EXPANDABLE LINER HANGER RESOLVES SEALING PROBLEMS AND IMPROVES INTEGRITY IN SHALLOW LINER COMPLETION SCENARIOS

PETE SMITH AND JAMES WILLIFORD
HALLIBURTON ENERGY SERVICES, INC.

Abstract
Liner hanger systems typically rely upon the primary cement job as the main method of sealing the liner/casing overlap. Liner top packers are run either integrally with the liner hanger or separately in a second trip. When cementing the complete liner is not feasible or obtaining a primary seal at the liner can not be achieved, the liner top packer must be used as the primary seal. In cases where the top of the cement is above the overlap, the liner-top packer is used as a back-up seal for the overlap.

Almost all liner top packers run integrally are set through the application of weight through the drill-pipe or landing string. The capability of the liner-top packer to seal at the maximum pressures rated requires that sufficient setting force be applied through the drill-pipe to the packer mechanism. Recently, work performed in Latin America showed the limitations of this process as a result of the shallow liner top and the string weight available to apply a setting force.

This paper will discuss how the problem was resolved with an expandable liner hanger. With this solution, the setting force for the packer was measurable and consistent. The expandable liner hanger successfully resolved the previous problems in two shallow installations in Latin America. In addition, three successful installations have been run in the UK, and one has been run in Oklahoma. In each case, several days of rig time were saved for the operators. The discussion presented here will verify the flexibility and integrity of the expandable liner hanger system.

Introduction

Historically, problems in obtaining a good primary cement job at the top of a liner have been associated with the installation of a liner in oil and gas wells. Innovations in technology to backup the primary cement job initially led to the development of the conventional liner-top packer, which is mechanically set by applying weight down. This method has been accepted along with most modern types of conventional liner hangers and setting tools to some degree by the industry. However, in some situations, it has not been possible to fully energize the liner-top packer sealing element where string weight is insufficient to apply minimum recommended weight down. In other cases, due to well deviation and/or drag, the pipe-weight deployed is not capable of acting effectively on the liner-top packer to affect the seal. As a conventional alternative to an integral packer, a secondary tie-back packer could be run, but this requires at least two extra trips into the wellbore and picking up of a string of large drill collars to be capable of supplying the force required. These solutions were not always cost effective.

Since conventional liner tops are prone to failure, an informal study performed in 1999 by operators in the Gulf of Mexico, highlighted several problems associated with liner tops during the 18 months prior to the survey **(Fig. 1)**.

Prevalent among the failure modes were:

- Loss of liner-top integrity—lap squeezes
- Packer/hanger/centralization issues—preset, or failure to set, failure to seal

- Failure of shoe integrity—shoe squeezes

These results confirmed earlier studies that identified the effort and expense that operators pursued to ensure liner-top hydraulic integrity.

Expandable liner hanger technology was designed to offer several major advantages over conventional systems, since it has capability to successfully run, cement, and isolate liner tops in shallow-wellbore situations **(Fig. 2).** This paper provides a detailed overview of that experience.

System Application Review

An operator in Latin America was having difficulty in obtaining a liner cement job where the cement, when pumped, overlapped at the top of a conventional liner that could not provide sufficient sealing integrity on its own. In an attempt to overcome the problems, technical options for sealing off the liner top were reviewed. When using conventional liner system technology, an option would be to use a liner-top tieback packer. This option would require a trip to clean out the tieback receptacle followed by picking up a string of heavy drill collars. Given the available conventional systems, the liner-top tie back packer was the preferred solution; however, due to the shallow depths at which the drill-string weight was available, there was not sufficient weight down to affect a useable seal. Additional tools, developed to assist in applying weight such as those used with bearing-race systems in highly deviated wells, would not have benefited the application. Thus, it was time to consider a totally new approach.

The New Solution

The expandable liner hanger offers several major advantages over conventional systems since is it is designed to successfully run and cement liners as well as affect a gas-tight seal in difficult wellbore situations. The expandable liner hanger combines the functions of the liner hanger and the isolation packer into a single component. With the new technology, the hanger uses elastomeric bands to provide the axial load capacity of a conventional liner hanger and the annular sealing capability of the liner-top isolation packer. The expandable liner hanger is expanded hydraulically with the liner running/setting tool assembly. During expansion, the elastomeric bands are compressed into contact with the ID of the supporting/intermediate casing, virtually eliminating the annular space between the liner hanger and the casing.[1, 2] An added advantage is that the liner-hanger/packer body does not contain slips, hydraulic cylinders, pistons, and setting mechanisms. Also, the setting mechanism is contained in the setting tool assembly and is retrieved, which eliminates potential leak paths in the flow stream. The following paragraphs describe the system more fully.

