SPE 68507

Slimclearance – Small Diameter Reeled Exploration Wells and Conventional Well Deepening

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This paper was prepared for presentation at the SPE/ICoTA Coiled Tubing Roundtable held in Houston, Texas, 7–8 March 2001.

Abstract

A joint industry project (JIP) was formed in 1998, the object of which was to provide an effective solution to 'slim' down the wellbore geometry whilst overcoming the associated drawbacks of excessive swab and surge pressures during installation. After two years of research and development, the current system makes use of innovative coiled tubing completion technology to provide the safest and most cost effective well geometry possible.

The design philosophy was based on the following:

1. Minimum top hole diameter.
2. Minimum new equipment and technology.
3. Minimum operations required in the well or at surface.
4. Minimum risk while in the well.
5. Minimum cost.

The main technical challenges to overcome were:

How to terminate each liner hanger with so little annular space while still retaining the same tensile load capacity as the virgin pipe. This was achieved by engineering a unique liner hanger system which requires no moving components and forms a metal to metal seal with the previous liner.

To prevent the open hole being exposed to excessive pressures during liner installation, and while cementing. This was resolved by a novel conveyance system which allowed fluid to move from below the liner to above the liner while still providing circulation to the shoe, and when at setting depth converts to normal bottoms up circulation for cementing operations.

With the current trend towards smaller riser and casing configurations, particularly in deep water operations, this innovative development now allows a broader range of options for well architects. Unlike current practice wells may now be designed to fit within a reducing riser envelope whilst maintaining conventional size completions across the reservoir.

Project Objectives

The following criteria were the corner stones for this project;

Maintain usable diameter size across reservoir

Previously to reduce top hole size, meant a small hole across the reservoir which clearly restricted production, reservoir measurements and future servicing. The premise for this work was to maintain existing casing sizes across the reservoir section while slimming the overall casing wall thickness.

Integrate latest developments in drilling technology

Underreaming open hole had historically been very time consuming and fraught with mechanical problems. However, developments in under reaming while drilling10 particularly bi-centred bits has changed this whole aspect of reliable single trip under reaming. In addition, there has now been quite some success with bi-centred bit used for directional drilling. Finally, there are some exciting developments due for field trails which are true expandable bits, the results from which will provide invaluable assistance to enabling this technology to become established.

Use flush jointed and reeled casing with minimum clearance between casings

An essential component of this project was to minimise clearance between casing strings without expansion or casing deformation. This is the only other way of fitting the required number of casings into the well while still maintaining a small top hole size.

Provide full circulation capability while deploying
An essential aspect for deploying casing is that it is possible to circulate bottoms up at all times and have little or no swab and surge pressures. These are typically associated with running tight annular clearances, to overcome these in this project a novel circulation system was used which allowed fluid to equalise across the liner being deployed through an additional flow path created by a stinger tube fitted in the centre of the liner. The stinger tube also provided a flow path from surface to the shoe.

Avoid risk associated with expandable/deformable tubulars
Although the rewards for expanding tubulars downhole are great, there is also an associated risk. Due to the normally conservative nature of this industry it was a conscious decision to provide an alternative to tubular expansion.

Employ conventional technology and practice whenever possible
Again, an essential aspect to gain acceptance was to use conventional equipment design, conveyance procedures, setting tool operations and component recovery.

Development Plan
The project included, the detailed design, manufacture and bench testing of the individual tools, well simulated operation, with a full scale test planned to demonstrate the operation of the entire system.

Phase I
The first phase of the project was to concentrate on a flush jointed casing solution. It included detailed engineering of the hardware, prototype manufacture and bench testing. From the initial concept considerable redesign went into the system so that it could achieve full circulation while being conveyed to TD, and allow the liner hanger to be set in any section of flush pipe.

