on adjusting a component. The background shows more of the industrial equipment under a clear blue sky.

Schlumberger

Well Integrity Technology

Plug and abandonment catalog

Content

Cementing for Well Decommissioning 1

Products

CemFIT Heal flexible self-healing cement system 2

CemPRIME Scrub engineered scrubbing spacer 3

D264 nanosealant high-injectivity, self-diverting leak repair fluid 4

EverCRETE CO₂-resistant cement system 5

FlexSTONE advanced flexible cement technology 7

FlexSTONE HT advanced high-temperature flexible cement technology 8

SqueezeCRETE remedial cementing solution 9

Cementing for Well Decommissioning

Restore caprock integrity

Once an operator assesses a mature reservoir and determines the output is no longer economically viable, the decommissioning phase is the next step. Among the many considerations is making sure the well abandonment process restores the seal at the caprock for long-term protection against potential fluids migration.

Wellbore isolation using cementing fluids is crucial to restoring the integrity of the reservoir caprock by sealing each well with a permanent, leak-free barrier, enabling the operator to meet compliance obligations. And because any intervention can be complex, Schlumberger offers a fully managed cementing service, along with a line of cement solutions for well abandonment campaigns with varying intricacies.

- CemFIT Heal* flexible self-healing cement system
- CemPRIME Scrub* engineered scrubbing spacer
- D264 nanosealant high-infectivity, self-diverting leak repair fluid
- EverCRETE* CO₂-resistant cement system
- FlexSTONE* advanced flexible cement technology
- FlexSTONE HT* advanced high-temperature flexible cement technology
- SqueezeCRETE* remedial cementing solution





CemFIT Heal flexible self-healing cement system

Provides long-term wellbore isolation to allow for the next stages of the well decommissioning process

Where it is used

Wells marked for permanent abandonment where setting wellbore sealing plugs are required

How it improves wells

- Improves long-term well integrity by resisting set-cement-plug failure
- Reduces risk of wellbore pressure buildup
- Seals complex through-tubing scenarios with gauge cable(s) against hydrocarbon migration
- Autorepairs cement cracks and microannuli that can cause hydrocarbon leaks
- Minimizes or eliminates the need for operators to monitor or revisit the wells over time

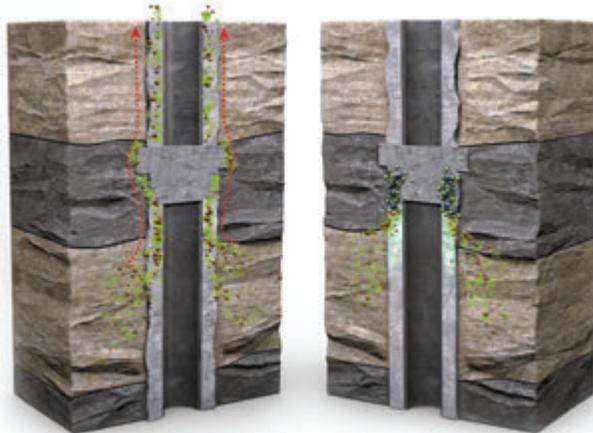
How it works

CemFIT Heal flexible self-healing cement system isolates the well to enable the next stages of the decommissioning process. When placed in a plug configuration, the system provides a competent pressure seal and protects against hydrocarbon migration and sustained casing pressure at the wellhead. The adaptive cement technology is the industry's only cement-based system that couples optimal mechanical properties with self-repair, thus managing postdecommission wellbore stresses with its ability to seal over time, should any isolation defects appear through contact with hydrocarbons.

What it replaces

Conventional cement barriers can develop cracks and microannuli caused by pressure changes and other stresses, enabling formation and other wellbore fluids to potentially migrate along the wellbore and escape at surface or between zones via downhole communication.

Conventional



CemFIT Heal system

Conventional cement barriers (left) can develop cracks and microannuli caused by pressure changes and other stresses, allowing fluids to flow between zones and rise to the surface. The CemFIT Heal system (right) responds to any contact with oil or gas by automatically repairing and sealing itself.

What else I should know

The CemFIT Heal system may be used for small- and large-scale projects, making it highly efficient and versatile, depending on the decommissioning activity. Properties have been conclusively demonstrated in the laboratory and during field testing, and have been reviewed in technical papers such as IPTC 19399, and in case studies such as "US Denver-Julesburg Basin Production Casing" and "US Thomasville Basin P&A Campaign."

Achieve zonal isolation for the life of the well

CemFIT Heal system helps ensure well integrity from drilling to abandonment, providing a competent wellbore pressure seal and protecting against hydrocarbon leaks and sustained casing pressure at the wellhead in offshore and onshore environments. With set cement properties favoring flexibility and durability, along with the inherent ability to self-seal should any isolation defects appear, CemFIT Heal system provides a long-term, robust barrier to meet your decommissioning objectives.