Expandable Liner-Hanger Body

The system incorporates the liner hanger body with an integral packer, a tieback polished bore receptacle (PBR), setting sleeve assembly, and a crossover sub to connect the assembly to the liner. The liner hanger/packer is manufactured from materials meeting critical specifications for maximum expandability and performance. The hanger incorporates bonded Viton™ elastomeric sections for high temperature and performance requirements; other elastomers are available should Viton not be suitable for wellbore conditions. The elastomers supply both sealing and hanging capability of the liner hanger. A single one-foot elastomer section on the 7-5/8 x 9-5/8-in. expandable liner hanger is capable of supporting over 350,000 lbm of hang weight. The 7-5/8 x 9 5/8-in. liner hanger body incorporates five of these elastomeric sections. In addition to providing the hanging capacity for the liner, the elastomers are the components that also provide the gas-tight seal.

The liner hanger/packer body does not contain any setting mechanism or external components such as slips, hydraulic cylinders or pistons. The hydraulic setting mechanism is contained in the setting tool assembly and is retrieved, eliminating potential leak paths in the flow stream. The liner can be rotated and reciprocated while running in the hole or during cementing operations as required. The 7-5/8 x 9 5/8-in. system's torque rating is 15,000 lbf. The hanger may not be rotated after setting as the elastomeric sections are expanded and will not allow any movement of the hanger at that point.

The liner hanger/packer is assembled with the liner setting sleeve and a crossover sub to connect to the liner. The crossover sub is machined with a pin down to match the liner connection. The liner setting sleeve incorporates a collet profile to accept the setting tool, eliminating any of the coarse running threads normally used on liner setting tools. The setting sleeve is designed to allow easy passage of bits, mills, wireline tools, etc. The pre-expansion ID of the hanger is nonrestrictive to the liner below, with the minimum ID through the assembly located at the crossover pin bored to the ID of the 33.7 ppf 7 5/8-in. liner connection.

The liner-top packer is an integral part of the expandable liner hanger system. The hanging mechanism and the sealing mechanism are provided by the elastomeric seals and are designed for individual support casing sizes and weights. As mentioned, the expandable liner hanger does not use slips to hang the liner. Instead, multiple elastomeric bands are used to support the weight of the liner and to supply adequate sealing capabilities. Support casing hardness has no affect on the ability of the hanger to support the liner. This design also allows for an immediate liner-top pressure integrity test. The standard tieback polished-bore receptacle (PBR) is manufactured from stock with a minimum yield strength of 125,000 psi. The PBR is designed to provide a balanced configuration with the tieback seal assembly. The tieback PBR seal surfaces are controlled to tight tolerances to optimize sealing capability and minimize seal extrusion gap for maximum seal pressure capability.

SIGNIFICANT FEATURES OF THE SETTING TOOL

Crossover Valve

The crossover valve provides several key components in the setting tool. The valve contains multiple ports to allow fluid flow paths for hydraulic expansion pressure and fluid returns during the expansion process. By providing a seal in the polished bore of the tieback receptacle (TBR), it also forms the upper limit of the pressure chamber created during expansion and the retrievable packoff. An additional significant benefit is the prevention of debris and fines ingress into the PBR/setting tool annulus, thereby assuring retrieval of the setting tool from the liner

Expansion Cone Assembly

Each weight range of support casing requires a unique expansion cone assembly. The expansion cone forms the lower end of the pressure chamber during expansion and provides the lower seal at the expansion face that is machined into the transition area between the TBR and the hanger body. The seal is maintained through contact pressure as provided by the compression spring in the assembly.

Bypass Sleeve

A bypass sleeve is incorporated onto the expansion mandrel. When the cone is driven down by pressure, the sleeve, which contains multiple seals, straddles a bypass port; when the sleeve is driven past the port, the fluid and pressure is allowed to bypass. This bleeds the hydraulic (applied) pressure, and stops the expansion.

Collet Assembly
The collets are engaged in the setting sleeve of the hanger body. They act to transfer the load of the liner string being conveyed into the wellbore to the drillpipe. They also transmit torque to the liner through contact with the collet retainer/torque adaptor. The collets are released at the end of the expansion process by moving the setting tool down, which shifts the collet retaining collar.

Discussion of the Hydraulic Setting Sequence
Unlike conventional liner hanger technology that requires weight down to affect a seal, the expandable liner hanger requires hydraulic pressure to drive an expansion cone through a hanger body while, at the same time, energizing the elastomer packages on the hanger body to the parent casing ID, forming a gas tight seal. (See Fig. 3)

The following steps indicate the basic sequence for expanding the hanger body.

