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Subsea Wellhead and Conductor Fatigue

29th January 2014

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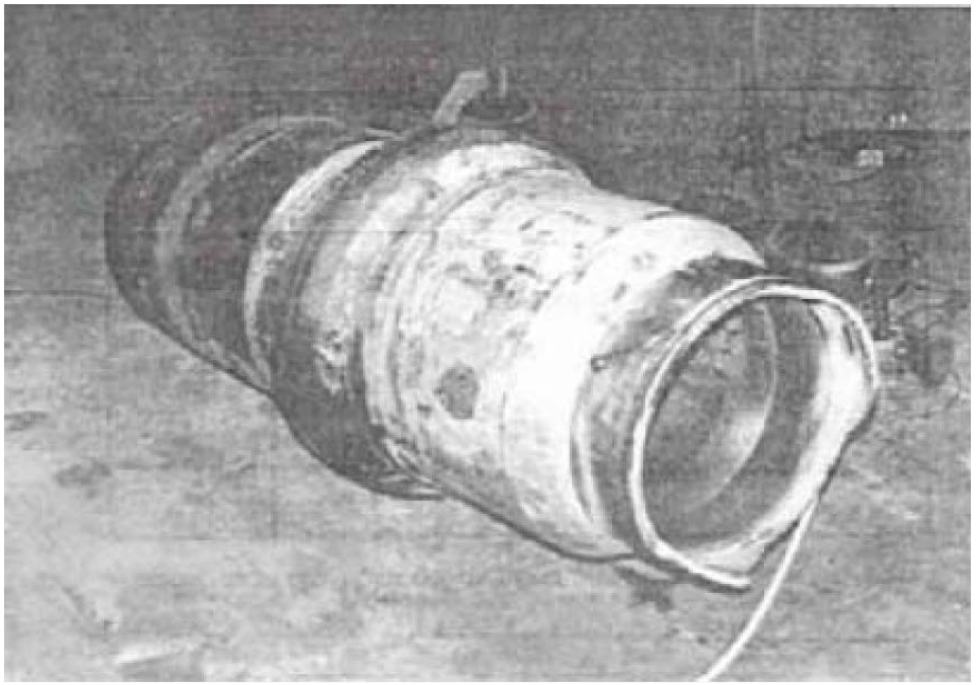
Importance of Wellhead Fatigue

- 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



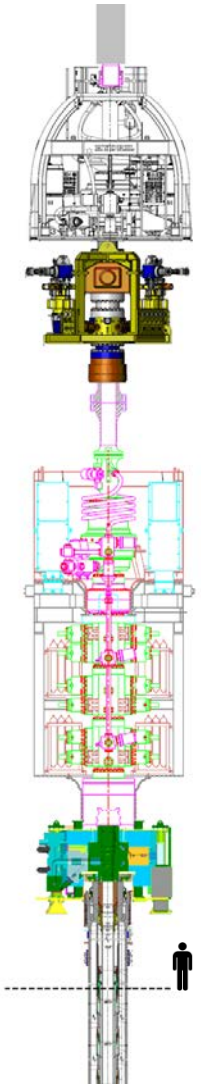
- Reference DOT paper 1983, C. Hopper, Britoil

