Calcite Inhibition Systems Tubing Recovery

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ABSTRACT

Chemical Inhibition Systems (CIS) are widely used in geothermal wells to deliver antiscalant chemicals that mitigate mineral scaling. Over time, CIS tubing can become stuck due to scale buildup, caused by inappropriate chemical selection, changes in fluid chemistry, and lack of routine maintenance. This paper presents field-proven results using the Solenis chemical cleaning method to dissolve scale and recover immobilized CIS tubing in high-temperature geothermal wells.

The method has been successfully deployed in geothermal fields in New Zealand and the Philippines, with each case involving different scale types—primarily silica, calcite, and mixed mineral compositions. We detail the assessment process, tailored chemical program design, and safe retrieval procedures that avoided more costly well intervention methods involving a rig or coiled tubing unit. These interventions restored injection capability, improved well performance, and extended system life. The paper discusses practical recommendations for preventing stuck tubing and optimizing CIS reliability across a variety of geothermal environments.

1. INTRODUCTION

Chemical Inhibition Systems (CIS) are an essential part of modern geothermal well operations, used to deliver antiscalant chemicals that prevent mineral scale from depositing in production infrastructure. When functioning properly, these systems help maintain well performance, extend equipment life, and reduce the frequency of costly interventions.

However, in many geothermal fields, CIS tubing itself can become stuck or immobilized inside the well. This typically occurs due to mineral scale buildup on or around the tubing, but is often compounded by other factors such as suboptimal chemical selection, changes in reservoir chemistry, or lapses in regular maintenance. When tubing becomes stuck, it compromises chemical delivery, potentially accelerating scale formation and increasing the risk of well failure.

In the past, retrieving or replacing stuck CIS tubing often required significant mechanical intervention — including the use of rigs or coiled tubing units — which adds time, cost, and operational risk. In response to this challenge, a chemical-based approach has been optimised using the Solenis chemical cleaning method. This technique targets mineral scale directly with customized cleaning agents, allowing tubing to be freed and recovered without the need for major mechanical operations.

This paper presents the results of field applications of the Solenis method across geothermal wells in New Zealand and the Philippines. Each case involved different operational conditions and scale compositions, providing a broad perspective on how chemical cleaning can be successfully applied to restore CIS functionality. The goal is to share practical, field-tested insights with geothermal operators and asset owners looking for efficient, lower-risk alternatives to conventional well interventions.

2. BACKGROUND

Geothermal wells are subject to complex mineral scaling due to the high-temperature and chemically aggressive fluids they produce. The most common forms of scale encountered are amorphous silica, calcium carbonate, and occasionally mixed-phase deposits containing iron or other trace minerals. Scaling occurs as geothermal brine experiences pressure and temperature changes while flowing to surface, leading to supersaturation and mineral precipitation within production infrastructure.

To mitigate this, operators rely on CIS, which inject antiscalant chemicals directly into the wellbore. These systems typically use small-diameter capillary tubing to deliver the chemical downhole at low but continuous rates. When properly installed and maintained, CIS systems significantly reduce scale formation, thereby preserving production flow, protecting surface hardware, and reducing the frequency of major well interventions.

However, CIS systems themselves are not immune to scaling. Tubing can become immobilized due to internal blockage (if chemicals are not delivered at the correct rate or pressure), or external deposition, where scale forms around the tubing in the production casing, effectively cementing it in place. In some cases, tubing becomes blocked internally due to flashing of the injected fluid — particularly when the CIS pressure is insufficient to prevent vaporisation inside the wellbore. Common causes of CIS tubing failure include:

- Inadequate or intermittent chemical dosing
- Incompatibility between chemical formulation and brine chemistry
- Changes in reservoir pressure, enthalpy, or fluid composition
- Poor surface pump performance or system airlocks
- Lack of flushing or regular line maintenance

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When CIS tubing becomes stuck, the ability to deliver scale inhibitor is lost, and the well is exposed to accelerated deposition. Traditionally, recovering immobilized tubing often required rig-based workovers, snubbing units, or coiled tubing — all of which come with high operational cost, safety risk, and downtime.

In response to these limitations, a chemical cleaning method has been developed through collaboration between Thermal Clean Ltd and Solenis, targeting scale in situ using tailored formulations. This method uses a rigless surface injection approach through the wellhead's side outlet valves and has been successfully applied in both New Zealand and the Philippines, under a range of field and scaling conditions.