1. Drop the setting ball
2. Allow ball to fall on its own or circulate it down
3. Apply pressure from surface to the top of the ball
4. Once the ball seats in the setting sleeve and shifts down, pressure is diverted to the crossover valve where it is channeled into the force multiplier and simultaneously to the face of the cone.
5. Pressure continues to be applied until the force required to expand and set the hanger has been reached.
6. Once the hanger has been fully set, the bypass sleeve is moved, and the pressure is relieved ending the setting sequence.

In all recorded cases, on average of less than 8 minutes to expand the hanger body from the time the setting ball is on seat until the by pass is opened and pressure relieved was required. Once the tool is on depth, the cement is pumped, and the shoe tacked, the liner hanger is set.

Case History
After a review of the available options, the new expandable liner hanger system was selected for the troublesome applications in Latin America for the following reasons:

- The hanger would allow for washing and reaming operations with no concerns of pre-setting the hanger.
- Zonal isolation over the cemented section would improve through pipe movement since the hanger is set after cementing.
- System rotates through difficult downhole sections with no fear of setting the hanger or releasing the setting tool.
- Less tortuous flow path directly around the hanger assists in reducing surge and equivalent circulating density.
- Primary or secondary liner-lap integrity is through hydraulically energized multiple redundant element packages with no set-down weight being required.

Conclusion
In the 2 case history wells in Latin America, the use of the hydraulically pressured expandable liner hanger system proved that it is possible to provide a gas tight seal, even with extremely shallow liner tops. In addition, the improved flow geometry and the capability to provide pipe movement during cement placement improved the success in the primary cement job. The operator in this case was able to save the cost of a tieback packer assembly plus the cost of two trips on each of the well completions.

The expandable liner hanger system has enabled successful deployment of liners in very difficult hole sections. Other advantages have included:

- integrity of tool performance in long difficult reaming operations through problematic shale beds
- a reduction in cement requirements since cement is no longer required in the lap section of a drilling liner to provide an adequate seal. Drilling liners no longer require cement throughout the lap and above the liner top, as the expandable liner hanger's superior seal prevents any pressure from jeopardizing the cement sheath integrity in the lap, allowing immediate cleaning.
- Immediate testing of the liner top since there is also no reason to wait for the cement to cure and develop full compressive strength.

The above benefits all contribute to significant savings in rig time, increasing cost efficiency for the operator.

Acknowledgements

The authors would like to thank the management of Halliburton for their support and permission to publish this paper.

References

1. Melvin J. Moore, M.J., Campo, D.B., Hockaday, J. L., Ring, L.: "Expandable Line Hangers: Case Histories,: Paper OTC 14313 presented at the 2002 Offshore Technology Conference held in Houston, Texas U.S.A., 6–9 May 2002.
2. Cantu, J., Smith, P., Nida, R.: "Expandable Liner Hanger Application in Arduous Well Conditions Proves Reliability: A Case History," Paper SPE 88510 presented at the SPE Asia Pacific Oil and Gas Conference and Exhibition held in Perth, Australia, 18–20 October 2004.