Agenda

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

Emerging Concerns

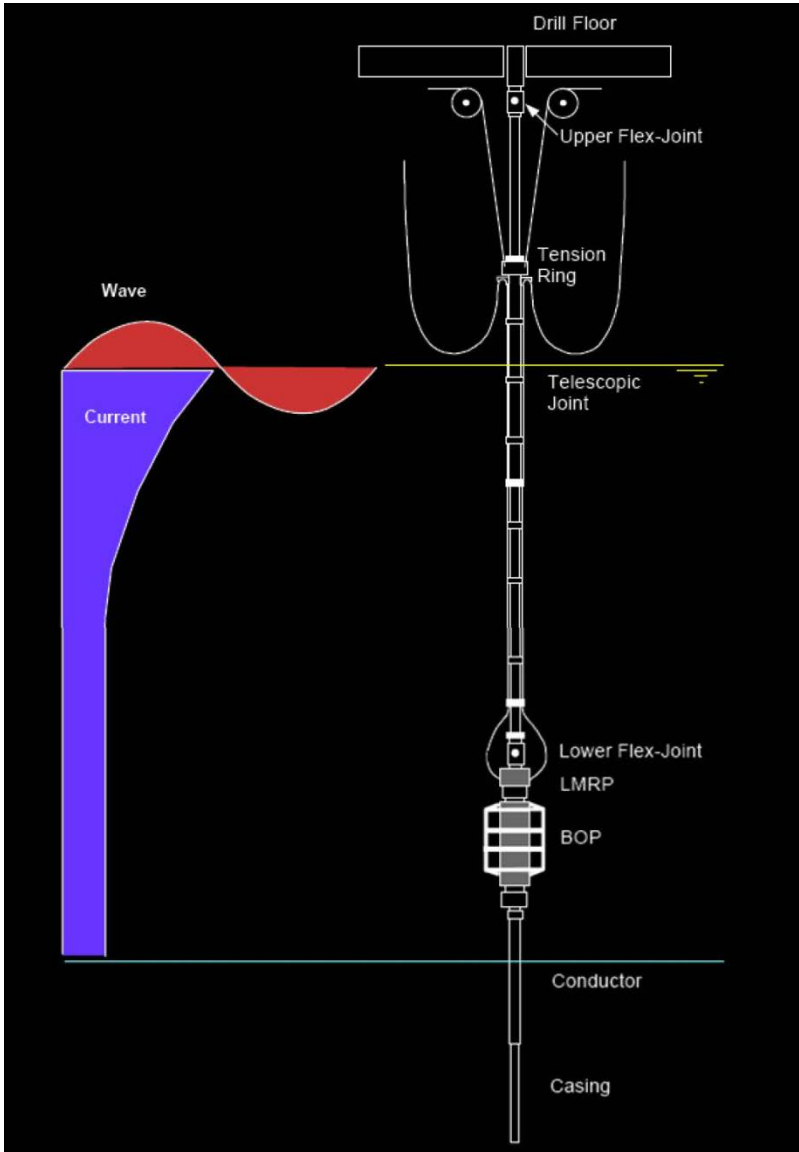
- Increased recovery times
  - Longer times on well
- Higher pressure (deeper) wells
  - Longer drilling durations
- Post-Macondo design requirements
  - Larger BOPs and capping stack requirements
- Use of newer vessels on older wells
  - Larger BOPs and LMRPs