Additionally, the cement plug's low Young's modulus nature enables it to withstand external stresses induced by other decommissioning activities such as

- section milling
- re-entry activities
- temperature changes
- pressure changes.

Deploy with ease

The cement job is simple to design, with one standardized concentration of the self-sealing additives for an oil environment and another for gas. Blend, solid volume fraction, and slurry properties can be easily adjusted for optimal results to accommodate changes to cement designs and job programs. The CemFIT Heal system is also easy to blend and mix using conventional equipment, making it suitable for large-scale use. The increased efficiency and higher reliability reduce NPT.

CemFIT Heal System Specifications

Density range	11–16.2 lbm/galUS [1,320–1,940 kg/m ³]
Temperature range	70–280 degF [21–138 degC]
Hydrocarbon activation	Oil, any type of gas, even dry gas



CemPRIME Scrub engineered scrubbing spacer

Enhances the removal of wellbore deposits in cement plug placement operations

Where it is used

- Cement plug operation for decommissioning in openhole and casing environments
- Plug operations in wells in environmentally sensitive areas
- Bottomhole circulating temperature from 68 to 284 degF [20 to 140 degC]

How it improves wells

- Improves drilling fluid and particulate removal with scrubbing fibers
- Enhances cement-to-casing bond with better hole cleaning
- Primes the wellbore site before cement introduction
- Aids in transport of unwanted material left in place during cleanup run

How it works

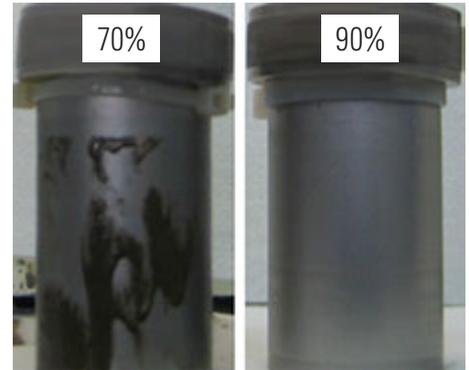
CemPRIME Scrub engineered scrubbing spacer is a multicomponent spacer system that enhances the removal of drilling fluids and other wellbore deposits in all cement plug placement scenarios and during decommissioning. The system is pumped as a prejob cleanup circulation pill before the main train of spacer and cement fluids are introduced into the wellbore, enhancing cleaning ability because of the added scrubbing capability of the fibers. It can also be included as part of the main spacer.

CemPRIME Scrub spacer builds on combinations of surfactant and solvent that water-wet surfaces and demulsify over a wide range of temperatures, base oils, and salinity. The combination of these surfactants and solvents with special scrubbing material do not interfere with important cement sealant properties, such as thickening time and compressive strength, but actively prime the abandonment region to maximize the chances of cement bonding to steel and rock surfaces.

CemPRIME Scrub spacer is easy to handle and disperse in water-based fluids. It may be mixed in batches or during the job. Compatible with water-based cement sealants and water-wetting spacer fluids, it enables flexibility at the decommissioning site. Additionally, scrubbing fibers can be added to any standard spacer with surfactants and solvents for nonaqueous fluid (NAF) removal.

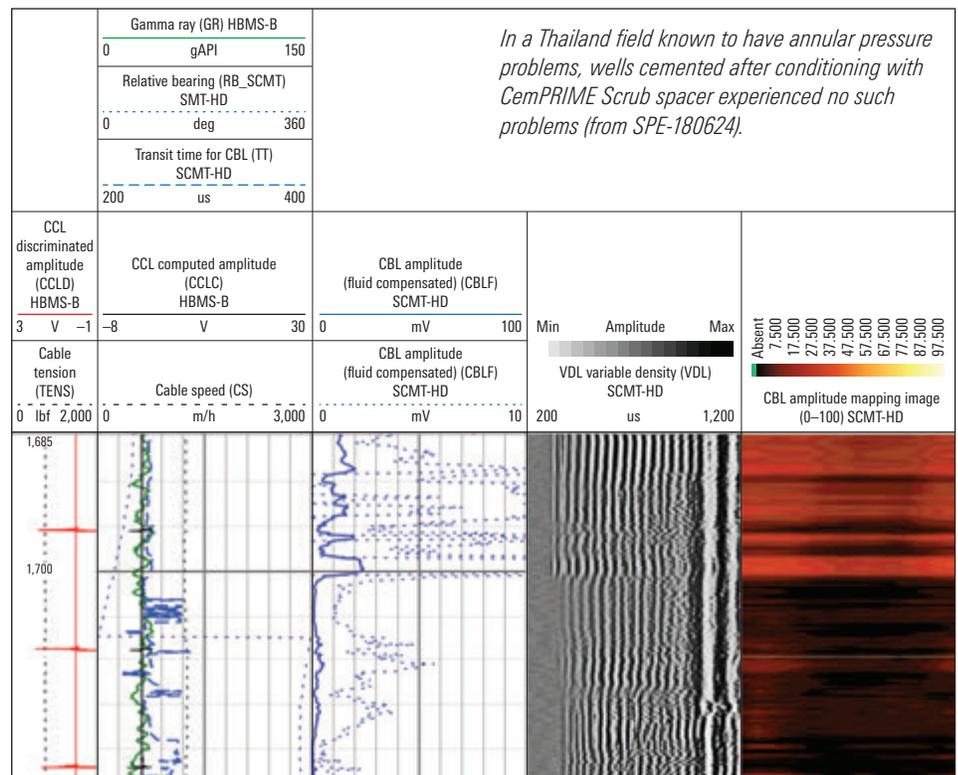
Engineered for wellbore bond enhancement

