

PRODUCTION
TECHNOLOGIES.
FULL SERVICE.

SCALE MANAGEMENT

Outstanding scale inhibition
for demanding field conditions

PREVENT — PERFORM — CURE

Schlumberger



PROVEN SCALE SQUEEZE INHIBITION PROGRAMS TO MAINTAIN MAXIMUM PRODUCTION

Scale is a major cause of declining production worldwide, costing the industry millions of dollars annually in inhibition and removal costs as well as lost revenue from deferred production.

Schlumberger is a worldwide leader in scale squeeze treatments and has designed an effective scale management strategy. This comprehensive approach includes scale formation and location prediction, evaluation of potential inhibitor chemicals, deployment techniques for long-term effectiveness, and alternative removal options.

As part of the PREVENT portfolio of trusted products and services to mitigate production issues, Schlumberger has developed a comprehensive range of inhibitors, including biodegradable, polymeric, and phosphorous-containing scale chemistries.

Customized to field requirements

All treatments are customizable to address any scaling regime, using field-proven products that rapidly return well hydrocarbon production profiles after squeezing.

Deployment techniques focus on

- preemptive squeezing of reservoirs using nonaqueous-base scale inhibitors
- conventional squeeze technologies, including tagged and end-capped polymeric inhibitors
- continuous injection via gas lift, capillary, and direct surface injection.

FULLY TESTED TECHNOLOGIES, COMPLETELY TAILORED SOLUTIONS

Schlumberger technical service scale laboratories have considerable expertise and the latest specialist equipment to carry out all necessary tests to qualify a suitable package, including

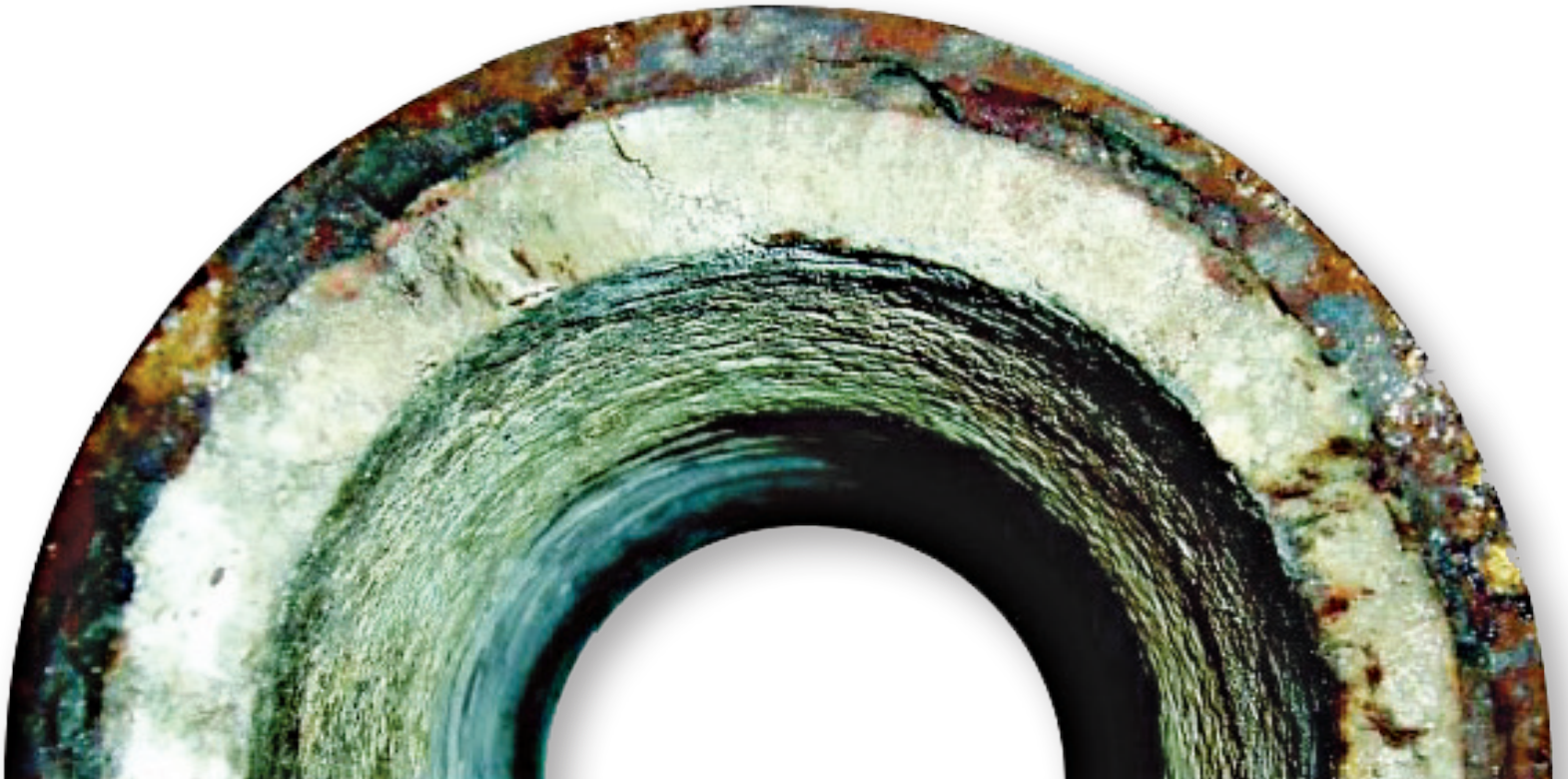
- static prescreening for compatibility, efficiency, and adsorption
- dynamic tube-blocking tests at high-pressure, high-temperature (HPHT) conditions
- low-pressure, low-temperature (LPLT) testing for determining injection dose or minimum inhibitor concentration
- full core studies to enable squeeze sensitivity modeling.

