Expandable Liners Remediate Casing

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HOUSTON—The number of mature oil fields around the world will continue to grow exponentially. That increase will necessitate repairing a large number of damaged casing strings where shutting off water and sealing old production perforations are required prior to targeting deeper reserves or restimulating existing zones.

As global demand for oil grows, and as developing new oil and gas reserves becomes riskier and more complicated, operators are looking for solutions that are more advantageous operationally than conventional methods, and that provide cost-efficient ways to maximize production in mature fields. Increasingly, they are examining new ways to improve long-term well life and productivity.

Restoring the productivity of aging wells often makes good economic sense. For example, in one North Dakota field, spending $1 million to repair a 30 barrel-a-day well and returning it to production is easily supported by considering life-of-well reserve recovery. Applied to the many aging wells in the area, casing repair could have a significant impact on field economics.

The development and use of expandable liners is helping this trend gain momentum. Applying expandable liner technology has resulted in companies taking a second look at mature fields that might otherwise have been abandoned. As depicted in Figure 1, using casing remediation solutions to overcome mature field challenges can result in a significant and rewarding increase in production.

Cased-hole expandable liners are helping North American operators improve the performance of their wells by safely restoring wellbore integrity and maximizing output. Applied as part of an integrated remediation system, the technology has a significant advantage as a casing repair methodology that restores long-term casing integrity and extended recovery for reduced intervention costs.

In contrast to short-term, inconsistent and unreliable cement squeezes, or conventional methods such as straddle packer systems and conventional liners, the expandable cased-hole liner system is a safe, reliable, and cost effective tool for restoring casing integrity. With single-trip installation and no drill-out required, both rig and nonproductive time are reduced significantly.

In many cases, expandable liners can be installed in one to two days, enabling the operator to test immediately and quickly return the well to production. Completions, production, and future interventions are optimized because the expandable liner conserves hole size to provide the largest possible wellbore inside diameter.

**Overcome Limitations**

Solutions achieved with conventional liners and packer methods often are limited or unacceptable because valuable hole size is lost. A smaller ID constrains the completion and ensuing production, and reduces options for future production optimization.

In 4½- and 5½-inch cased holes, expandable liners provide a permanent remediation option in smaller diameters where a standard liner is not a viable alternative. And while conventional liners are more cost effective over intervals measured in thousands of feet, expandable liners are a cost-effective solution for shorter sections.
with more specific problems.

Using straddle packers to isolate a casing problem can reduce ID even more than a conventional liner. While the straddle packer can be removed to allow work deeper in the well, it provides only temporary isolation and is not a permanent solution at the cost of severely limiting ID.

The other standard casing remediation method is a cement squeeze. While a very common repair method, squeezing typically exhibits unpredictable results, exposes the formation to high-pressure risks, and in the end, is a short-term treatment that often requires repeated application.

Although typically viewed as a lower cost solution, a cement squeeze ultimately may be a more expensive approach. A side-by-side comparison of a conventional cement squeeze operation and an expandable cased-hole liner illustrates the relative economics. A study of casing remediation methods found that when factoring in time-related expenses, the total cost of using a cement squeeze for a single repair operation was nearly $225,000, accounting for nine days from the time the rig was moved on location until the well was back on production.

Using the same base costs from a job performed for an East Texas operator, using a solid expandable liner saved an average of three days while incurring 36 percent less in associated costs.

The other cost consideration is that cement squeezes often are not successful on the first attempt. A second squeeze in the same operation could increase costs to nearly $291,000 and add two days of rig time. Using a solid expandable cased-hole liner, however, remains at the fixed cost and the overall savings rise to as much as 50 percent.

Engineered Approach

Expandable liner technology employs an engineered approach to reliably find the problem, prepare the wellbore, fix the casing, and recomplete the well without requiring any cement and applying any pressure to the formation during installation. The expandable liner approach has a strong and successful track record of repairing and remediating many common problems, allowing the operator to facilitate new completions and enabling hydraulic fracturing to optimize field output.

As depicted in Figure 2, cased-hole wireline logs are used to precisely locate casing problems, sources of water production, wellbore obstruction and bypassed production zones. These tools include advanced casing imaging tools and multisensory caliper tools used to locate internal and external defects caused by corrosion, scale, wear and failure.

Second, after the problem is identified, the wellbore is prepared for remediation. Depending on conditions, a variety of clean-out mills such as junk, taper, or watermelon mills (among others) could be deployed to provide a clear path for running the expandable liner. In addition, chemical, hydraulic, or other mechanical methods can be applied prior to installing the liner.

Third, remediation involves installing solid expandable cased-hole liners to cover the problem area. The expandable technology conserves wellbore ID while restoring its integrity. The liners can be run in short and long lengths to cover target intervals precisely. They are installed in a single trip, and require no cement or drill-out (Figure 3).