3. METHODOLOGY

The chemical cleaning operations described in this paper were carried out using a rigless surface-based method, adapted for high-temperature geothermal wells. This approach was developed in collaboration with Thermal Clean Ltd and Solenis, using proprietary chemical formulations designed to dissolve geothermal scale deposits—primarily silica and calcium carbonate—without damaging well infrastructure or requiring invasive intervention. The process is intended to restore the function of immobilized CIS tubing systems by breaking down the mineral accretion that causes tubing to seize in place. Treatment was delivered through a side-injection spool at the wellhead with the well on quench. The approach is based off the Solenis patented well cleaning and stimulation method.

3.1 Diagnostic Preparation

Prior to any on-site chemical treatment, each well underwent a structured diagnostic process. This included a review of the CIS performance history, chemical dosing logs, and production data to identify likely causes and timing of the tubing failure. Where physical scale samples could be obtained—typically from surface strainers, recovered components, or previous interventions—they were subjected to laboratory dissolution testing. These tests, using the Solenis geothermal product range, provided valuable input into the formulation, concentration, and expected contact time required for effective treatment. In the absence of scale samples, treatment parameters were determined based on field-specific scaling history and conservative design assumptions.

In the absence of physical samples, treatment design relied on historical knowledge of scaling tendencies in the field and trends in the brine chemistry. In both New Zealand and the Philippines, previous laboratory data and operational experience indicated that silica and calcium carbonate were the dominant constituents, occasionally with minor iron or mixed-phase precipitation.

It is important to maintain effective communication and rapport with the operators and subsurface engineers to enable the efficient sharing of information. A competent wireline operator is also required who have experience and the right equipment to pull on the capillary tubing. Ideally the operator will have the original CIS tubing specs to determine the max yield strength and ensure this isn't exceeded. In the absence of original specs a section of tubing on the surface may be obtained and measured, then have destructive testing performed. If possible it is important to perform a stretch test to help determine the stuck point. This requires an accurate weight indicator and measurement of tubing stretch. The stuck point and water level information is used to determine concentrations and flowrates for the treatment.

3.2 Surface Equipment Configuration

To deliver the chemical treatment safely and effectively, a Thermal Clean-designed specialty chemical dosing skid was mobilized to site. This skid is purpose-built for geothermal well applications and includes a dedicated circulation pump, precision chemical metering system, and integrated instrumentation to monitor flowrate and pressure in real time.

Because the CIS tubing was immobilized within the wellhead, it was not possible to modify the wellhead configuration to enable dosing through an additional side port like we do for production well stimulations. The treatment was therefore delivered via the existing side outlet valves on the wellhead, using high-pressure flexible hosing and appropriate cross overs to suit the side valve flange. This is often the same port as the quenching line, particularly where only one side valve is available This method allowed for controlled chemical injection without the need for intrusive mechanical intervention.

All injection equipment and chemical transfer operations were conducted within fully bunded containment areas and in compliance with site-specific environmental and health and safety protocols. Personnel involved in chemical handling and system operation were trained in spill response, chemical compatibility, and dosing system control.

3.3 Chemical Treatment Execution

The cleaning process began with quenching the well to take the well off pressure. This also ensures that the chemicals can go past the stuck point to ensure successful treatment. A wireline unit is rigged up and maintains a pull equivalent to 50% of the yield strength or enough to ensure the free weight of the tubing and sinker bar should be moving out of the well.

Following this, the main cleaning solution, based on the Solenis geothermal formulation, was injected at controlled rates. A thorough understanding of the wellbore geometry is required to ensure the treatment fluid is gaining suitable contact time with the scaled section. Throughout the treatment oscillations the wireline team are monitoring tubing weight for any changes and when the tubing becomes free we flush the well bore with fresh water prior to pulling out of hole with the CIS tubing assembly.

3.4 Post Tubing Recovery-Cleaning and Well Assessment

Following the successful tubing recovery often the clients chose to continue with a well stimulation to enhance production. This was actively achieved and followed the Solenis well stimulation methodology.

To confirm the effectiveness of the cleaning process, a Pressure-Temperature Spinner (PTS) logging tool was deployed where required. For one important customer we employed an EV camera to assess the stuck point and

determine any scale remaining in the well bore. This proved that no remaining scale was present and showed the effectiveness of the treatment fluid selection and corrosion inhibition products. This also allowed for confirmation of improved injectivity, restored connection to the production zone, and gives the operator confidence the well will be back to original production.

Once the investigations were complete, the CIS system was reinstated, well allowed to heat up or an air cap placed to initiate production and chemical inhibition was resumed—often with updated dosing rates or improved procedures based on learnings from the cleanout.

4. CASE STUDIES

4.1 New Zealand

The recently completed tubing recovery jobs in NZ were on an old armoured tubing system and a relatively new ¼" tubing system. Both systems had a period where CIS chemicals were not pumped down hole due to either pumping issues on surface or ineffective delivery mechanism. The ineffective delivery mechanism is where the dilution ratio is not enough and pump rate not enough to maintain a tubing pressure well above the well head pressure to ensure the liquid inside the tubing doesn't flash once it heats up inside the flowing well.