CemPRIME Scrub spacer is engineered based on expected downhole temperature, mud system base oil, and salt concentration requirement. Performance is simulated in the laboratory to verify emulsion inversion, spacer stability under expected conditions, cleaning ability, and compatibility with the cement slurry design. CemPRIME Scrub spacer can be used when bottomhole circulating temperatures are in the range of 68 to 284 degF [20 to 140 degC].



CemPRIME Scrub spacer (right) removes NAF more efficiently compared with a conventional cementing spacer (left).

It can be mixed using freshwater, seawater, or brine and mixed in batches or during the job. The typical concentration of fibers is approximately 2.33 lbm/bbl of spacer.





D264 nanosealant high-injectivity, self-diverting leak repair fluid

Repairs microcracks, fissures, or microannuli in cement prior to decommissioning

Where it is used

- Remediation of sustained casing pressure
- Repair of pinhole leaks in cement casings and cement plugs
- Prevention of microannulus or leak path beyond old casing prior to well decommissioning

How it improves wells

- Repairs leaks as small as 20 μm with injectivity similar to that of water
- Minimizes operation time and number of squeezes by self-diverting to plug multiple gaps or cracks of different widths
- Simplifies operations as a single-component fluid requiring no mixing at surface
- Reduces cleanup time

How it works

Nanosealant high-injectivity, self-diverting leak repair fluid sets after contact with set cement and hardens within hours. This property extends the possible squeeze time and combines with the self-diverting property to enable penetration into more leakage paths. As each leak is sealed, the fluid flows into the next gap. The setting mechanism can be implemented rapidly without laboratory testing of thickening or curing times, which are required for well cement or other sealants. It also improves postsqueeze cleanup because of the low risk of setting inside tubulars or surface equipment.

Features

The single-component system requires no mixing or blending at surface. Because of low rheology and nanosized particles, injectivity is similar to that of water and has been demonstrated to penetrate leaks as small as 20 μm .

Nanosealant is a single-component, self-diverting technology that can be used to repair small cracks and microannuli in old cemented annuli prior to abandonment or even for prior abandonment cement plugs that show signs of leakage. It is ideal for repairs for which injectivity is too low to pass Portland cement-based systems or microcement systems such as SqueezeCRETE remedial cementing solution.

Plug more leaks in a single squeeze

Nanosealants are alternatives to in situ polymerization technology (resin or monomers) for sealing pathways smaller than 120 μm and exhibit some key advantages over traditional noncementitious fluids. As the nanosealant activates only upon contact with divalent ions, including those available in set cement, the specific activation of the material can be carefully controlled, thus enabling almost unlimited deployment time until the nanosealant contacts the required divalent ions in the desired leak path. This extended working time reduces risks associated with placement and enables alternative deployment techniques. The nanosealant can be deployed via dump bailers on coiled tubing or via wireline for precision low-volume placements.

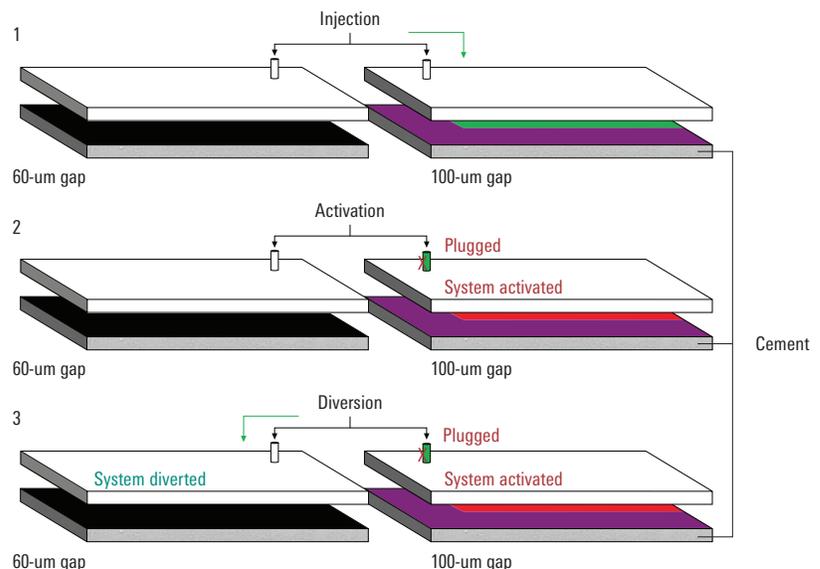
The single-component nature of the nanosealant significantly reduces the fluid formulation complexity versus cementing and resin alternatives. The simple on-location deployment is inherent as the only concentration measurement needed is the volume to be pumped into the well. Finally, the elementary fluid concept extends this advantage to the laboratory side where it eliminates extensive laboratory testing requirements before treatment that comes with cement or resin cements.