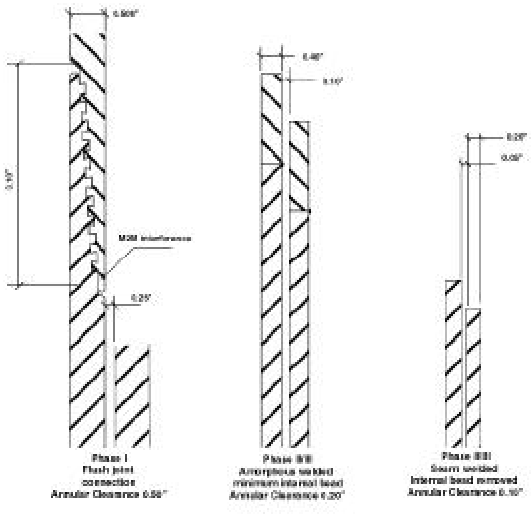

Figure 1

Phase II
This phase of the project is currently ongoing and is tasked with preparing all the necessary casing and hardware to convey a 6" liner into a conventional 7" casing sting. This has completed all it bench testing phases and is currently awaiting field trails

Phase III
Further phases of the project aim to slim the clearance much further and this will be achieved by using seam welded coiled tubing which is currently available in sizes up to 6.5/8" diameter. Wall thickness is these applications will be .200" and annular clearance will be 0.100" providing steps in casing sizes of 0.500". This will have applications for hole deepening, multilaterals and potential exploration pilot wells.

Wellbore Architecture
Figure 2. illustrates examples of wellbore geometries using smaller diameter riser systems. Although not shown these may be terminated in conventional sleeved wellheads or wellheads manufactured specifically for the smaller riser and BOP required. Although this is not detailed in this particular paper, significant work has been conducted by all the wellhead manufacturers for small diameter systems.

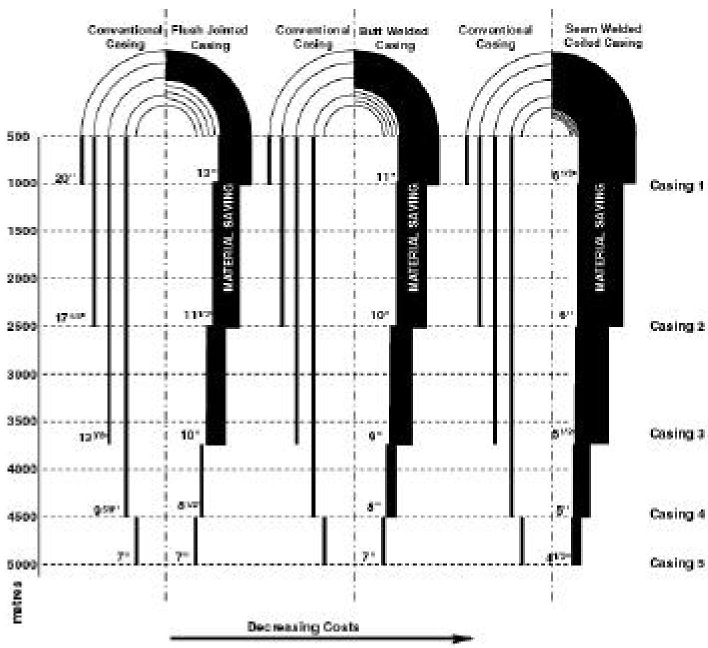

Figure 2

The process of well constructing a well as a series of liners offers the following advantages:

- Reduced tensile loads, both at the wellhead and in the entire section being deployed;
- Reduced rating of conveyance tubing (of more relevance when deploying with coiled tubing);

- Reduced load and storage requirements on vessel for deepwater operations;
- As a consequence of the conveyance hardware no swab/surging issues as with conventional slimhole wells, while maintaining complete well control;
- Potential to integrate expanded casing developments, thereby increasing the surface steel thickness the deeper the well is drilled, and hence its structural integrity;
- The reduction in size also has an impact on the drilling fluid selection. Smaller hole volumes make the selection of high quality drilling fluid more economic. This in turn enhances the drilling process and reduces the risk of other hole / drilling fluid related problems. Also high quality mud selection assists in the mechanical location and operation of the conveyance and landing hardware.
- Potential for casing deployment with well at balance (using coiled casing);
- Tie back liners can be installed as the well is deepened, to provide "sacrificial" wear liners for the drilling process, provide additional pressure containment barriers or increase the structural integrity across a particular high pressure zone, and
- Monobore production tie back string could be installed under live well conditions if large diameter coiled tubing is used.