4.1.2. 1/4" Tubing recovery

The ¼" system was on a major production well for the client and the job scheduled during a plant outage. The client had decided to run a full well stimulation as part of the tubing recovery job. The well was shut in and quenched effectively. The tubing stuck point had been identified and no movement occurred while the well was on quench and the casing relaxed into its cooled state.

Chemical treatment commenced with the wireline team maintaining the required tension on the tubing and constantly monitoring weight. After the first batch of treatment fluid was pumped the tubing showed no signs of being displaced but once the second batch was about to commence we noticed a weight change and the team could begin to pull the tubing out of hole. Water was flushed into the wellbore to displace acid and we pulled the tubing free with a fully intact sinker bar.

Figure 1: Successfully Retrieved CIS Tubing

With the tubing out of hole the stimulation section of the job commenced without a hitch. Post stimulation PTS runs showed injectivity was back to better than completion test and the camera showed clean casing around the stuck point area and historical scale formation. With the well back on line and feeding the station the production was back to over 100%. The CIS tubing was reinstated and functioning well at the start of production.

4.1.2 Armoured Tubing Recovery

The client with the stuck Armoured tubing system chose to focus on tubing recovery as the production well was still going strong with very minimum reduction in output being realised in the last few years. The team chose a minimum volume recipe and the effective treatment plan was agreed by all parties. This well suffered from a pump fault where an airlock prevented inhibitor from being pumped for a few weeks before it was identified. This was long enough to ensure the tubing was adhered to the casing wall. The well pad was quite a compact site and good planning and communication was again required to ensure all parties were well aware of what was needed to ensure success.

The client took care of the quench and a reliable wireline contractor was utilised to pull the tubing. Conducting a stretch test with armoured tubing is difficult due to the wire armour shroud around the capillary tubing. These systems are rarely used in the NZ geothermal industry anymore and this particular one had been in service for more than 10 years. The treatment went well with all treatment fluid pumped the tubing came free with an additional pull from the wireline. Some of the armoured strands had unravelled, jamming just below the pressure gland which made the retrieval difficult. This can certainly be an issue with armoured tubing systems and efforts should be made to determine if this is the sole reason for tubing immobility. In this case it would have had a contribution. These old systems didn't have lubricators either so retrieval was done open hole.

Figure 2: Successfully Retrieved Armoured Tubing

With the old tubing out a new system was installed to meet current standards and the well was brought back to full production and inhibitor dosing was successfully resumed.

4.2 Philippines

Solenis have performed a number of reinjection well and production well cleans in the Philippines to give the customers confidence to allow us access to their tricker problems. The well is a production well drilled in the 90s with a total depth of ~1400 mMD. The well has two feed zones: a major feed zone at 1,250 mMD and a minor feed zone at 1,067 mMD.

The well has experienced recurring calcite scaling, which has necessitated three workovers involving acidizing with coiled tubing, conducted in 2007, 2011, and 2017. Following the third workover, a CIS system with a 1/4" diameter was installed at a depth of 1,200 mMD.

In January 2021, an attempt to pull out the CIS was unsuccessful due to the tubing parting upon closure of the crown valve, resulting in lost-in-hole equipment. A new CIS tubing was subsequently installed at a shallower depth above the fish, slightly above the minor feed zone at 1,067 mMD. This caused the possibility of fluid in saturated condition prior to coming in contact with scale inhibitor, therefore reducing treatment effectiveness.

In June 2022, the well experienced a collapse, with its last recorded production at approximately 3 MW. During this event, the CIS became stuck in the well. An attempt to pull out the CIS in 2023 was unsuccessful, pull testing determined that the stuck point was very near the tubing set point. The downhole scaling samples that collected form the well gave us a good analysis to match the treatment chemistry to.

The fluid geochemistry indicated a mildly basic environment, which is favourable for calcite scaling. Additionally, CO_2 monitoring suggests that the well manifests degassed fluid. Calcite scaling index simulation revealed that the well is highly prone to calcite scaling. As shown in figure 3.

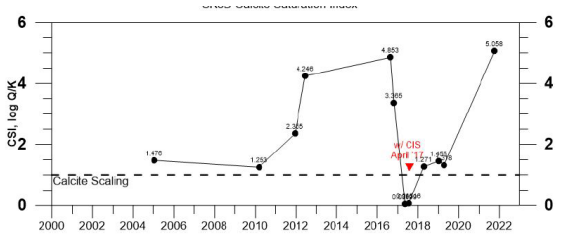

Figure 3: Calcite scaling simulation chart

April 2025, Solenis conducted a successful CIS tubing recovery operation. The well was shut in and quenched effectively by the client. However, no movement was observed, indicating that the tubing remained fixed even as the casing contracted and stabilized in its cooled condition.

