Riserless Casing Seat Optimization: a Big Bore Liner Drilling Application

An innovative approach for a reliable deepwater well design


Owned by -
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Concept presented at:
- IADC/SPE Drilling Conference in New Orleans, LA in February 2010, IADC/SPE 127817 Riserless Drilling with Casing: Deepwater Casing Seat Optimization

11/06/13 RCO & Liner Drilling
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1. Introduction to Riserless CasingSeat Optimization

Unique patented well design process for placement of casing strings in the riserless well sections

Presented at 2009 OTC & IADC/SPE 2010
Developers: Seasoned drilling engineering professionals in well engineering & drilling hazards management

Uses pore pressure/fracture gradient geological properties to select optimum casing seats

Current practice is “top set” geological & drilling hazards with casing
With RCO, 36” conductor is dual purpose – structural support & suitable casing seat for increased reliability
RCO decreases casing strings & results in more reliable well design

Casing drilling

Vehicle to mitigate shallow hazards
Require development of purpose built tools & service
Secondary benefit is added drilling efficiency
(12) United States Patent
Pritchard et al.

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(54) METHOD AND SYSTEM FOR RISERLESS CASING SEAT OPTIMIZATION

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(57) ABSTRACT

A system and method for optimal placement of a riserless casing in a subsea drilling environment having the steps of: receiving input of pore pressure data for a well site; receiving input of fracture gradient for said well site; receiving input of the anticipated true vertical depth of said well site; integrating pore pressure data, fracture gradient data with said true vertical depth values; computing a pore pressure and fracture gradient verses true vertical depth graph; determining the true vertical depth at which the pore pressure begins to exceed the normal gradient of salt water; and determining the placement of a conductor casing string by corresponding the gradient true vertical depth to the true vertical depth of where the pore pressure beings to exceed the normal gradient of salt water. The method improves upon conventional placement of the riserless casing by optimizing the placement to achieve larger diameters in the wellbore, increased well depth, and mitigation of shallow hazards. Furthermore, the method of the present invention transforms readily available data to calculate optimal placement of a structural casing string to serve a dual purpose by providing not only structural integrity for the wellbore, but also ensuring leak-off integrity by taking advantage of the early growth of the fracture gradient of the natural subsea environment. Also, the suggestion that casing drilling will assist in mitigating shallow drilling hazards to allow casing seats to be placed as prescribed by this present invention. The method of the present invention may be implemented by a computer based apparatus or implemented using executable computer code on a computer based system.
Industry Recognition of RCO Value

*Shell SPE 156254: Narrow Margin Drilling in Deepwater – Solution Concepts*

“Kotow and Pritchard (2009) have shown that in DW, where drilling with casing is used to deepen the otherwise maximum allowable drillable, especially in top holes, there has been tangible value added.”

*Shell & Halliburton SPE 147189: Casing-Running Analysis in Riserless Topholes*

“There are other references (Kotow et al 2009) using the casing drilling in riserless environment to reduce the cost of operation in addition to the advantages of riserless drilling.”
2. The Current Well Design Basis in Deepwater GOM
Current Deep Water Well Design

• Is not reliable for deep water challenges, especially in exploration operations (Slide 6 indicates random performance for complex GOM wells, nor learning)

• The positioning of 20” or 22” casing, with HP wellhead housing, is dominated by shallow drilling hazards which requires large number of casing strings:
  – Often exasperates narrow operating windows with high ECD’s, preventing to reach well objectives. Refer to Slide 7 for ECD reduction with larger annulus.
  – Limits opportunities for geological & mechanical sidetracks, no available contingency casing strings
  – Decreases optimum completion size
Deepwater Exploration Well Trends*

- Most planned deepwater exploration wells are greater than 8000 MRI
- There is no general learning curve
- Many wells are > 10,000 MRI, with a reverse learning curve
- Wells that failed to reach planned TD, are not normally reported to Dodson, and there are many ....
- **BP Macondo was reverse learning with current well design**

* Mechanical Risk Index Data supplied by J.K. Dodson Company
Comparison of Current Well Design
Deepwater & Onshore/Shallower Water?