Open Hole Underreaming

An essential component for the success of both this casing and expandable casing systems is an efficient one trip under reaming system to enlarge the open hole to a size equal or larger than the OD of the previous casing. This is currently achieved using a bi-centred bit. Figure 3. shows an example of this. These are capable of drilling out the previous shoe and then expanding the open hole to the limit of the radial offset of the eccentic cutter. These have also shown they are capable of directional drilling so providing an under reaming drilling system for the entire length of the well.

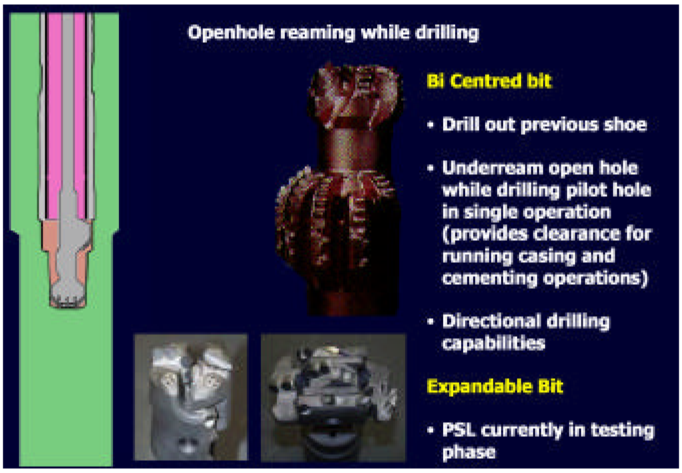

Figure 3

Liner installation operation

The major obstacle to overcome while installing the liner system is that the very small annular clearances produce extremely high equivalent circulating densities (ECDs). This is turn can cause excessive pressure in the open hole section resulting in lost circulation or, in extreme cases total loss of wellbore fluids to a weaker formation. This has a considerable impact on well control issues, increased cost due to the loss of drilling fluids and potential damage caused to the reservoir itself.

These drawbacks are overcome by an innovative liner running tool and float collar/shoe which are connected by a flow tube (stinger tailpipe). This combination provides a high flow rate circulation path while conveying a new liner into the well, while converting to a conventional circulation mode when it has reached its setting depth.

High circulation facility while running in hole

Figure 4 shows a high circulation rate flow path exists to the shoe (via the conveyance tubing) through the "stinger tailpipe" connecting the running tool to the float shoe. The return path passes through ports in the float shoe to the inside of the liner and then via ports in the running tool back into the annulus around the conveyance tubing. This circulation path provides excellent hole cleaning capability, while exerting minimum circulation pressure on the open hole. The liner can also be rotated while being lowered into the well and, if used in combination with a reaming shoe[10], the risk of getting stuck is greatly reduced.

