Mitigating Drilling Riser and Conductor Fatigue

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Mitigating Drilling Riser and Conductor Fatigue

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Agenda

- Sources of fatigue
- Riser, wellhead and conductor fatigue hotspots
- Fatigue analysis
- What factors contribute to high fatigue
- Why drilling riser fatigue is an increasing concern
- Steps to minimise riser and wellhead system fatigue damage
- Drilling riser maintenance and fatigue management

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Riser Loading

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Wellhead System Loading

- Cyclic loading
- Riser tension
- Flex-joint
- LMRP
- BOP
- Tree
- HP and LP housing
- Housing extension weld
- 36” x 1.5” seam welded conductor pipe
- 36” x 1” seam welded conductor pipe
- -10.5m Weld-on connector
- Snag Load

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Vortex Induced Vibration

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Wave Induced Motion - Flowbase

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Wave Induced Motion - BOP

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Riser Fatigue Hotspots

- Pipe to pipe welds
  - One or two per joint

- Pipe to coupling welds

- Riser couplings
  - Transitions in section
  - Load shoulders
  - Bolts

- Along entire riser length
Wellhead System Fatigue Hotspots

- **Riser pipe**
  - E-Class, SCF=1.3

- **LMRP / BOP**
  - No fatigue check performed

- **Conductor to Wellhead Girth Weld**
  - E-Class, SCF=1.3

- **Conductor to Compression Ring Girth Welds**
  - E-Class, SCF=1.3
  - (Not Typical)

- **Extension Girth Weld**
  - E-Class, SCF=1.5

- **Conductor Coupling**
  - B-Class, SCF=5.0

- **Conductor to Coupling Weld**
  - E-Class, SCF=1.3

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Conductor Fatigue

UNFACTORED FIRST ORDER FATIGUE LIVES ALONG CONDUCTOR
Rigid Lockdown WH

Fatigue Life (Years)

Elevation Above Sea Bed (m)

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Wellhead Fatigue Hotspots

**Unavoidable hotspot at LP housing weld**

Connectors < 10m below mudline impair OVERALL fatigue resistance

Peak bending loads at 3-5m below mudline

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VI V and First Order Fatigue

FATIGUE LIFE ALONG LENGTH OF DRILLING RISER
485.6ft Water Depth, Water Filled, Dual Annular BOP Model, E-Class Curve

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VI V Fatigue Damage Build-Up

FATIGUE DAMAGE
150T Overpull At LFJ, High Surface Currents, Upper Bound Soil

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Wellhead VIV Variation with Location

WELLHEAD VIV FATIGUE LIVES WORLDWIDE

(Low Pressure Housing Weld)

** Calibrated software and safety factors - x3 improvement

Environmental Harshness

Scatter due to different BOP heights and weights

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• BOP stack natural frequency excitation has been observed in loop currents and under wave loading

• This can result in high accumulated fatigue damage in the wellhead and conductor system below the mudline

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BOP Resonance

Effect Of BOP Stack on Curvature at LP Housing Weld

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

Increasing BOP Height and Weight (addition of tree)

New vessels with large BOP’s give more severe fatigue damage

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Just how bad can it be?

- GoM BOP stack VIV at 0.16Hz (6.25 sec stack natural period),
- Total fatigue consumption at the first connector is 40% in 12 days
What We Don’t Want to Happen

- West of Shetland Region
- Discoverer534 DP drillship
- 440 meter water depth
- 42in air cans on riser
- Periodic cycle 5-12 sec
- 2 degree angular motion at riser base
- Failed in 29 days
- Reference DOT paper 1983, C. Hopper, Britoil

One (the only) well documented fatigue failure
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Fatigue Drivers

- Deep water
  - High VIV fatigue damage
  - Currents greater than 1m/s (2 kts)
  - Generally low FOF damage

- Shallower water
  - Wave generally drives fatigue
  - Riser vibration frequencies may not correspond with current excitation (VIV) frequencies

- Large BOP and LMRP’s enable wellhead excitation at higher periods (lower frequencies)
  - Results in greater wave and VIV induced fatigue

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Fatigue Damage Mitigation - Things to Consider/Avoid

- Extension joint length/connector location
- Casing swedges (20 to 13-3/8in)
- “Add-ons” that do not consider fatigue
- Non-rigid-lockdown wellheads
- Fatigue details/weld quality
- VIV suppression

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Cement Top-Up System

Learn more at www.2hoffshore.com
Guidance System Below Wellhead

Learn more at www.2hoffshore.com
Anti-Rotation Fins

Learn more at www.2hoffshore.com
Non-Rigid Lockdown Wellhead

Vertical Gap

Resting on Landing Shoulder

Lateral Gap

Lateral Gap Closed

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Non-Rigid Lockdown Wellhead - Conductor and Casing Stresses

Maximum Stress in Casing, Conductor & Wellhead
0.0m Cement Height

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Fatigue Improvement - VI V Suppression Devices

Learn more at www.2hoffshore.com
Strakes - Below Choke and Kill Lines

Learn more at www.2hoffshore.com
Fins – (Langhorst)

Learn more at www.2hoffshore.com
Riser Fabrication Considerations

- Need to achieve high quality
- Welding to get good quality fatigue details with high grade steels is not simple
- How does C-class quality need to be proved?
- Effort spent on qualifying and obtaining good quality fabrication is generally good value
  - Pipe dimensional control, welding, coating

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Fatigue Integrity Management

- Record riser joint usage and times on well
- Schedule and implement regular joint inspection
  - Typical - every 5 years in service
  - Brazil - every 2 years offshore
- Inspection
  - Limited ability to inspect fitted riser joints
  - Strip down of auxiliary lines and buoyancy needed
  - Inspection of fatigue hotspots needs good access requiring strip down of joints
- Use extended monitoring where needed to measure riser and wellhead system fatigue
  - Calibrate analysis software and assumptions – reduce conservatism
  - Verify design data – soils

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Example Wellhead Monitoring

- 3 axis accelerometer
- Dual axis angular rate
- Loggers located on
  - BOP
  - Wellhead
  - Conductor
  - Template
- Magnetic holders
- ROV Installed

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Stress and Motion Monitoring - Steps

- Monitoring system design
- Offshore installation
- Signal processing of measured data

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Ways to Manage Fatigue - Monitoring

- Software and Model Calibration

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VI V Fatigue Analysis Calibration
Future Current Concerns

- Increased recovery targets
  - Longer times on the well

- Higher pressure (deeper) wells
  - Longer drilling durations

- Post-Macondo design requirements
  - Larger BOP’s, capping stacks

- Use of newer vessels on older wells

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Developments

- Greater emphasis on fatigue specification of wellhead systems
- Longer wellhead extension joints (18m)
- Braced wellheads
- Wellhead caissons
- Larger diameter (42in) conductors

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Summary

- Fatigue wasn’t a major design challenge

- Vessels, risers and BOP’s are changing to provide greater capability and operating conditions are more diverse

- The wellheads are lagging behind

- Greater care is required when developing new wells or working on old wells (with new equipment) to ensure fatigue fitness-for-purpose

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Thank you for your time.

Questions......

Further information:

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