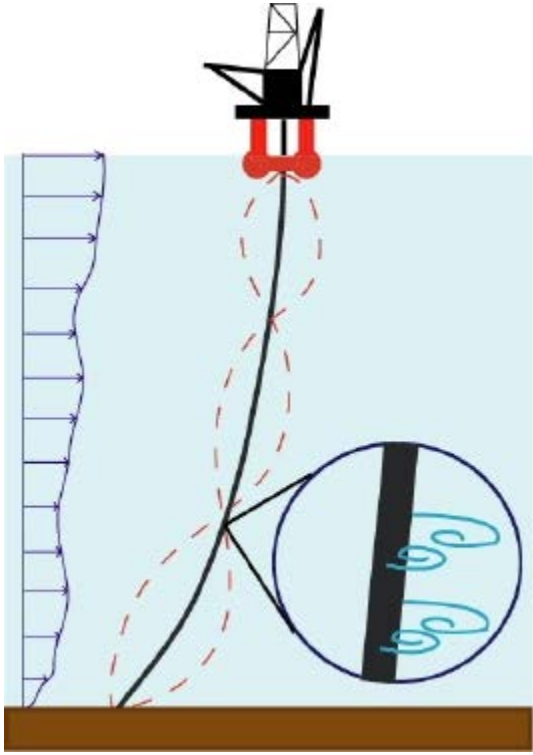
Sources of Fatigue Damage

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

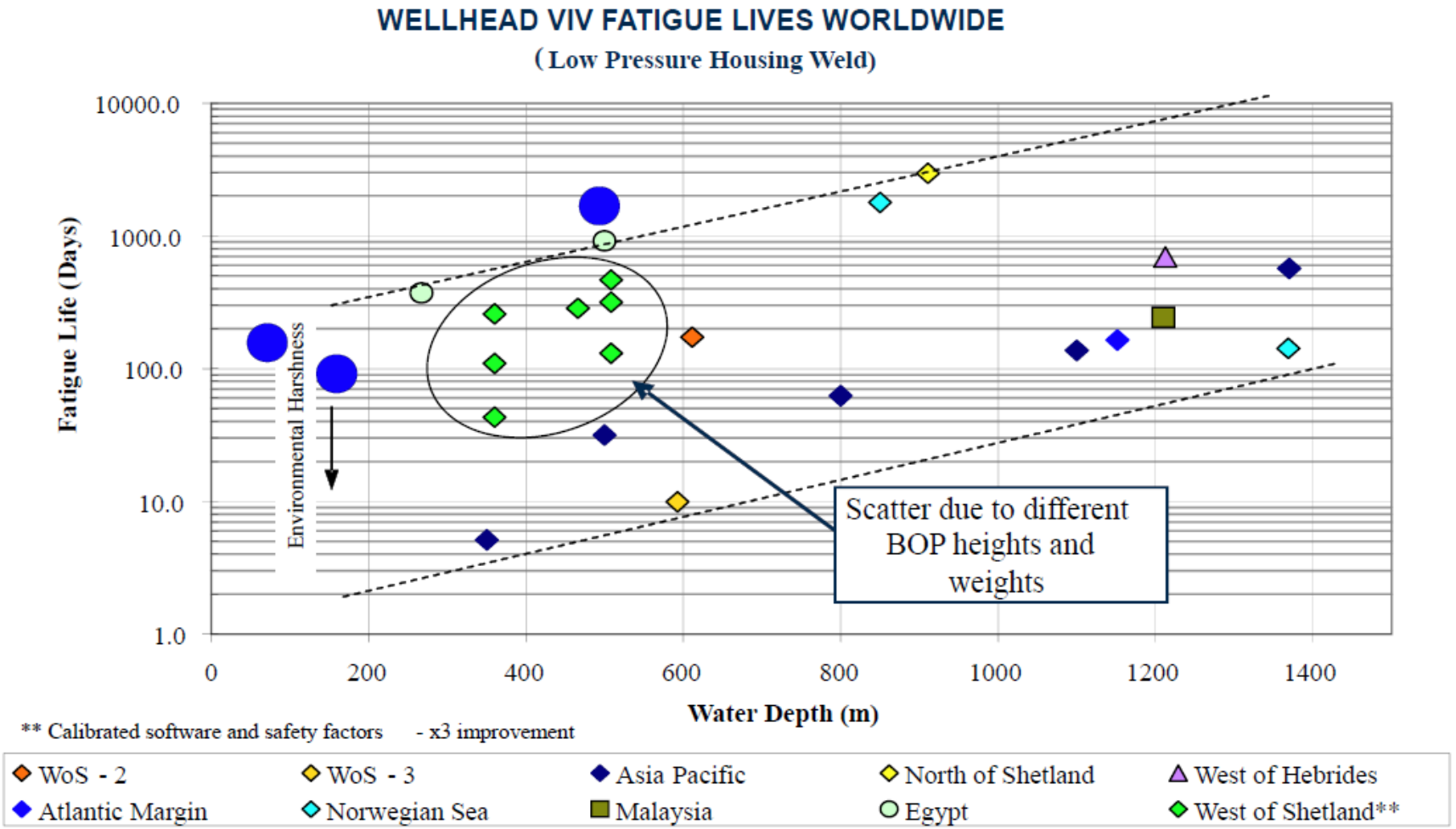
- Shallow water driven by:
  - Wave dynamics
  - Failed mooring line condition
- Deep water driven by:
  - Currents
  - Drift-off and drive-off