The Schlumberger ecotoxicological laboratory in Bergen approves all chemistries before use. Through biodegradation, bioaccumulation, and toxicity testing, the laboratory ensures that all products comply with environmental requirements.

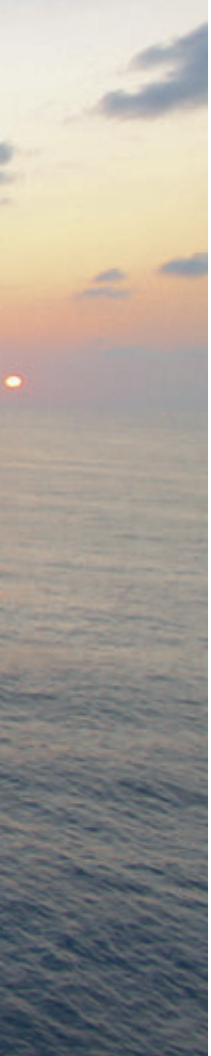
Optimized treatment design and results

Schlumberger designs scale squeeze treatments based on the specific information available for each well, inhibitor properties determined in the laboratory, and computer simulation tools, thereby optimizing treatment and placement.

In addition, Schlumberger is a lifetime member of the Heriot-Watt Flow Assurance and Scale Team (FAST) joint industry project group that provides direct access to leading squeeze design modeling software. Schlumberger also provides ECLIPSE* industry-reference reservoir simulator, OLGA* dynamic multiphase flow simulator, and PIPESIM* steady-state multiphase flow simulator, enabling us to remain at the forefront of reservoir scale management science.







COST-EFFECTIVE GAS LIFT DEPLOYED SCALE INHIBITION TREATMENTS

Deploying scale inhibitors via gas lift is a cost-effective way to manage scale formation within the production tubing. Schlumberger has a range of gas lift deployed scale inhibition technologies that can be customized for any scaling regime.

These technologies have been fully assessed for inhibition and have been evaluated using a technique that examines performance under dynamic conditions. The evaluation replicates the actual flow regimes and gas-to-scale-inhibitor mixing ratios at critical points within the system, including the annulus, gas lift valve, and sump.

Schlumberger gas lift deployed scale inhibitors all exhibit four key characteristics:

- Acceptable environmental properties
- Viscosity of <20 cP as supplied and after any volatile loss
- Corrosivity of <0.1 mm/a
- Compatibility with a wide range of brine compositions, including high calcium

PREEMPTIVE SQUEEZING WITH NONAQUEOUS-BASE SCALE INHIBITORS

Nonaqueous-base scale inhibitors are required for wells in which severe scaling is predicted at the onset of water production or for unmanned platforms where the mobilization time can be so lengthy that it puts the asset at risk. Additionally, reservoirs containing illitic or smectitic clays are sensitive to the application of aqueous-base scale-inhibitor treatments.

Schlumberger has a comprehensive range of nonaqueous-base scale inhibitors, independently proven as the best in class for preventing scale formation and protecting asset value, thereby delivering significant increases in field oil productivity.

Key features

- Customization to any scaling regime
- Elimination of emulsion tendency
- Proven field results
- Oil production stimulation after squeezing





BIOPOLYMERS FOR MAXIMUM ENVIRONMENTAL ACCEPTABILITY

Schlumberger remains at the forefront of biopolymer development for downhole scale inhibition. Biopolymers are considered the most environmentally acceptable chemistry used for topside and subsea scale control.

Because the molecules are completely mineralized after discharge, biopolymer chemistry meets the requirement for no harmful discharge to sea. Although biopolymers have been used for scale squeeze, they require optimization for temperature stability and adsorption and desorption properties in the reservoir.

Technology development has yielded several molecules that are temperature stable above 248 degF [120 degC] and show outstanding efficiency for scale inhibition.



Photo: Harald Pettersen/Statoil

SI-4117 scale inhibitor has increased our ability to maximize scale squeeze lifetime in the field through superior detection.

Case Study

NORTH SEA: SCALE INHIBITOR TRANSFORMS SQUEEZE LIFETIME CONFIDENCE

CHALLENGE

A North Sea operator required more accurate scale inhibitor residual detection to reduce uncertainty in whether minimum inhibitor concentration (MIC) was being maintained to prevent scale-induced production decline and to maximize squeeze lifetime.