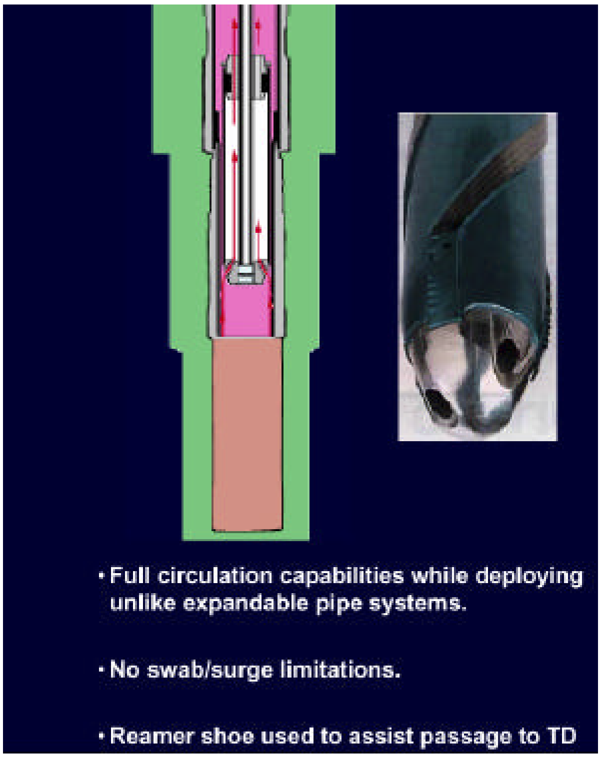

Figure 4

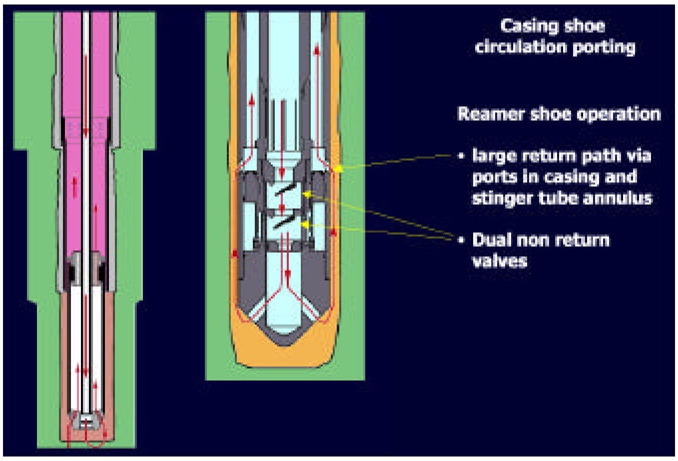

Figure 5

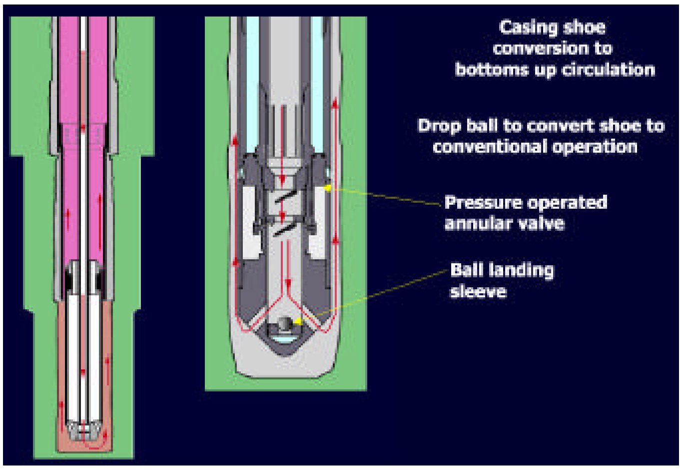

Figure 6

Casing Shoe Design and Operation
Referring to figures 5 and 6, the high circulation rate to wash and clean in front of the shoe is achieved by circulating the returns through unique porting back inside the liner being run. Once the liner has reached the necessary setting depth, a ball is dropped which lands and seats on the sleeve retaining the non-return valves open. Internal pressure is applied from surface and, at a predetermined pressure shear pins are activated which allow the annulus valve to move to the closed position. The ball and sleeve continues moving downwards where it is stored in a catcher sub. This process allows dual non return valves to become active for the cementing operation.