Viton® is a registered trademark of DuPont Company

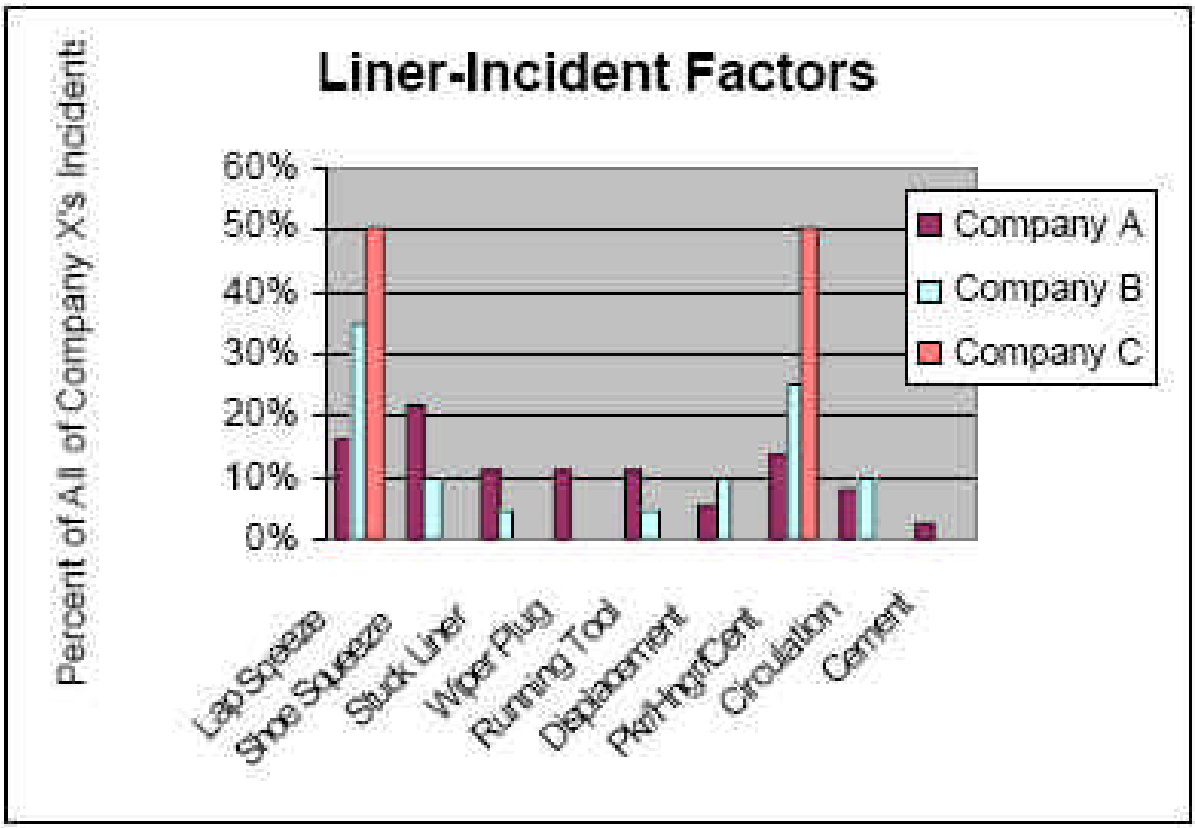
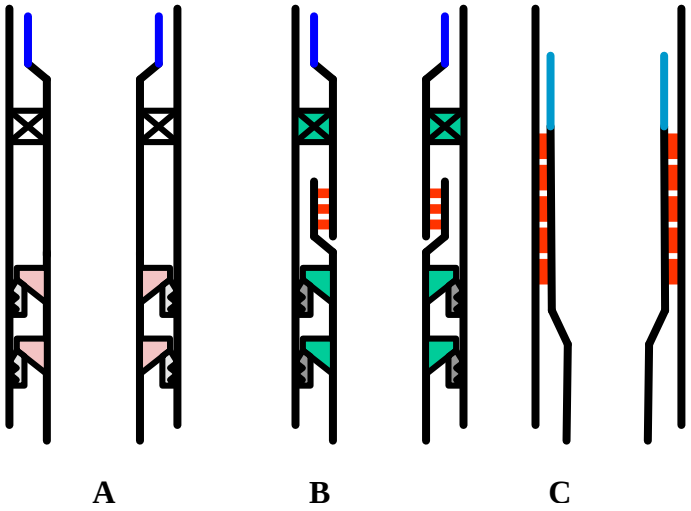


Fig. 1 - Liner-top failures



A. Conventional Single Trip Integral Liner Top Packer on Liner Hanger
B. Conventional Two Trip Liner Top Packer and Liner Hanger
C. Single Trip Expandable Liner Hanger

Fig. 2 - Comparisons of Systems

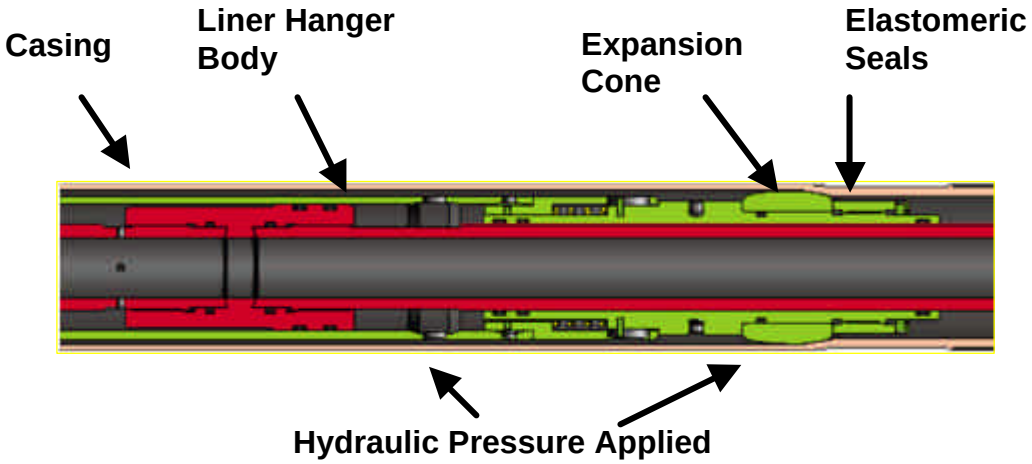


Fig. 3 - Figure showing application of hydraulic pressure to expand liner hanger body.