World's first solid expandable monobore liner extension installed in southeast Oklahoma well

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IN SEPTEMBER 2006, the exploration and production industry achieved a milestone — the world's first true monobore expandable liner extension system, successfully installed by **Baker Oil Tools** in a commercial well in southeast Oklahoma. The successful installation of the linEXX expandable liner system was the result of a collaborative development project ongoing since spring 2003.

PROOF OF CONCEPT

For a number of years, the E&P industry has sought to prove the feasibility of monobore expandable liner extensions as an advantageous alternative to conventional, telescoping casing designs. As a basis of design, the goal of an expandable monobore liner extension is to enable the operator to optimize drilling casing programs by drilling deeper wells with larger hole sizes at the reservoir. As a contingency plan, the goal is to enable the operator to isolate zones that contain reactive shales, subsalt environments, low-fracture-gradient formations or other drilling situations. Utilization of this technology will allow wellbore construction to continue without having to reduce the casing and subsequent drilled hole size.

Earlier in 2006, installation of recess shoes on 9 5/8-in. casing strings in 4 North Sea wells set the stage for future contingency applications of monobore expandable liner extension technology. However, the Oklahoma linEXX installation proved the applicability of the technology for a planned monobore expandable liner extension.

EXPANDABLE SYSTEM

The linEXX expandable liner system employs a top-down expansion system to extend a casing string while maintaining the same casing drift. The system provides an optimized, cost-effective casing configuration without the reduced hole size encountered in typical telescoping casing programs or with other solid expandable drilling liners. The system consists of 5 primary components:

- RC9 series casing shoe — a recess shoe installed with the previous 9 5/8-in. (or 9 7/8-in.) casing string that provides a means to positively locate the expandable liner in the previous casing string. It is available in 2 versions: one that facilitates cement circulation (RC9-R) and one that does not (RC9).
- FORMlock liner hanger/packer — an expandable hanger that locates in the RC9 series shoe and ties the linEXX liner to the previous casing string.
- linEXX casing — an expandable solid tubular run below the FORMlock hanger and expanded to 8 ½-in. ID drift. Pre-expanded OD of the linEXX casing is 8 in.
- RNX guide shoe — a retrievable guide shoe installed at the bottom of the linEXX string to guide the liner in the hole.
- catEXXSM top-down expansion system — the hydraulic expansion assembly used to carry in and expand the linEXX liner.

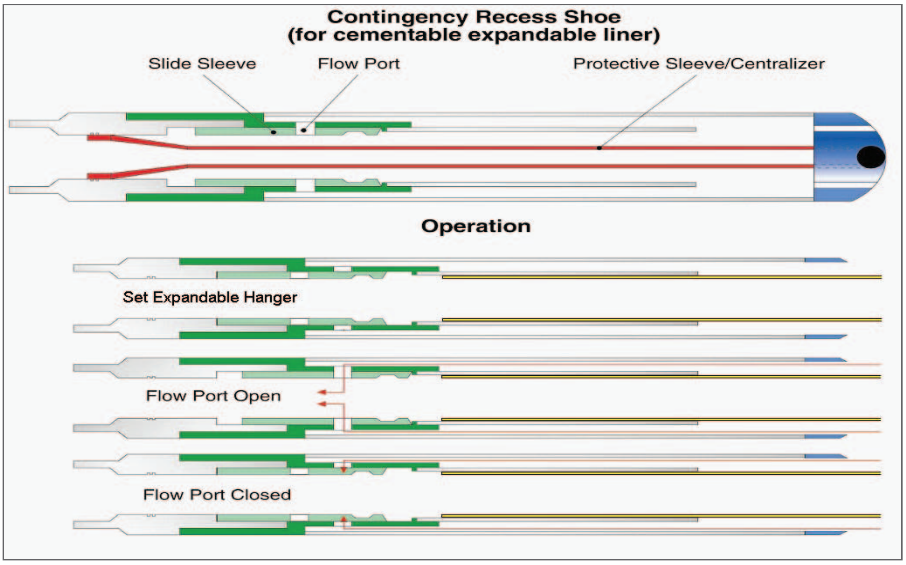


Figure 1: In the successful installation of the linEXX expandable liner system in southeast Oklahoma last year, the 9 5/8-in. parent casing and RC9-R shoe were run to a depth of 2,589 ft. The casing then latched and packed off in the surface wellhead. The parent casing string was run but left uncemented to allow for contingency removal.

The system accommodates expandable liner lengths up to 3,000 ft (914 m). The expansion system relies on pressure contained within the drill pipe to expand the liner. This design does not rely on drill pipe set-down weight or over pull, nor does it apply expansion pressure to the expandable casing or rely on a dart sealing process to assure pressure integrity during expansion.

The RC9 series casing shoe distinguishes the linEXX expandable monobore liner system from others that have an internal diameter (ID) size restriction from hanging off in the parent casing. The Baker shoe has a recess ID and location profile that enable the liner to be anchored on the bottom of the parent casing and then expanded into the shoe with no ID size restriction below the parent casing.