Onshore / Shallow Water

Bottom Up Design

Once pore pressures & fracture gradients are estimated, the desired casing size at TD generally determines casing points to surface.

Deep Water

Top Down Design

Driven by Shallow drilling hazards mitigation to determine riserless casing points.

Mitigating shallow drilling hazards with casing/liner drilling to deepen riserless casings to make design more reliable like the onshore/shallower water design.
3. The Riserless CasingSeat Optimization (RCO) Concept
Recommended RCO Practice

- Top of Salt: 6700'
- Mudline: 3500'

- Pressure/Fluid Densities - ppg
- FG+400 psi in Salt
- OBG RHOB
- PP Mid Supra Salt
- DG MW ppge

Shallow Hazard

36" Csg
Recommended RCO Practice

- **Top of Salt - 6700'**
- **Mudline - 3500'**

- **Pressure/Fluid Densities - ppg**
  - FG+400 psi in Salt
  - OBG RHOB
  - PP Mid Supra Salt
  - DG MW ppge

- **Depth - ftKB**
  - 28" Csg
  - 36" Csg
  - Shallow Hazard

- **Recommended RCO Practice**

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RCO & Liner Drilling
Recommended RCO Practice

- Recommended RCO Practice

- FG+400 psi in Salt
- OBG RHOB
- PP Mid Supra Salt
- DG MW ppg

- Top of Salt - 6700'
- Mudline - 3500'

- 36” Csg
- 28” Csg
- 22” Csg

- Shallow Hazard

Depth - ftKB
Pressure/Fluid Densities - ppg

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RCO & Liner Drilling
8 vs 6 casing strings ....

Deepwater GOM Well Design
Conventional vs RCO Casing Drilling

Pressure Equivalent - ppg

Depth - ft KB

Salt

- OBG
- FG + 400 psi in Salt
- 90% OBG in Salt
- PP high rge Supra Salt
- PP high rge Sub Salt

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Another GOM Deepwater Example

(Next Slide)

1. Decreases casing strings by one w/ 18 5/8” to depth of the previous 13 5/8” casing

2. Decreases well cost (5 to 10 days per hole section @ $1 million/day)

3. Increases operating window at deeper depths and across targets

4. Increases opportunities for geological & mechanical sidetracks

5. Creates more reliable well design to maintaining BHP between PP & FG during drilling & cementing (reduced ECD with larger hole section)
1. 36"
2. 28"
3. 22"
4. 18” and so on
RCO difference ...

GOM Deep Water Current Practice vs RCO

- Time saving in riserless section
- 22” significantly increased
- Larger hole near TD
- 14 less days
Larger hole sizes reduces ECD, the Biggy ...

Proposal is at least 200 psi less ECD, which can be the difference between a successful or junked well.
4. Summary of Casing / Liner Drilling Technology
RCO & Riserless Liner Drilling

• RCO uses PP/FG data of the riserless hole sections to determine casing setting depths rather than “top” setting shallow drilling hazards, as in current practice.

• In riserless hole sections, RCO proposes casing strings be drilled-in with landing string, hence liner drilling.

• Casing drilled vertically with drill shoe or directionally with inner BHA & LWD for formation evaluation.

• No modifications to existing wellhead to land casing in wellhead (only PDM/bit rotating for last casing joint).

• Casing cemented with pre-run cement plugs as in liner operations.
Liner Drilling – Well Design Improvement

Drilling Hazard Mitigation: loss of circulation, shallow water/gas flow & wellbore instability
Smaller annulus results in more efficient fluid displacement for well control & better cement zonal isolation

Able to determine casing points from pore pressure / fracture gradient estimations rather than drilling hazards

Reduction of casing strings in well design

Reduction of operating time:

1) Decrease number of casing strings

2) Drill & run casing simultaneously

3) Reduction of NPT with DHM
Description of **Casing Drilling**

1. Casing drilling an established process of simultaneously drilling and casing a hole section

2. The traditional primary drivers are:
   
   i. **Efficiency** - Improves well construction by drilling and running the casing in the same operation
   
   ii. **Enabler** - Reduces Non Productive Time with drilling hazard mitigation of loss circulation, well bore instability and well control, with its “smear” effect and small annulus