Choose the best placement for each well

The nanosealant can be placed through conventional tubing or coiled tubing. Other placement techniques may be feasible depending upon the wellbore configuration. Self-diverting maximize the number of leak paths to be plugged.

Nanosealant Specifications

Placement temperature	Up to 250 degF [120 degC]
Maximum exposure temperature	300 degF [150 degC]





EverCRETE CO₂-resistant cement system

Creates a barrier for reservoirs containing CO₂

Where it is used

Provides wellbore isolation during well decommissioning in cases where there are risks of exposure to aggressive CO₂-laden fluids over time

How it improves wells

Withstands harsh environments and wellbore fluids with elevated CO₂ content

How it works

EverCRETE* CO₂-resistant cement system for decommissioning in CO₂ corrosive environments enables a high level of resistance to withstand cement matrix attack and fulfill long-term well decommissioning objectives.

Self-healing capabilities can be added to the EverCRETE system to repair any crack created in the cement matrix in presence of CO₂.

Features

The cement-based EverCRETE system is robust and engineered for harsh environment decommissioning needs. The robust nature of the system provides a high level of resistance to withstand corrosive attack and fulfill long-term well decommissioning objectives. A reliable barrier against CO₂-laden fluids without degradation is one of the crucial aspects of a cement system used to permanently decommission oil and gas wells. EverCRETE system operates at temperatures up to 284 degF [140 degC], making it a versatile choice for plugging and abandoning wells. With intrinsic low permeability, the EverCRETE system provides long-term resistance to aggressive wellbore fluids that may leach into the abandoned wellbore over time. Accelerated reaction kinetics lead to a stabilized matrix within days of exposure to the CO₂ environment. If the cement matrix is damaged and CO₂ starts to migrate, self-healing capabilities can be added to the EverCRETE system to repair the crack, reestablishing the integrity of the well and recovering zonal isolation.

CO₂ isolation challenges

Portland cement systems are used conventionally for zonal isolation in wells. However, Portland cement is thermodynamically unstable in CO₂-rich environments and can degrade rapidly upon exposure to CO₂ in the presence of water. As CO₂-laden water diffuses into the cement matrix, the dissociated acid (H₂CO₃) reacts with the free calcium hydroxide and the calcium silicate hydrate (C-S-H) gel. The reaction products are soluble and migrate out of the cement matrix. Eventually, the compressive strength of the set cement decreases, and the permeability and porosity increase, leading to loss of zonal isolation.

CO₂-resistant isolation solution

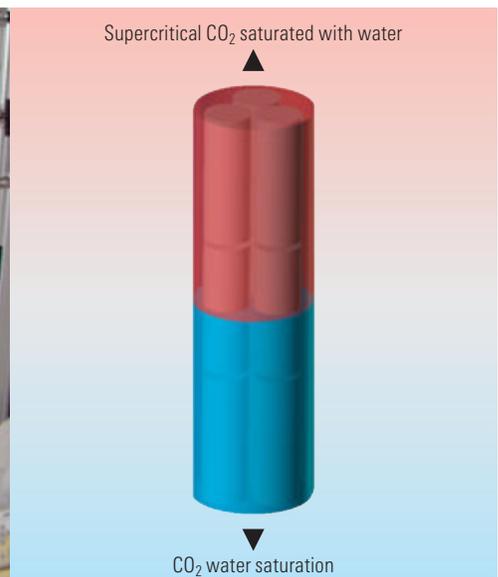
In developing the EverCRETE system, Schlumberger has

- extended the duration of zonal isolation
- established testing methodology using a computer-controlled titanium reactor to assess the long-term durability of cement cores under well CO₂ conditions.

Laboratory tests have proved the fixed CemCRETE* concrete-based cementing technology-based designs of the EverCRETE system to be highly resistant to CO₂ attack from wet supercritical CO₂ and water saturated with CO₂ conditions.

EverCRETE system can be prepared locally using the standard bulk plant. The density can be tailored to well requirements, providing operational flexibility.

Unlike other offerings, EverCRETE system is compatible with Portland cement. EverCRETE system cement can be used in combination with conventional Portland cement slurries, depending on the requirements for CO₂ resistance and the complexity of the decommissioning operation. The EverCRETE system can be used as a cement across potential CO₂-producing formations or as the primary barrier in the wellbore for any in situ fluids that could migrate postabandonment. It can be prepared and pumped using standard equipment. Additionally, the cement can be engineered with self-healing properties that are reactive to CO₂ exposure.

