Well Control When Drilling With a Partly-Evacuated Marine Drilling Riser LRRS

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CTO
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Applicability of LRRS

New well control procedures needed when drilling Intermediate sections (Overburdon)
Case 1 GoM: Conventional Drilling

Gradient (ppg)

Pressure (psi)

Frac_Data
Pore_data

LOSS
KICK

Depth (ft TVD)
Case 1 GoM: Drilling with LRRS

Gradient (ppg)

Pressure (psi)

Mud Weight: 17.2 ppg

Frac_Data
Pore_data
Case 2 Macondo: Drilling with LRRS
Case 2 Macondo: LRRS Improves Margins
# Case 2 Macondo: Riser Margins with LRRS

## Gradient (ppg)

<table>
<thead>
<tr>
<th>Casing/liner</th>
<th>Conventional</th>
<th>LRRS @ 1700 ft</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mud Weight</td>
<td>Riser Margin</td>
</tr>
<tr>
<td></td>
<td>[ppg]</td>
<td></td>
</tr>
<tr>
<td>22&quot; Casing</td>
<td>9.6</td>
<td>Yes*</td>
</tr>
<tr>
<td>18&quot; Liner</td>
<td>10.1</td>
<td>No</td>
</tr>
<tr>
<td>16&quot; Liner</td>
<td>11.1</td>
<td>No</td>
</tr>
<tr>
<td>13 5/8&quot; Casing</td>
<td>12.3</td>
<td>No</td>
</tr>
<tr>
<td>11 7/8&quot; Liner</td>
<td>13.3</td>
<td>No</td>
</tr>
<tr>
<td>9 7/8&quot; Liner</td>
<td>14.0</td>
<td>No</td>
</tr>
<tr>
<td>7&quot;x 9 7/8&quot; casing</td>
<td>14.2</td>
<td>No</td>
</tr>
</tbody>
</table>

### Notes:

* Pump & dump procedure

* A riser margin possible in 8 ½" section if 9 5/8” had been set 2000’ deeper, as planned.
Conventional Barrier Diagram

**Primary** barrier elements:
- Mud
  - Riser integrity

**Secondary** barrier elements:
- BOP

**Common** barrier elements
- Wellhead & seal assemblies
- Casing & cement
Barrier Elements LRRS+

**Primary** barrier elements:
- Mud
  - Level measurement

**Secondary** barrier elements:
- BOP
  - Casing & Cement
  - Wellhead & seal assemblies

**Common** barrier elements
- Wellhead & seal assemblies*

* Well and water depth specific
Avoiding Common Barriers with LRRS NCS (200mWD)
Improved Kick/Loss Control with LRRS

• Improved kick/loss detection
  – Pumps as improved kick indicator
  – Flowmeter backup
  – Riser as trip tank

• Primary barrier re-establish by changing level

• Less danger w/gas above subsea BOP

• New Procedures & Principles
Modified Drillers Method for LRRS+

1. Close subsea BOP
   - & open choke line

2. Circulate at constant DPP:
   - via subsea choke

3. Gas separated from liquid in riser
   - No gas or pressure in pump system

- Advantages:
  - Reduced choke-line friction
  - No pressure on the rig or riser
Conclusions

LRRS used to drill overburden
- Reservoir $\xrightarrow{}$ LRRS$^{ECD}$

... applicable for all drilling-related operations
- Drilling
- Casing operations & Cementing
- Completion operations (sand control)
- Workover

...results in improved well control
- Bigger margins - Mud weight fits drilling window
- Riser margin possible for most cases
- Improved well integrity
- Improved kick/loss detection
- Well control equal to or better than conventional