3. Casing connections are subject to severe drilling conditions, requiring satisfactory torsional strength, ability to resist fatigue & adequate sealability

4. Fatigue damage more dominate in deviated, extended reach wells or deep water due to VIV (vortex induced vibrations)
Casing Drilling - Enabling Technology

- Mitigates deep water drilling hazards: water/gas flows, loss of circulation, hole instability & can eliminate shallow gas pilot holes

- Decrease loss of circulation & improves wellbore stability with “smear or plastering” effect, “hardening” the wellbore area increasing FG, allowing deeper casing seats

- Drastically reduces mud volume of riserless sections (<< ½ of current practice): cost savings, logistics savings ...

- Smaller riserless annulus allows better well control with efficient annular fluid displacement
Casing Drilling: Smear Effect

- Particle size distribution performed on cuttings of casing drilled well indicate cuttings generated are unusually small, compared to larger conventional drilled cuttings

- Drill cuttings in the narrow hole-casing annulus are pulverized by side loading forces of the rotating casing

- Particles tend to become embedded in wellbore wall to help form a natural seal that is much more impermeable than a wall cake produced by mud additives alone

Casing while drilling “smear effect” improves wellbore stability – Fontenot, Strickler & Molina World Oil March 2006
Casing Drilling Torque

- Torque forces during casing drilling result from rock removal, and the resistance along the casing string from rotation.
- Casing string torque has two components, one is viscous drag, usually ignored, and the other is from friction against the wellbore.
- Torque of the bit, and under reamer, is due to rock removal and can be determined from the specific mechanical energy to remove the rock.
- Torque due to friction against the wellbore is proportional to the normal force and the wellbore string friction factor. It is in direct proportion to wellbore curvatures, tortuosity and dog legs.
- The surface drilling torque shall not exceed the maximum connection yield torque, nor the capacity of the rig’s top drive. The maximum torque value is in the top joint.
Casing Drilling Fatigue 1 of 3

1. Fatigue loads originate from curvature of the well, well tortuosity, string buckling, whirling and string vibrations
2. The bending stresses in the casing string are a combination of cyclic loading due to wellbore tortuosity and its rotation generating alternating tensile and compressive stresses
3. Aim of fatigue analysis is to evaluate the cumulative fatigue life of the selected strings (OD, linear mass, grade and connection) for a pre-defined drilling operation
4. Most common tool to characterize performance under fatigue loading is the S-N fatigue curve: the magnitude of alternating stresses is indicated in the Y-axis, while the number of cycles to failure (measured experimentally) is indicated in the X-axis
5. Usually 70% of cumulative fatigue life identified by the S-N curves is adopted as the maximum recommended value, however 20% is the maximum recommended useable fatigue life
Casing Drilling Fatigue 2 of 3

6. Different materials have a fatigue limit or endurance limit which represents a stress level below which the material does not fail and can be cycled, or cold worked infinitely, typical of steel in benign environmental conditions.

7. Endurance limit is not a true property of the material since other factors influence such as: surface finish, temperature, stress concentrations (connection design), notch sensitivity, size, environment (corrosive)

8. The S-N curve defines the endurance limit which is a function of:
   • Connection design (type)
   • Material (steel grade & composition) - endurance limit is related to UTS
   • Size (diameter & thickness) – not possible to define deterministic trends
   • Mean stress – the S-N curve to left-low when mean stress increased

9. Connection designs / types can be classified as:
   • Integral flush
   • Semi flush
   • T&C BTC type
   • Integral Upset.
Casing Drilling Fatigue 3 of 3

Nominal stress amplitude (s) vs. cycles to failure (N)
Curve A - Typical steel in benign environmental conditions, stress below endurance level has a infinite life
Curve B - Have continuously decreasing S-N response, fatigue strength for no. of cycles must be specified
Is liner drilling of these large casing OD’s feasible?

Required torque within limits of current deepwater top drive systems
Is liner drilling of these large casing OD’s feasible?