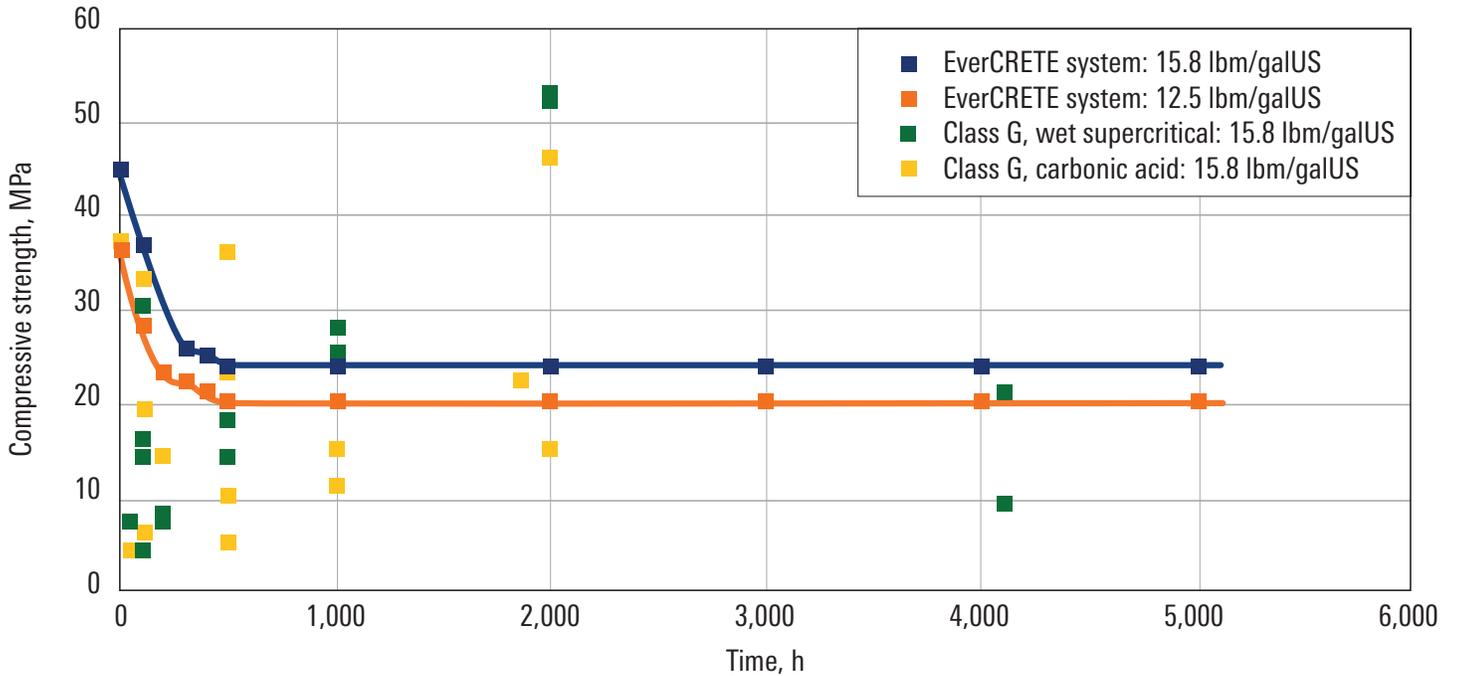


CO₂ durability test reactor: Cement cores are tested simultaneously in supercritical CO₂ that is saturated with water and in CO₂ water saturation under downhole temperature and pressure conditions.

