Fatigue Challenges from Deepwater Drilling Operations

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Does Fatigue Occur?

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Fatigue Failure Example

- High pressure housing to surface casing weld fatigue failure
- Facts
  - West of Shetland Region
  - 440m water depth
  - Run from a drill ship
  - Fatigue life – 29 days!
  - Observed angular motions at riser base = 2 degrees

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Loading

- Drilling Mode (Exploration and Development)
  - Weight of BOP and LMRP
  - Loads due to vessel offset
  - Wave action and first order vessel motions
  - VIV response of riser (currents)
Loading (contd.)

- Completion/Intervention/Workover Mode (Development)
  - Loading from drilling riser with horizontal tree in place
  - Loading from WO/completion riser (like drilling riser) – applicable on the wellhead and conductor system

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Typical Fatigue Locations

- Conductor to Wellhead Girth Weld: E-Class, SCF=1.3
- Conductor to Compression Ring Girth Welds: E-Class, SCF=1.3
- Extension Girth Weld: E-Class, SCF=1.5
- Conductor Coupling: B-Class, SCF=5.0
- Conductor to Coupling Weld: E-Class, SCF=1.3

LMRP / BOP: No fatigue check performed

Riser pipe: E-Class, SCF=1.3

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First Order and VIV Fatigue

- Wave induced Fatigue
  - <100m - ~ 40yrs
  - 500m - ~ 200yrs
- VIV Fatigue
  - <100m - ~ 7yrs
  - 500m - ~ 5yrs

- Water Depth <500m: Both wave and VIV fatigue loading needs to be addressed
- Water Depth >500m: VIV fatigue source tends to dominate

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Additional Challenges?

- Deeper wells especially HPHT reservoirs resulting in longer well durations
- Latest generation of drilling rigs have much heavier BOP/LMRP stacks
- Post Macondo requirement for a capping stack increasing the wellhead loading

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BOP Resonance

BOP RESONANCE
Effect Of BOP Stack on Curvature at LP Housing Weld

Increasing BOP Height and Weight (addition of tree)

Curvature Factor = 2.6
Damage Factor \((2.6)^3 = 19\)

New vessels with large BOP’s can increase fatigue loading by more than 10 times
What Should the Fatigue Analysis Address?

- How long can we stay connected to the wellhead?
- If we expect to re-enter the well for intervention/workover, do we have sufficient remainder fatigue capacity?
- Can we accommodate extended drilling duration due to side-tracking of the well?
- Most importantly reduce any over-conservatism in the existing design approach and tools via detailed FEA and calibration

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How to Optimise the System Design for Drilling Operations (1)

- Improve fatigue performance using VIV suppression devices

Strakes

Fins

Fairings

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How to Optimise the System Design for Drilling Operations (2)

- Improve weld quality at fatigue critical locations in addition to pipe dimensional control

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Implement Drilling Riser Integrity Management to address the following:

(Must Have’s)
- Riser joint usage recorded and rotated regularly
- Schedule and implement regular riser joint inspection
- Drilling riser and wellhead fatigue monitoring providing real time or deferred feedback for operational assistance

(Nice to Have’s)
- Implement drilling riser operation management system providing a real time feedback based on measured rig movement, environment and riser motions carefully manipulated by an onboard software

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Conclusions

- Fatigue loading has been an increasing cause of concern due to:
  - Environment uncertainty
  - Increased well durations
  - Increased water depths
  - Use of horizontal trees and/or larger BOP’s with or without capping stack

- How to manage potential fatigue problems:
  - Engineer the riser stackup, wellhead and conductor system with appropriate fatigue details
  - Implement fatigue mitigation strategies including equipment procurement, fabrication and integrity management

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Questions?

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