Liner Setting Tool Design and Operation
The tool achieves the following functions:

- supports the liner being conveyed into the well
- provides circulation modes during the conveyance and cementing operations
- provides surface indication of correct landing position.
- incorporates the securing and sealing mechanism.
- it can be released both in its designed manner and in an emergency override mode to allow safe recovery to surface.

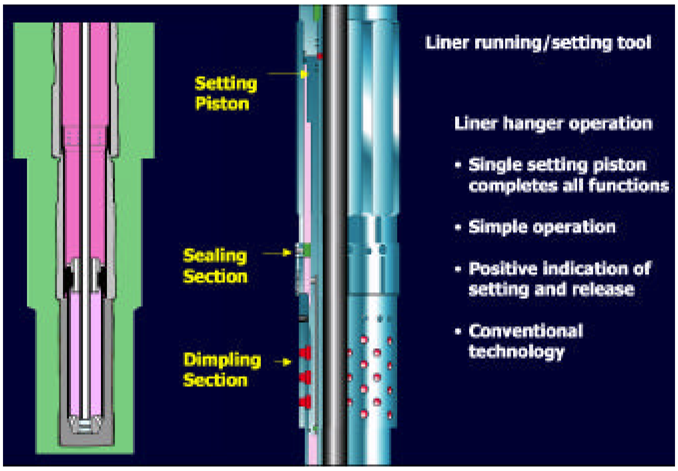

Figure 7

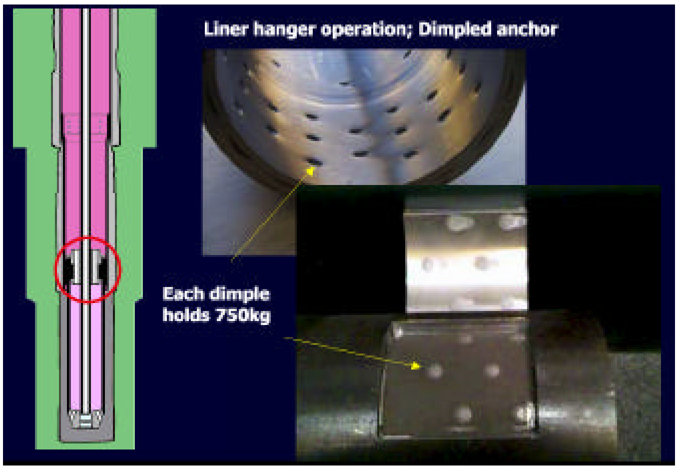

Figure 8

Figure 7 and 8 show the liner conveyance and setting tool. Technology has been adapted from production systems to provide a positive location while running the liner to TD. Once at setting depth, the liner may be rotated during the cementing operation. When required the setting piston is activated, this energises a series of dimples which anchor the liner to the previous flush casing. Once all the dimples have been energised, the hybrid metal-metal and elastomer seal is energised. At the end of its stroke, the piston activates a release collet which allows the running tool to disengage and be recovered to surface together with the stinger tailpipe.

Synergy with other industry developments
With the increased focus in activity in deepwater developments, ways of reducing exploration costs are being investigated and positive steps are being taken. One such project being considered is to use 6.5”CT or 8.0”butt welded tubing as a riser. This project offers an ideal link using readily accepted technology for immediate use in the deepwater

exploration market. Figure 9 show a reeled riser vessel currently under development for CT well intervention applications where the ultimate savings and rapid application of this technology are envisaged.