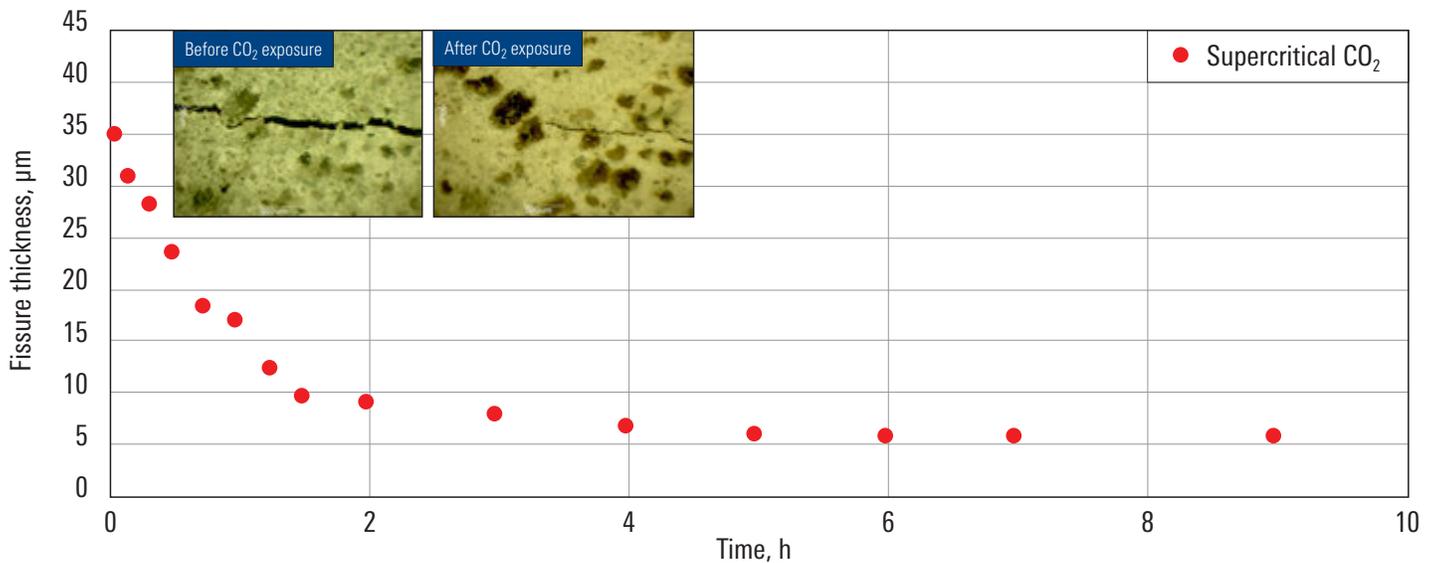


EverCRETE CO₂-resistant cement system

Creates a barrier for reservoirs containing CO₂



Compressive strength evolution of Portland cement and EverCRETE system samples with time in wet supercritical CO₂ fluid and in CO₂ saturated in water at 90 degC under 28 MPa of pressure. After 6 months in CO₂-saturated water, the compressive strength of Portland cement is not measurable because most of the samples are highly deteriorated. The stability of the EverCRETE system thus minimizes the degradation potential of the long-term barrier required in decommissioning activities.



EverCRETE system self healing capabilities demonstrated in the lab through core flow testing. A crack created in the core of EverCRETE system is healed once supercritical CO₂ is injected through it.



FlexSTONE advanced flexible cement technology

Enables customized zonal isolation for decommissioned wells

Where it is used

- High-risk wells set for decommissioning
- Plugging operations in wells located in environmentally sensitive areas
- Abandonment in fields prone to long-term temperature, pressure, or displacement activity after decommissioning
- Formations requiring sealing that may leach aggressive brines or other fluids

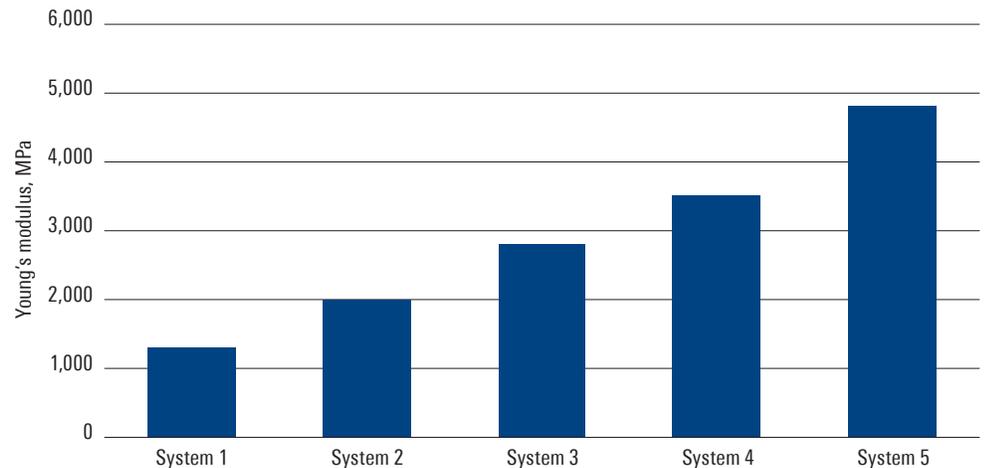
How it improves wells

- Withstands unexpected changes in the wellbore environment postdecommissioning activity
- Provides prolonged wellbore sealing and protection from aggressive environments or other reservoir fluids
- Reduces or eliminates well maintenance and remediation costs
- Lowers risk of annular pressure buildup

How it works

FlexSTONE advanced flexible cement technology enables customized solutions to be engineered for individual well decommissioning objectives. It can be designed with a wide range of Young's modulus values to cater to many high-stress wellbore isolation scenarios. And with the ability to operate at temperatures up to 300 degF [150 degC], the technology covers a diverse portfolio of well types. With intrinsic low permeability, it provides long-term resistance to aggressive wellbore fluids that may leach into the abandoned wellbore over time.

Tailored Young's Modulus to Well Conditions



Engineered Young's modulus for a FlexSTONE system indicating the tailored flexibility achievable with special design considerations. As an illustration of the system versatility in a decommissioning environment, all the systems shown are designed with the same density and solids fraction.

