Subsea Wellhead and Conductor Fatigue

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AADE Riser Meeting
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Subsea Wellhead and Conductor Fatigue

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Learn more at www.2hoffshore.com
Importance of Wellhead Fatigue

- Fatigue failure of high pressure wellhead housing
- Due to VIV
- West of Shetland Region
- 440 meter water depth
- Periodic cycle of 5012 seconds
- 2 degree angular motion at riser base
- **Failed in 29 days**
- One of the few well documented wellhead fatigue failures

Reference DOT paper 1983, C. Hopper, Britoil

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Agenda

- Why is fatigue an increasing concern?
- Sources of fatigue damage
- Wellhead and conductor fatigue hotspots
- Predicting fatigue damage
- Optimize the system
- Fatigue management

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Emerging Concerns

- Increased recovery times
  - Longer times on well

- Higher pressure (deeper) wells
  - Longer drilling durations

- Post-Macondo design requirements
  - Larger BOPs and capping stack requirements

- Use of newer vessels on older wells
  - Larger BOPs and LMRPs

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Sources of Fatigue Damage

- Vessel motion due to waves (high frequency)
- Vortex Induced Vibration (VIV)

- Shallow water driven by:
  - Wave dynamics
  - Failed mooring line condition

- Deep water driven by:
  - Currents
  - Drift-off and drive-off

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Riser VIV Impact On Wellhead

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Wellhead VIV Variation with Location

WELLHEAD VIV FATIGUE LIVES WORLDWIDE
(Low Pressure Housing Weld)

Scatter due to different BOP heights and weights

** Calibrated software and safety factors - x3 improvement

- WoS - 2
- WoS - 3
- Atlantic Margin
- Norwegian Sea
- Asia Pacific
- North of Shetland
- West of Hebrides
- Malaysia
- Egypt
- West of Shetland**

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Fatigue Sensitive Hardware

- Fatigue is an issue anywhere two components are joined together
  - Pipe to pipe Welds
  - Pipe to coupling welds
  - Connectors/couplings
  - High Pressure Housing (load shoulders, bolts)
  - Low Pressure Housing (load shoulders, bolts)

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Coupling Fatigue Response
Wellhead Local Stresses and SCF’s
Non-rigid Lockdown Wellhead

LOCAL WELLHEAD MODEL
Conductor Weld Stress vs. Bending Moment

- Vertical Gap
- Resting on Landing Shoulder
- Lateral Gap
- Lateral Gap Closed

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Fatigue Hot Spots – Rigid vs. Non-Rigid Lockdown

UNFACTORED FIRST ORDER FATIGUE LIVES
Rigid Lockdown vs Non Rigid Lockdown WH, Lower Bound Soil

Fatigue Life (Years)

Elevation Above Sea Bed (m)

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Fatigue Hot Spots – Rigid vs. Non-Rigid Lockdown

UNFACTORED FIRST ORDER FATIGUE LIVES
Rigid Lockdown vs Non Rigid Lockdown WH, Lower Bound Soil
DnV E SCF 1.3

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Effect of Vessel on Fatigue Life

MINIMUM UNFACTORED FATIGUE LIFE
C Class SCF 1.0, Weld 0.965m Below Top of Conductor
Drilling Mode, 0m Cement Shortfall

![Bar Chart](chart.png)

- **February - April**: Green bars
- **May - July**: Red bars
- **August - October**: Light blue bars
- **November - January**: Blue bars

- **Legend**:
  - Light blue bars: 4th Generation
  - Dark blue bars: 2nd Generation

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Effect of Operation Mode

MINIMUM UNFACTORED FATIGUE LIFE
C Class SCF 1.0, Weld 0.965m Below Top of Conductor
1.5m Cement Shortfall

<table>
<thead>
<tr>
<th>Load Cases</th>
<th>Fatigue Life (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>February - April</td>
<td>34,000</td>
</tr>
<tr>
<td>May - July</td>
<td>15,000</td>
</tr>
<tr>
<td>August - October</td>
<td>24,000</td>
</tr>
<tr>
<td>November - January</td>
<td>36,000</td>
</tr>
</tbody>
</table>

Drilling Mode | Completion Mode
Keys to Accurate Fatigue Analysis

- Use integral riser, wellhead and conductor model
- Need comprehensive field data
  - Extreme and long term waves, current and soils
- Need clear definition of service requirements and duration
  - Exploration, keeper
  - Drilling, completion and workover durations

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Wellhead and Conductor System Design/Analysis Challenges

- Uncertainty in soils and currents
  - Limited or no data for new regions
- Uncertainty in rig selection
  - Want to assess fitness-for-purpose before selection
  - Data may not be available
  - Future changes
- Lack of guidance on wellhead selection
  - Why choose one over another
- Variability in casing program
  - No two programs are the same
- Variability in soil properties
  - Even when data is defined we have to work between bounds

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Optimize System Design and Operation

- Avoid Non-rigid lockdown wellheads
- Locate connector outside of region of maximum bending
- Limit duration on well when using large BOPs or stackups

- VIV suppression
- Fatigue details and weld quality
  - Avoid add-ons that do not consider fatigue

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Fatigue Improvement – VIV Suppression Devices

- Strakes
- Fins
- Fairings
Fabrication Considerations

- Need to achieve high quality

- Welding to get good quality fatigue details with high grade steels is not simple

- Effort spent on qualifying and obtaining good quality fabrication is generally a good value
  - Pipe dimensional control, welding, coating
Fatigue Integrity Management

- Record riser joint usage and times on well
- Schedule and implement regular inspection
- Use extended monitoring where needed to measure riser and wellhead system fatigue
  - Calibrate analysis software assumptions – reduce conservatism
  - Verify design data

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Fatigue Mitigation Developments

- Greater emphasis on appropriate specification of wellhead systems
- Braced wellheads
- Wellhead caissons
- Larger diameter (42in) conductors

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Summary

- Fatigue was not a major design challenge in the past

- Vessels, risers and BOPs are changing to provide greater capability and comply with new regulations

- Wellhead designs are lagging behind

- Greater care is required when developing new wells or working on old wells with new equipment

- Monitoring can be used to measure system fatigue and calibrate analytical models

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Questions?

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