The Growing Use of Structural Monitoring as Part of Wellhead and Conductor Integrity Management

19th February 2014

www.pulse-monitoring.com
Agenda

• Overview
• Monitoring Technologies
• Case studies
• Summary

www.pulse-monitoring.com
Wellhead & Conductor fatigue

Industry Issues

- Significant loading from:
  - Environmental interaction from vessel & drilling riser
  - Axial loads associated with hang-off of internal casings
- ‘Fatigue hotspots’
- Soil stiffness
- Analytical fatigue response conservative
- Safer operations require understanding of strength & durability of riser systems

www.pulse-monitoring.com
Wellhead & Conductor fatigue

Environmental Loading

- 2 primary causes of environmental loading:
  - VIV
  - Wave induced loading
Wellhead & Conductor fatigue

Fatigue hotspots

www.pulse-monitoring.com
Wellhead & Conductor fatigue
A Worsening Problem

- Harsher Environments
  - Increasing the environmental loads on the drilling riser systems

- Taller & Heavier BOPs
  - Resonance of BOP stack under wave loading close to range of wave periods (5-8 s)

- Longer Well Operations
  - Increasing complexity of operations due to deeper drilling

www.pulse-monitoring.com
Wellhead & Conductor fatigue

Key challenges: Drilling vs Completion/Workover

<table>
<thead>
<tr>
<th>Drilling</th>
<th>Completion/Workover</th>
</tr>
</thead>
<tbody>
<tr>
<td>Large BOPs in shallow water</td>
<td>Smaller riser enhances effect of VIV</td>
</tr>
<tr>
<td>Jackup rigs in &gt;100m water</td>
<td>Combined height of BOP &amp; Xmas tree</td>
</tr>
<tr>
<td>Current loading in deepwater</td>
<td>Little fatigue data on old wells</td>
</tr>
<tr>
<td>Frontier environments require more conservative approach</td>
<td>Old wells not designed for modern equipment</td>
</tr>
</tbody>
</table>

www.pulse-monitoring.com
Fatigue Analysis

Limitations

• Areas of uncertainty require conservative assumptions

• Lack of infield data for comparison

• Often no basis to remove conservatism
Structural Monitoring

Approach and benefits

- Allow comparison between actual and predicted parameters
- Improve confidence during drilling operations
- Calibrating analysis models for improved predictions for future operations
Structural Monitoring

Instrumentation

- Environmental
- Motion
- Strain
- Software

www.pulse-monitoring.com
## Communication architecture

<table>
<thead>
<tr>
<th></th>
<th>Standalone</th>
<th>Hardwired</th>
<th>Acoustic</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Power</strong></td>
<td>Limited</td>
<td>Unlimited</td>
<td>Limited</td>
</tr>
<tr>
<td><strong>Data Transfer</strong></td>
<td>After retrieval</td>
<td>Continuous</td>
<td>On-demand</td>
</tr>
<tr>
<td><strong>Data Capacity</strong></td>
<td>Limited</td>
<td>Unlimited</td>
<td>Limited</td>
</tr>
<tr>
<td><strong>Data Synchronization</strong></td>
<td>Limited</td>
<td>Unlimited</td>
<td>Limited</td>
</tr>
<tr>
<td><strong>Interface</strong></td>
<td>Simple</td>
<td>Complicated</td>
<td>Simple</td>
</tr>
<tr>
<td><strong>Reliability / Repair</strong></td>
<td>Simple</td>
<td>Complicated</td>
<td>Simple</td>
</tr>
</tbody>
</table>
Case study 1: Standalone Monitoring

Overview

- Drilling campaign in Gulf of Mexico
- Analysis showed conductor fatigue life of just 8 days
- Conductor top weld shown as fatigue critical location
- Standalone monitoring provided

www.pulse-monitoring.com
Case study 1
Monitoring System

- Eexd-rated motion logger on vessel
- 10 standalone loggers along riser to measure riser motion
- 2 standalone loggers on BOP to measure angular rate of BOP/LMRP
- Subsea data loggers installed using magnetic interfaces

www.pulse-monitoring.com
Case study 1
ROV logger installation
Case study 1

Results & Lessons Learned

- Monitoring data used to determine actual conductor fatigue
- Showed acceleration threshold for conductor top weld not exceeded
- None of VIV events resulted in above-threshold riser fatigue damage
- Client did not have to undertake detailed fatigue analysis of drilling campaign
Case Study 2: Online Monitoring

Overview

- Exploration campaign in North Sea
- 500m water depth using 6th generation semisub
- Conductor weak point analysis showed base case fatigue life for system is low

www.pulse-monitoring.com
Case Study 2

Monitoring System

- Single online sensor installed on LMRP
- Standalone logger for redundancy
- Connected to topside via subsea cable

www.pulse-monitoring.com
Case Study 2

Cable Installation

www.pulse-monitoring.com
Case Study 2

Monitoring System

- System can display BOP/LMRP motions, displacement and wellhead fatigue in real time
Case Study

Results & Lessons Learned

• Good correlation between wave height and fatigue damage
• Data used to check that damage rates were acceptable at the start of operations
Cable Free Monitoring

Acoustic Monitoring Systems

- Online BOP monitoring systems using acoustic communication
- Removes issues with subsea cables:
  - Extra time to run riser
  - Added risks

www.pulse-monitoring.com
Cable Free Monitoring

Acoustic Monitoring Systems

- ROV deployable
- Real time operational decision making
- Cable free communication

www.pulse-monitoring.com
Wellhead & Conductor Fatigue

Summary

- Wellhead & conductor fatigue is a worsening issue
- Drivers are environment and equipment
- Monitoring is a key benefit for analysis and operations
- Simple solutions to verify the integrity of the wellhead and conductor

www.pulse-monitoring.com
Thank You

Any Questions?

www.pulse-monitoring.com