What it replaces

Conventional cement barriers can develop cracks and microannuli caused by pressure changes and other stresses, allowing formation and other wellbore fluids to potentially migrate along the wellbore and escape at surface.

What else I should know

Prestressing plugs using FlexSTONE technology enables a plug design that expands over time in a confined environment, causing it to fall into a state of compression. This compressive state is favorable for long-term isolation as the sealant naturally tends to push against the formation or steel wellbore walls during expansion.

Features

- Permeability <0.001 mD
- Temperature range from 40 to 300 degF [4 to 150 degC]
- Typical density range: 13 to 20 lbm/galUS [1,560 to 2,400 kg/m³]
- High tensile strength-to-Young's modulus ratios versus conventional cement
- High levels of expansion achievable in confined plug environment to prestress the sealant plug
- Field-proven CemCRETE concrete-based cementing technology to decouple density from Young's modulus

In an operational environment where there may be limited offshore rig deck space, the FlexSTONE technology can be delivered to the rig using special tanks that house the dry blended material prior to mixing. These tanks can be stacked and lifted with a full load of dry blended sealant.



FlexSTONE HT advanced high-temperature flexible cement technology

Enables customized zonal isolation for decommissioned wells

Where it is used

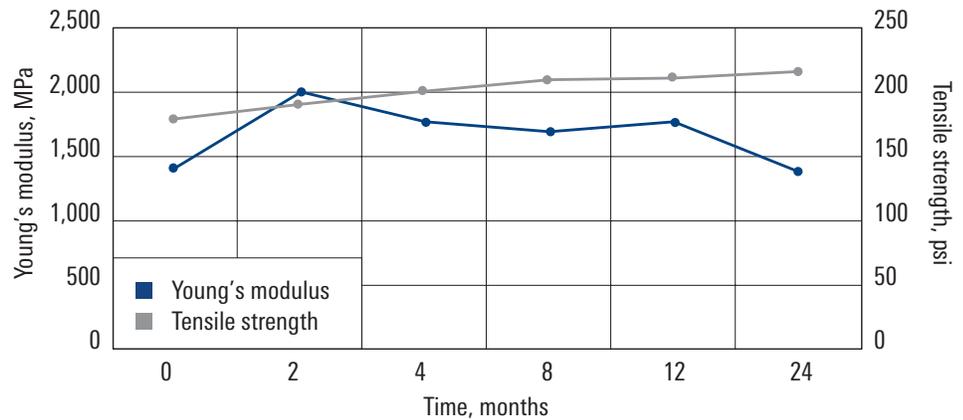
- HPHT wells set for decommissioning
- Plug operations in wells in environmentally sensitive areas
- Abandonment in fields that are potentially prone to long-term temperature, pressure, or displacement activity after decommissioning
- Formations that must be sealed and may leach aggressive brines or other fluids

How it improves wells

- Withstands unexpected changes in the wellbore environment postdecommissioning activity
- Provides prolonged wellbore sealing and protection from aggressive environments or other reservoir fluids that tend to migrate to surface
- Has wide range of engineered sealant properties enabling custom solutions to permanently plug wellbores
- Reduces or eliminates well maintenance and remediation costs
- Lowers risk of annular pressure buildup

How it works

A crucial aspect of a cement system used to permanently decommission oil and gas wells is the ability to remain flexible and adaptable. The FlexSTONE HT advanced high-temperature flexible cement technology can be designed with a wide range of Young's modulus values to cater to many high stress wellbore isolation scenarios.



A FlexSTONE HT technology system that has been aged over 2 years at elevated temperature indicating that key mechanical properties such as Young's modulus (flexibility) and the tensile strength remain stable over time, thus minimizing the degradation potential of the long-term barrier required in decommissioning activities.

What it replaces

Conventional cement barriers can develop cracks and microannuli caused by pressure changes and other stresses, enabling formation and other wellbore fluids to potentially migrate along the wellbore and escape at surface.

What else I should know

Prestressing plugs using FlexSTONE HT technology enables a plug design that expands over time in a confined environment, causing it to fall into a state of compression. This compressive state is favorable for long-term isolation as the cement naturally tends to push against the formation or steel wellbore walls during expansion.

Features

- Permeability <0.001 mD
- Temperature range: 40 to 482 degF [4 to 250 degC]
- Typical density range: 10 to 21 lbm/galUS [1,200 to 2,520 kg/m³]
- Field-proven CemCRETE concrete-based cementing technology to decouple density from Young's modulus
- High levels of expansion achievable in confined plug environment to prestress the cement plug
- High tensile strength-to-Young's modulus ratios versus conventional cement

The custom nature of the FlexSTONE HT technology enables engineering a wide range of properties for individual well decommissioning objectives. FlexSTONE HT technology is designed to operate at temperatures up to 482 degF [250 degC], making it an ideal choice for the plugging and abandonment of HPHT wells. With intrinsic low permeability, the FlexSTONE HT technology provides long-term resistance to aggressive wellbore fluids that may leach into the abandoned wellbore over time.