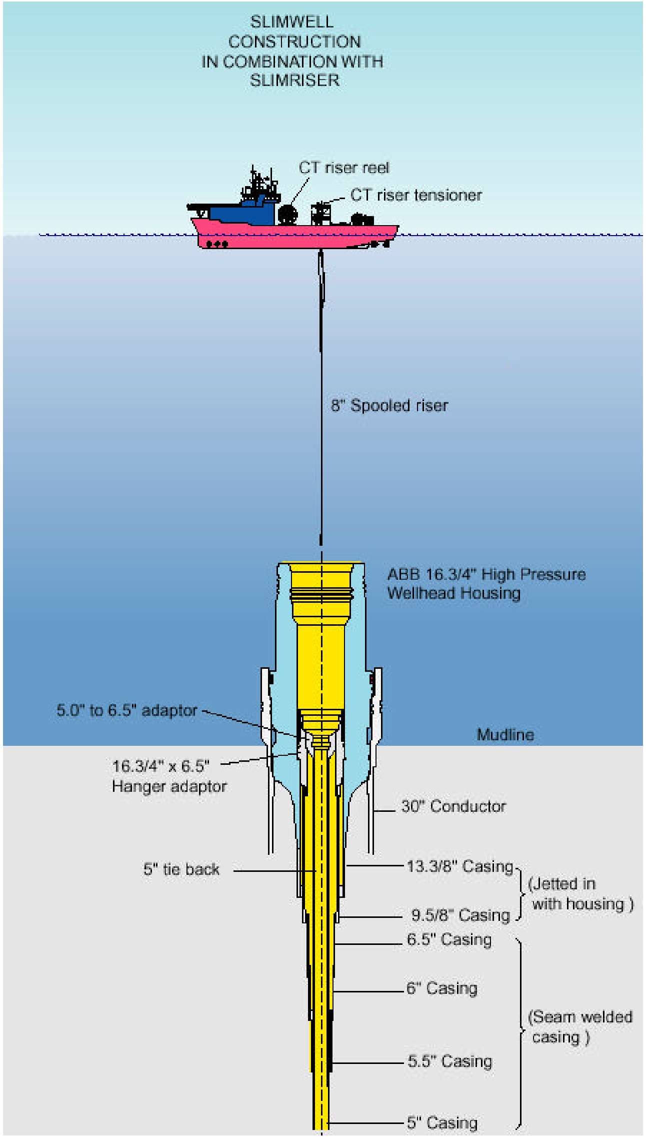

Figure 9

Summary
With the increased focus on deepwater drilling and the slimming down of risers, the results from this project could offer considerable advantages for reducing well costs without sacrificing hole size across the reservoir.

The main advantages of the system are:-
- A conventionally sized bore is maintained through the reservoir.
- Reduced logistics, handling and disposal costs.
- Simple, and effective liner hanger system.
- Significantly reduced well drilling and completion costs.
- This innovative development now allows a broader range of options for well architects.

Acknowledgments
The authors wish to thank the support and permission of the supporting companies to present this paper. These being ENI Agip SpA, Amerada Hess, BP Exploration Co., Enterprise Oil plc, Saga Petroleum ASA and Shell International.

References
1. Hans Hopper, US patent number 5,307,886 Method for casing a hole drilled in a formation
2. R.N. Worrall et al. “An Evolutionary Approach to Slim-hole Drilling Evaluation and Completion” SPE24965 Europec 1992 Cannes France
3. E Carstens et al “Slimhole Drilling and Well Intervention from a Light Vessel” IADC/SPE 35043 IADC/SPE Drilling Conference 1996 New Orleans USA
4. Roger W Jenkins “New Concepts Lower Deep Water Drilling Costs” SPE30466 SPE Annual Conference Dallas 1995
5. E Kroell et al “Slimhole Completion and Production - What to do after we drilled the well” IADC/SPE 35129 IADC/SPE Drilling Conference 1996 New Orleans USA
6. B R Ross et al “Innovative Slimhole Completion” SPE24981 Europec 1992 Cannes France
7. C E Robison “Monobore Completions for Slimhole Wells” SPE 27601 European Production Operations Aberdeen 1994
8. Erwin Kroell et al “Slimhole Completion and Production” JPT September 1996 p846-847
9. R Cooper et. al. “Novel coiled tubing workover riser for cost effective well intervention” 2nd International Conference in Riser technologies. Aberdeen 25-26th June 1997
10. Reamer shoe Offshore Engineer April 1998 page 50