During the first treatment batch, at slow controlled rates we observed movement. After approximately 2 hours and 15 minutes, a change in CIS weight was observed, indicating that the tubing had begun to move. Following this, the treatment injection was continued using an increased flow rate. Upon completion of this, fresh water was flushed through the system to displace residual chemicals, after which the tubing was successfully pulled out without resistance up to the nozzle assembly.

Figure 4: Recovered sinker bar

The second batch involved the stimulation treatment oscillation process. This stage was aimed at wellbore cleaning to remove calcite scaling and initiate formation stimulation. The final stimulation step was primarily targeting formation stimulation to enhance permeability and productivity.

Upon completion of the chemical stimulation work, the client proceeded with a fishing operation to retrieve the tubing that

had been stuck since 2021. The operation was successful and enabling the reinstallation the CIS at a more suitable depth to inhibit calcite. In addition to the successful CIS recovery, the formation stimulation led to a notable increase in well generation, with output rising to 4.5 MW.

5. DISCUSSION

The case studies presented demonstrate that chemical cleaning of immobilized CIS tubing can be a highly effective and low-disruption alternative to mechanical intervention. Across different tubing types, scaling mechanisms, and operational environments, the Solenis-based approach successfully freed tubing, restored chemical delivery, and — in many cases — enabled further well stimulation and performance improvement.

Key insights from these field applications include:

- **Diagnosis and planning are critical:** Understanding tubing construction, scale type, and likely stuck point location are essential for designing an effective treatment. The combination of operator records, physical sampling, and tubing pull testing gives engineers a solid basis for treatment design.
- **Tubing type matters:** Armoured tubing is no longer utilised in geothermal fields in New Zealand. Modern stinger designs and effective maintenance of CIS strings ensures the reliable use with standard as drawn or annealed tubing sizes. Tubing size should be sized based on target inhibitor flowrate and dilution to ensure does pressure is above fluid saturation pressure downhole.
- **Operator coordination is essential**: Success depended on close collaboration between the wireline contractor, chemical team, and site operators. Timely access to historical data, surface tubing specs, and fluid chemistry accelerated both planning and execution.
- **Chemical cleaning avoids costly rig-based workovers:** In all cases, tubing was recovered without the need for a rig or coiled tubing unit. This represents a significant cost saving for asset owners and minimizes surface disturbance — particularly valuable in compact or constrained wellpads.
- **Post-treatment verification adds confidence:** The use of PTS logging and downhole camera inspection in some jobs provided direct evidence of treatment success and gave asset owners confidence to resume normal operations with modified CIS protocols.

These outcomes suggest that chemical cleaning is not just a contingency measure, but a practical, first-line intervention for many CIS-related issues. It offers a balance between technical rigour and operational simplicity, making it accessible to both large operators and smaller geothermal developers.

6. CONCLUSION AND RECOMMENDATIONS

This paper has demonstrated that chemical cleaning using the Solenis geothermal formulation is a reliable and effective method for recovering immobilized CIS tubing in geothermal production wells. Through successful field applications in New Zealand and the Philippines, the method has proven capable of dissolving scale deposits, releasing stuck tubing, and restoring chemical inhibition functionality — all without the need for rig-based intervention.

The approach is built around thorough diagnostics, surface-based chemical dosing, and coordinated field execution, and is particularly valuable where access, cost, or infrastructure constraints make mechanical recovery impractical. Importantly, the ability to confirm treatment success through wireline monitoring, PTS logging, and downhole camera inspections provides operators with a high level of confidence in the process.

Based on these outcomes, the following recommendations are offered to geothermal operators and asset owners:

- Integrate chemical cleaning into well intervention strategies as a first-response method for immobilized CIS tubing.
- Establish strong collaboration between operations, chemistry, and wireline teams during planning and execution.
- Maintain accurate records of CIS tubing specifications, installation depths, and dosing history to support future diagnostics.
- Consider regular flushing and injection validation tests as part of standard CIS maintenance to reduce the likelihood of immobilization.
- Utilize dissolution testing where samples are available to optimize cleaning programs and reduce treatment uncertainty.

Chemical cleaning represents a cost-effective, low-risk, and field-proven tool for sustaining scale inhibition in geothermal assets. Its application will continue to evolve as operators gain more experience and as new chemistry is developed to address increasingly complex scaling challenges.