Finally, once casing integrity has been restored, a variety of cased-hole completion services are applied, such as packers, fracture plugs and artificial lift.

Fixing Leaks

Several case histories drawn on experiences in North America illustrate how cased-hole expandable liners have been used to restore wellbore integrity in a variety of remedial applications.

Cement squeezes—sometimes several of them—had failed to mitigate corrosion leaks in 7-inch, 26 pound-foot (lb/ft) casing installed in a North Dakota well. Running conventional casing significantly limited wellbore ID. To re-establish casing integrity for a 150-foot section, the operator elected to run a 5 1⁄2-inch, 17 lb/ft expandable liner.

The wellbore was cleaned and a wireline multisensor caliper tool was run to identify the extent of damage and determine the

![FIGURE 2](image1)

**FIGURE 2**

**Employing Expandable Liner Technology**

1. **Find the Problem**
   - Pinpoint casing problems, water production sources, and/or unwanted perforations

2. **Prepare the Wellbore**
   - Effectively prepare wellbore prior to remediation

3. **Fix the Problem**
   - Restore wellbore integrity using predictive, permanent and reliable long-term solutions

4. **Recomplete the Well**
   - Recomplete the fixed wellbore (if required) to maximize your potential reservoir output

![FIGURE 3](image2)

**FIGURE 3**

**Expandable Cased-Hole Liner Installation**
best remedy. Visualization software processed the caliper data to identify casing restrictions, assess drift ID, and determine casing damage. The analysis identified severe damage across the section that was the target for the expandable liner.

The cased-hole remediation provided a long-term, cost-effective means to restore casing integrity in the wellbore. The solution brought the well to full integrity standards in less than two weeks.

In California, a slotted liner section of a steam injection well was producing 600 barrels of water a day. It was critical that as much flow as possible be shut off. Multiple attempts using cement squeezes failed in about a week when the cement broke down. Installing an 80-foot expandable liner section succeeded in holding back more than 50 percent of the water, leading to further engineering to increase the water shut-off.

Because the application was in a steam injection well, the installation was subjected to temperatures of approximately 450 degrees Fahrenheit. As a result, standard elastomer seals rated to 300 degrees were replaced with swellable elastomers rated to 450 degrees F. The isolation joints and anchor are wrapped with HNBR (hydrogenated nitrile rubber) and swellable elastomers.

An operator in Alaska chose to remediate with expandable cased-hole liner technology soon after it was introduced to the area. About 1,100 feet of liner were installed successfully to repair the leak. The solid expandable system was highly effective in remediating the corrosion leak and provided a long-term solution, leading to plans by the operator to remediate additional wells.

**Restoring Production**

An operator in New Mexico needed to cost effectively cover and isolate perforations in 5¼-inch, 15.5-pound production casing to seal off watered-out zones and continue on to refracture new intervals.

A 4¼- by 5½-inch expandable liner with a post-expanded length of 700 feet was installed in the target interval at 5,000 feet. The installation covered and isolated the upper perforations so that newer intervals could be fractured at 5,500 psi.

The permanent liner provided an economic solution that eliminated the need for multiple cement squeeze operations. Unlike a conventional liner solution, the expandable liner maximized the hole size for optimal production and to facilitate future well intervention. A unique composite frac plug was used to allow the operator to set 5½-inch parent casing back inside after passing through the expandable liner.

In West Texas, a split in 5¼-inch, 20-lb/ft, N-80 casing threatened production. Remediation involved permanently sealing off the damaged casing section by covering and isolating the damage and re-establishing casing integrity.

A 4¼- by 5½-inch expandable liner was installed over the problem interval in a single trip to isolate the problem. Post-expanded length of the installation was 97 feet. Casing and hydraulic pressure integrity over the damaged interval was restored after installation. The liner solution provided long-term, stable, and cost-effective repair for the split casing, and brought the well to full quality, health, safety, and environmental integrity without multiple cement squeezes and the need for drill-out.

Multistage hydraulic fracturing in another West Texas well was enabled using a cased-hole liner system and a multisensor caliper tool to identify and repair damaged 5½-inch casing and to provide production packer seats.

After the extent of casing damage was determined, the wellbore was cleaned and prepared for a five-stage stimulation treatment. Four short, expandable liners were run and set below the damaged casing to serve as production packer seats. An upper 4¼- by 5½-inch liner was run and expanded to isolate a 125-foot section of damaged casing. Completion packers were set then to isolate the annulus from the production conduit. The success of the expandable liner installations led to six additional jobs with averages of 18-24 packer seats.

The number of aging oil- and gas-producing and injection wells in North America presents a tremendous challenge and opportunity. Located in a fully developed infrastructure, these assets exhibit a wide range of age-related casing integrity problems that often are key impediments to continued production and recompletions that can significantly extend well life and maximize production.

Expandable cased-hole liners enabled by an integrated process of finding, preparing, fixing and recompleting them changes the productive outlook for thousands of wells.

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