Drilling and Intervention Riser Tensioner Load Modelling and its Impact on Wellhead Fatigue and Riser Loading

Subsea 2012 Exhibition & Conference 8th Feb
Introduction

- Wellhead & conductor fatigue loading key importance in offshore well design
- Deepwater oil and gas exploration (>10,000ft) – Modern vessels
- Modern tensioning systems - Complex hydro-pneumatic systems
- Detailed tensioner model - Includes individual hydraulic and pneumatic components (*DeepRiser*™)
- Existing modelling and API recommended practices
- Accurate assessment of expected fatigue damage and riser loading
Presentation Outline

- Description of Riser, Wellhead and Conductor Systems
- Overview of Marine Riser Direct Acting Tensioners (DAT)
- Existing Industry Modelling Techniques for Wellhead Fatigue/Riser Loading
- Case Study #1 - Offshore Brazil (7,000ft Water depth) – Riser Loading
- Case Study #2 - North Sea (4,000ft Water Depth) – Wellhead Fatigue
Wellhead and Conductor System

- 36” Conductor
- 20” Casing
- Conductor Connector (Weld & Body)
- Wellhead Weld
- Conductor Weld
- Rigid Lock Down
- Low Pressure Wellhead Housing (LPWHH)
- High Pressure Wellhead (HPWH)
Wellhead and Conductor System
Direct Acting Tensioner System (DAT)

- Slip Ring – Direct Connection
- Trip Saver
- Up to 5,000,000 lbs Capacity
- 50ft Stroke Capacity
- Manufacturer – NOV N-Line, Aker MH
- Vessels – 5th & 6th Generation
Direct Acting Tensioner System (DAT)

1. PLC
2. Anti-Recoil Valve
3. Flexible Hose
4. Air Pressure Vessels (APVs)
5. HP Air/Oil Accumulator
6. Tensioner Piston and Rod
7. LP Nitrogen Accumulator
8. Flexible Hose
9. Shackle Connection to Vessel
10. Tensioner Cylinder - LP Side
11. Tensioner Cylinder - HP Side
12. Shackle Connection to Tension Ring
13. Tension Stroke Signal

Experience that Delivers
Dynamic Characteristics – DAT System

Piston Velocity (m/s)
Piston Stroke (m)
Cylinder Load (KN)
Cylinder Pressure (bar)
Case Study #1 – Offshore Brazil, 7,000ft Water Depth

- Location – Offshore Brazil
- Water Depth – (approx 7,000ft)
- Max Connected Seastate – (based on 8m allowable vessel heave)
- Max Drilling Seastate – (based on 5m allowable heave)
- Mud weight – Max 12 ppg
- Tensioning System – 6 Cylinder DAT System rated to 3600 kips
- Key Requirements – Maintain positive riser tension and keep wellhead loading to a minimum.
Case Study #1 – Top Tension Methodology

### API RP 16Q

The formula for calculating the minimum tension is given by:

$$T_{\text{min}} = T_{SRmin} \frac{N}{R_f (N-n)}$$

<table>
<thead>
<tr>
<th>Tension (kips)</th>
<th>1515</th>
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<tbody>
<tr>
<td>Mud (ppg)</td>
<td>10</td>
</tr>
<tr>
<td>$T_{SRmin}$ (kips)</td>
<td>1200</td>
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<tr>
<td>N</td>
<td>6</td>
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<tr>
<td>n</td>
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<tr>
<td>Rf</td>
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</table>

### Detailed Tensioner Model

#### Seastate – Max Connected

- Tension (kips): 1920
- Mud (ppg): 10
- $T_{SRmin}$ (kips): 1200
- N: 6
- n: 1
- Rf: 0.75

Detailed Tensioner Model – Iterate on top tension for given seastate to achieve positive tension at base of riser (factored up by 1.2 to account for 1 tensioner failure)
Case Study #1 – Top Tension V Wellhead Tension

Wellhead Tension occurs when Top Tension > Weight Riser + LMRP + BOP
Case Study #1 – Wellhead Tension Variations

- Max Connected, Top Tension = 1920 kips
- Max Drilling, Top Tension = 1920 kips
- Max Drilling, Top Tension = 1690 kips

Effective Tension (kips) vs Time (s)

- 1590 kips
- 1275 kips
- 725 kips
- 75 kips
Case Study #1 – Riser Stress Comparison

Max Drilling, Top Tension= 1920 kips
Max Drilling, Top Tension= 1690 kips
Case Study 1# – Detailed Tensioner Model
With API Top Tension

Max Connected, Top Tension=1920 kips, 7000ft

Max Connected, API Top Tension=1515 kips, 7000ft

Compression
Case Study #1 – Shallow Water (1,000ft) - Wellhead Tensions

Max Connected, Top Tension = 1920 kips, 7000ft

Max Connected, Top Tension = 1050 kips, 1000ft

1590 kips

1125 kips
Case Study #2 – North Sea, 4200ft Water Depth

- Location – North Sea
- Water Depth – 4,200ft
- Vessel – 6th Generation
- Tensioning System – 6 Cylinder DAT System rated to 3600 kips
- Wellhead Stick-up – 12ft
- Conductor System – 36” x 20” – 200ft BML
- Soil Type – Soft
- **Objective** – Assess Fatigue Damage – Detailed V Simplified Tensioner
Case Study #2 – Effect of Tensioner Model on Fatigue Life (yrs)

- Riser: SCF=1.3, DnV E Curve
- Conductor: SCF=5.0, DnV B1 Curve

<table>
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<tr>
<th>Location</th>
<th>Detailed Tensioner model</th>
<th></th>
<th>Simplified Tensioner model</th>
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<td>0m offset</td>
<td>6.5m offset</td>
<td>13m offset</td>
<td>0m offset</td>
<td>6.5m offset</td>
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<td>Drilling Riser</td>
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<td>117.6</td>
<td>123</td>
<td>112.5</td>
<td>115.3</td>
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<td>LPWHH Weld</td>
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<td>0.10</td>
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<td>36-inch Conductor</td>
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<td>2.2</td>
<td>1.9</td>
<td>3.7</td>
<td>2.2</td>
</tr>
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</table>

- Unfactored Fatigue Life
Case Study #2 – Effect of Tensioner Model on Fatigue Life (yrs)

60% Reduction

Conductor Connector Fatigue Life

Riser Fatigue Life

Telescopic Joint Location
Key Conclusions

• Accurate Fatigue & Riser modelling must incorporate tensioner load variations – Drilling & Intervention Fatigue Budgets

• Modern tensioning systems - Large wellhead tensions and stress ranges for large seastates

• Existing API top tension recommendations – Riser compression

• Accurate seastate forecasting – Reduce top tensions and risk of wellhead fatigue issues

• Tension primarily dependent on stroke velocity - Independent of water depth
Acknowledgements

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Thank You

Any Questions?