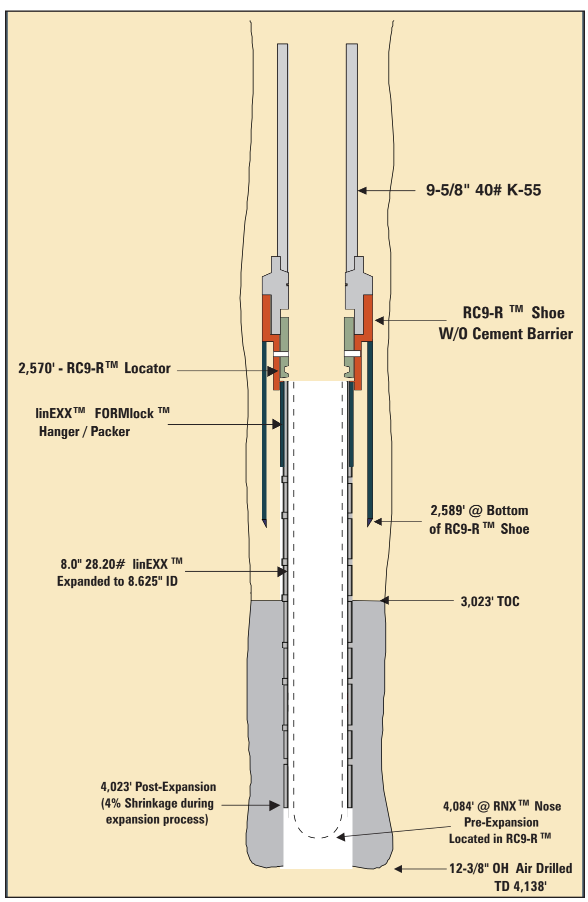
The top-down expansion approach emanated from a desire to address frequently voiced concerns about the risk of not being able to retrieve the expansion cone from currently available expandable products as a result of catastrophic loss of expansion pressure.

The expansion assembly consists of an anchor, hydraulic cylinder and expansion cone. As pumping begins, slips extend from the anchor and lock the expansion assembly in place. Continued application of pressure extends the hydraulic cylinder and moves the cone downhole in 15-ft incremental stroke lengths.

The top-down expansion method allows Baker to incorporate a retrieval collet into the expansion assembly, which makes it possible to retrieve the expandable liner RNX guide shoe, thus leaving an open ID through the entire length of the liner when it is fully expanded. Typical expansion rates are approximately 100 ft/hr (30m/hr).

Mass is conserved during expansion. In this case, the wall thickness thins only slightly, while the length shrinks approximately 4%. This shrinkage will cause a portion of the open hole at TD to not be cased by the expandable system since the expansion is top-down and shrinkage occurs at the "free" end, requiring some rat hole to be drilled below the specifically targeted trouble zone being isolated. The system is applicable to the majority of standard drilling hazards.

Figure 2 (above): As part of a recent Oklahoma installation, the liner was expanded 18% to 8 5/8-in. nominal and 8 ½-in. drift ID. The operations was performed in 15-ft (5-m) increments by applying drill pipe pressure to the expansion tool, then de-pressuring and slacking off. Figure 3 (below): In this fashion, the entire 1,514-ft (461-m) liner was expanded, completed with a truck-mounted cement pump to supply expansion pressure.



TESTING, MODIFICATIONS AND VALIDATION

A full-scale field testing program of the linEXX system has been conducted over the past 4 years. During this program, a key nondestructive test (NDT) method, deemed "enhanced UT" (Ultrasonic Transmission), has been proven as developed and designed. This proprietary method has now been implemented to perform acceptance and qualification of unexpanded 8-in. OD tubes. The field testing program also proved the functionality of several running tool modifications and helped to refine standard operating practices, improved running procedures and documentation.

OKLAHOMA INSTALLATION

The successful linEXX installation in Oklahoma marked the culmination of an extensive collaborative qualification, testing and field trial program. The system was installed in an air drilled 12 3/8-in. vertical hole at approximately 4,100 ft (1,250 m).

The 9 5/8-in. parent casing and RC9-R shoe (shown in figure 1) were run to a depth of 2,589 ft (789 m), and the casing latched and packed off in the surface wellhead. The parent casing string was run but was left uncemented to allow for contingency removal of the casing if needed.

A total of 1,514 ft (461 m) of 8-in. OD unexpanded liner was run in hole using running and handling procedures similar to those for chrome tubulars. Typical make-up torque of approximately 4,300 ft-lbs was verified by torque-turn equipment. After installing the FORMpack hanger, the catEXX expansion tool assembly was made up and the liner was run in the hole on drill pipe. The hanger was then positively located in the RC9-R recess shoe profile, and pressure was used to "stroke" the expansion tool and expand the hanger into the shoe.

The liner was expanded 18% (as shown in figure 2) to 8.625-in. nominal ID and 8 ½-in. drift ID in 15-ft (5-m) increments by applying drill pipe pressure to the expansion tool and then de-pressuring and slacking off to re-cock the tool until the entire 1,514-ft (461-m) length was expanded (figure 3). The expansion process was completed as planned using a truck-mounted cement pump to supply expansion pressure.

After retrieving the expansion assembly, post-expansion drift was verified by 2 independent methods. First a drift run was made with a stiff 3-point contact drilling assembly, which went "directly to bottom," thus providing "mechanical" assurance. This was followed by a caliper logging tool, which provided digital data to support the mechanical method. These verifications combined left no doubt as to the ability to deliver a well with 8 ½-in. drift to the customer to meet their needs and expectations.

A cement retainer was run in hole and set near the bottom of the expanded liner, and the liner was cemented in place using the same pump truck that had supplied expansion pressure. Cement volume was selected to ensure that the planned formation integrity test would be achieved without taking cement returns into the 9 5/8-in. casing through the recess shoe ports. No changes were required to the cement thickening time since the cement is pumped after expansion, a benefit of the linEXX top-down expansion method. After successfully pressure-testing the expanded liner, the retainer and excess cement were drilled out. Drilling then continued below the linEXX shoe with rotary steerable directional tools. The linEXX system was isolated with the production casing before completing the well.

linEXX, RC9 and FORMlock are trademarked terms of Baker Oil Tools.