Required torque within limits of current deepwater top drive systems.
Liner Drilling – Notional Running Procedure (1st Casing String)

1. Pick up casing drill shoe joint

2. Pick up required casing length & 36” or 30” conductor housing

3. Pick up inner cementing string & run in hole

4. Pick up RCO liner running & drilling tool, make up to inner sting, stab in float collar & grab inside of conductor

5. Rotate at optimum RPM to drill to casing depth as per FG

6. Circulate annulus clean, begin cementing operations

7. WOC & then pull out of hole with inner string
Liner Drilling – Notional Running Procedure (2\textsuperscript{nd} & Subsequent Casing Strings)

1. Pick up RCO reamer shoe joint, required casing length & 28” wellhead housing
2. Pick up inner BHA (under reamer, PDM, logging tools) & run in casing. BHA sticks out of casing.
3. Pick up RCO liner running & drilling tool, make up to inner BHA & grab inside of casing string
4. RIH to drill out float collar & drill shoe, continue to drill to section TD based upon FG
5. Stop casing rotation when 28” housing is near conductor hsg
6. Pull RCO liner running & drilling tool out of 28” casing to release set down dogs to push casing to land into conductor hsg
7. Pick up RCO subsea cementing plug launchers to prepare for cementing operations
5. The Riserless CasingSeat Optimization*
Opportunity

* Registered trademark of David M Pritchard & Kenneth J Kotow
The Opportunity – **Casing Drilled Well**

Develop big bore liner drilling into a high impact on safety and cost for deep water technology

- Integrate all services & products to mitigate drilling hazards to develop a more efficient drilling process i.e. operator – service provider win-win
- Develop casing/liner drilling for every deep water hole size
- Run BHA inner strings drilled-in casing where required for drilling performance & data acquisition, using PDM’s & LWD
- Integrate MPD to further improve ECD management for drilling risks & improved performance in narrow operating windows
## SWOT Analysis/RCO & Big Bore Liner Drilling

### Strengths
- ✓ Increase PP / FG operating window, previously undrillable wells now drillable
- ✓ Decrease number of casing strings: less well time, less casing material
- ✓ Mitigates shallow drilling hazards
- ✓ No need 5th / 6th gen rig riserless section
- ✓ Significant decrease mud & cement in riserless sections

### Weaknesses
- ✓ No experience in deep water shallow hazards mitigation
- ✓ Drilling with casing/liner technology not developed for required large casing diameters & weights
- ✓ Limited data for large casing connections to withstand drilling fatigue (but exists for VIV of risers)

### Opportunities
- ✓ Become a leader in deep water drilling technology
- ✓ High revenue potential
- ✓ Pull in related technologies into well design
- ✓ Low risk of $ to prove application
- ✓ Take casing/liner drilling to higher level of utilization

### Threats
- ✓ Fear of change (high)
- ✓ Failure to mitigate shallow hazards (low)
- ✓ Belief dual gradient drilling is a replacement
- ✓ Unknown drilling casing coupling for large diameters
The RCO Opportunity

**Operator**

• Lead deep water well design development

• Provide safer drilling operations

**Service Provider**

• Develop technologies to capture RCO deep water opportunities

• Adapt existing technologies and product lines for deep water niche

• Supply full cycle deep water well construction services, leveraging increased product line utilization

• Increase reliability attaining well objectives

• Decrease deep water well costs

• Improve utilization of rig fleet (lighter older rigs for riserless sections, newer heavier rigs for riser sections)
What’s Next?

Form Joint Venture Development group with an Operator, Major Service Provider and RCO Engineering Team for further RCO patent development

**For the Operator:**
- Provide well objectives
- Provide deep water drilling engineering expertise
- Provide pilot well(s) to trial large diameter casing drilling

**For the Service Provider:**
- Provide expertise & facilities for development of large diameter liner drilling (include casing couplings)
- Integrate product lines for RCO Casing Drilling application

**For Patent Owners:**
- Provide engineering expertise in RCO development & well engineering
- Develop software framework for RCO implementation
The End

Thank you

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