In an operational environment where there may be limited offshore rig deck space, the FlexSTONE HT technology can be delivered to the rig using special tanks that house the dry blended material prior to mixing. These tanks can be stacked and lifted with a full load of dry blended cement.



SqueezeCRETE remedial cementing solution

Repairs cracks and fissures with superior injectivity

Where it is used

- Oil and gas wells with isolation problems
- Onshore and offshore wells
- Wellbore isolation during well decommissioning

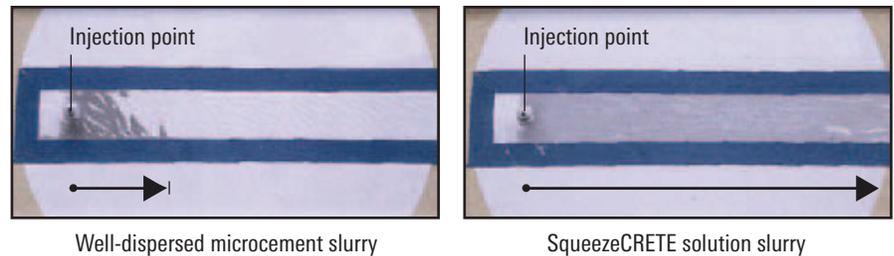
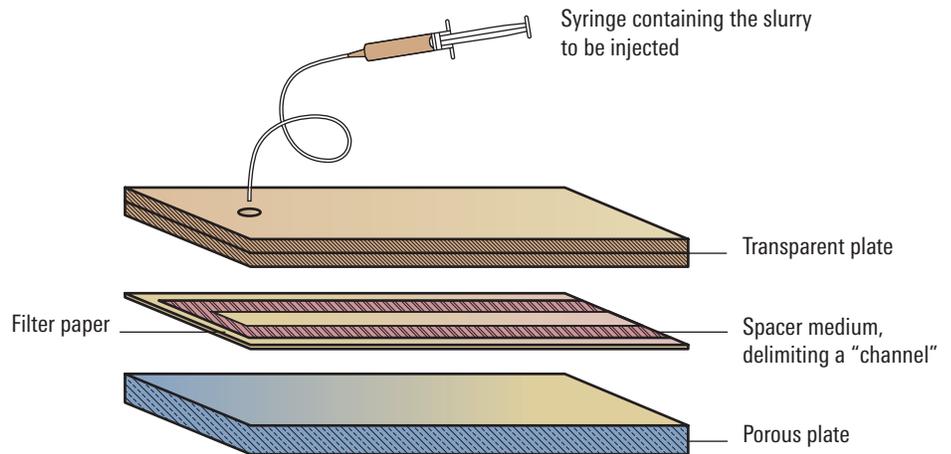
How it improves wells

Oil and gas wells can develop isolation problems that normal cements cannot repair. Microannuli, leaking liners, and old perforations are just some of the problems that may yield unsatisfactory results even after multiple squeeze cement attempts.

SqueezeCRETE remedial cementing solution is specifically designed to solve these problems by penetrating farther and more efficiently into narrow gaps than microcement or standard squeeze slurries, and without bridging or dehydrating during placement.

How it works

Once placed, SqueezeCRETE solution develops more than 2,000-psi compressive strength and extremely low permeability. This solution can seal liner tops, microannuli, or other situations where primary isolation has failed. It is resistant to acid and corrosive brine, enabling the cement to seal old perforations even when future acid stimulations are planned. SqueezeCRETE solution can be prepared with existing cement equipment and perform in temperatures ranging from 40 to 320 degF [4 to 160 degC].



Standard microcements have limited penetration in narrow slot tests. SqueezeCRETE solution slurry penetrates farther, even in slots 120 microns wide.

What it replaces

SqueezeCRETE solution displaces conventional remedial systems, including microcements due to superior injectivity. Standard squeeze slurries are also replaced because SqueezeCRETE solution has superior slurry and set-cement properties including low slurry viscosity, low slurry fluid loss, high set-cement compressive strength, and low set-cement permeability.

What else I should know

SqueezeCRETE solution benefits include

- improved penetration into difficult-to-repair and difficult primary isolation problems
- superior channel-filling properties that result in complete isolation repair
- low-placement pressures for improved fluid placement control
- complete restoration of zonal isolation or well integrity.

Well Integrity Technology plug and abandonment catalog



slb.com/decommissioning

CamCRETE, CamFIT Heal, CamPRIME Scrub, EverCRETE, FlexSTONE, FlexSTONE HT, SqueezeCRETE are marks of Schlumberger. Other company, product, and service names are the properties of their respective owners. Copyright © 2021 Schlumberger. All rights reserved. 20-CE-850387

Schlumberger