Commonly used polymeric scale inhibitors have a ±2-ppm detection error, which is within the MIC range and conse-quently leads to doubt as to whether the well is effectively protected.

SOLUTION

The Schlumberger team developed the SI-4117* scale inhibitor, providing efficient protection against calcium carbonate ($CaCO_3$) and barium sulfate ($BaSO_4$) scales while improving detection accuracy and biodegradability.

This phosphonate molecule for scale squeeze application is detectable to 1 ppm (± 0.3 ppm) by inductively coupled plasma (ICP) in moderate salinity waters. Specific functional groups incorporated into the molecule make it biodegradable.

RESULTS

The improved detection accuracy from ±2 ppm to ± 0.03 ppm for residual SI-4117 scale inhibitor has significantly increased the operator's confidence that the well was above MIC and extending time between resqueeze treatments.

ENVIRONMENTALLY SENSITIVE SCALE SQUEEZE INHIBITORS

Traditional phosphonates have been used extensively for scale squeeze, but their geometrically locked backbone and sterically hindered functional groups prevent bacteria from breaking them down in seawater. Phosphonates are preferred for scale squeeze applications because of low MIC, long treatment lifetime, and low-level detection monitoring.

Ongoing research has identified some phosphonates that show significant biological degradation in seawater. They are being evaluated for efficiency, temperature stability, adsorption and desorption properties, detection in produced water, and compatibility.

These polyaspartates have been used for topside scale control for several years in the North Sea. As well as being regarded as the most environmentally acceptable scale inhibitors on the market, biopolymer capabilities now extends beyond 194 degF [90 degC]. Five different polyaspartate molecules with temperature stability up to 248 degF [120 degC] for at least 24 hours have been identified. As a result of this work, new polyaspartates were selected for subsea continuous injection at customer installations.





Case Study

NORTH SEA: INNOVATIVE BIODEGRADABLE SCALE INHIBITOR PREVENTS SCALE BUILDUP AND MINIMIZES FORMATION DAMAGE

CHALLENGE

A North Sea operator required to protect a well from $BaSO_4$ scale precipitation without causing formation damage. The well had a long horizontal production well with a 7-in perforated liner across two segments: an oil-producing upper segment, and a high-water-cut lower segment.

To support a zero-water-cut upper segment, the operator drilled a water injection well then planned a preemptive scale squeeze prior to water injection breakthrough in the upper segment, which was at connate water saturation.

There was a risk that a large-volume, fully aqueous scale squeeze would result in formation damage because of an increase in near-wellbore water saturation.

SOLUTION

The Schlumberger team deployed the SI-4117 scale inhibitor to preemptively treat the connate water saturation zones while limiting formation damage. The inhibitor was chosen for its proven prevention of carbonate and sulfate scales as well as its adsorption characteristics and biodegradable properties.

To help inform treatment design, the Schlumberger team performed a coreflood experiment to investigate formation damage potential and obtain inhibitor adsorption-desorption characteristics. SI-4117 scale inhibitor passed all stability and compatibility criteria, and showed an MIC of 2 ppm.

RESULTS

The environmentally sensitive squeeze treatment was delivered via bullheading with no significant pressure buildup recorded. No process upsets were logged during flowback. Postsqueeze oil and water production rates rapidly recovered to the presqueeze levels, indicating minimal formation damage.

After 12 months and 400,000 m^3 of water production, the inhibitor concentration was still significantly above MIC, considerably outlasting the initial squeeze design of 125,000 m^3.





PIONEERING HALITE INHIBITION

Halite (NaCl) scale is a growing challenge for the oil and gas industry, given growing worldwide production from hotter and deeper gas fields.

Schlumberger has developed innovative halite inhibitors to mitigate this type of scaling, which is particularly problematic in high-salinity wells.

Halite scale formation can occur as the hydrostatic pressure in production tubulars decreases when the volume of hydrocarbon gas expands and the hot brine phase evaporates.

Unchecked, this scale can ultimately plug downhole production tubulars and negatively impact topside equipment.

Schlumberger test results using field cores in North Africa showed no formation damage with applications of these newly developed halite inhibitors. Testing is also underway for squeeze applications.

UNLOCK POTENTIAL
OPTIMIZE PRODUCTION

A full service offering to maintain and restore full production.

Schlumberger production technology specialists deliver targeted, integrated strategies that help to decisively remediate production issues, such as deposit formation and naturally occurring gases, enabling customers to restore and improve flow performance and revenue while avoiding costly repairs and shutdowns.

Firmly established at the forefront of technology, Schlumberger has a full service offering that integrates pioneering chemical and process solutions, equipment, and software with unrivaled technical expertise.

Working with the world's largest oilfield services provider, customers benefit from a truly unique combination of outstanding technological capabilities and improve their understanding of how to successfully address production challenges in an increasingly competitive marketplace.

The team's global footprint and extensive suite of technologies helps customers reliably and efficiently maximize production—regardless of system complexities or geography.


MAXIMIZE PRODUCTION
FROM RESERVOIR TO REFINERY
20 TON
Schlumberger

UNLOCK POTENTIAL
OPTIMIZE PRODUCTION

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