Riser VIV Impact On Wellhead

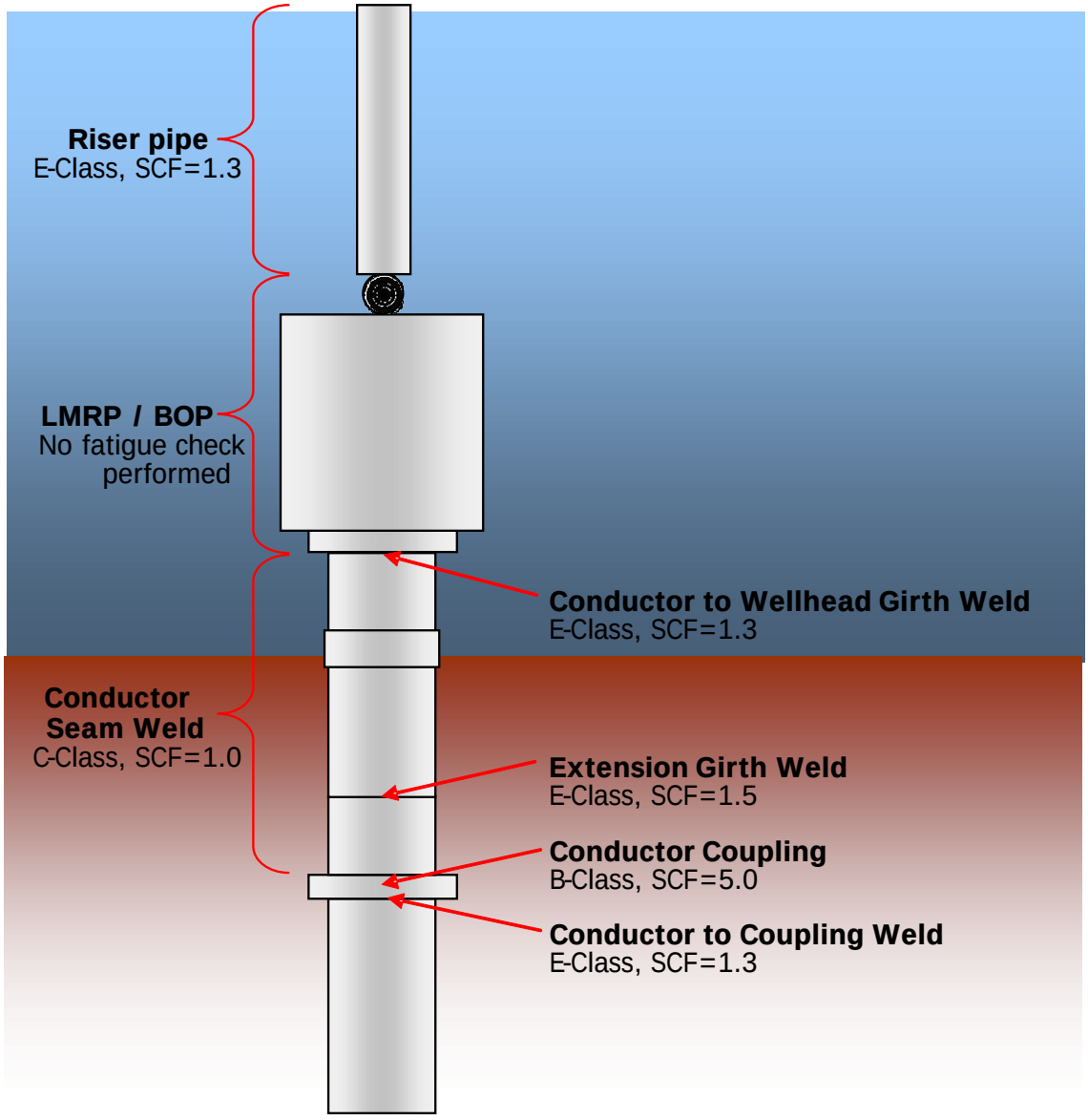


Wellhead VIV Variation with Location



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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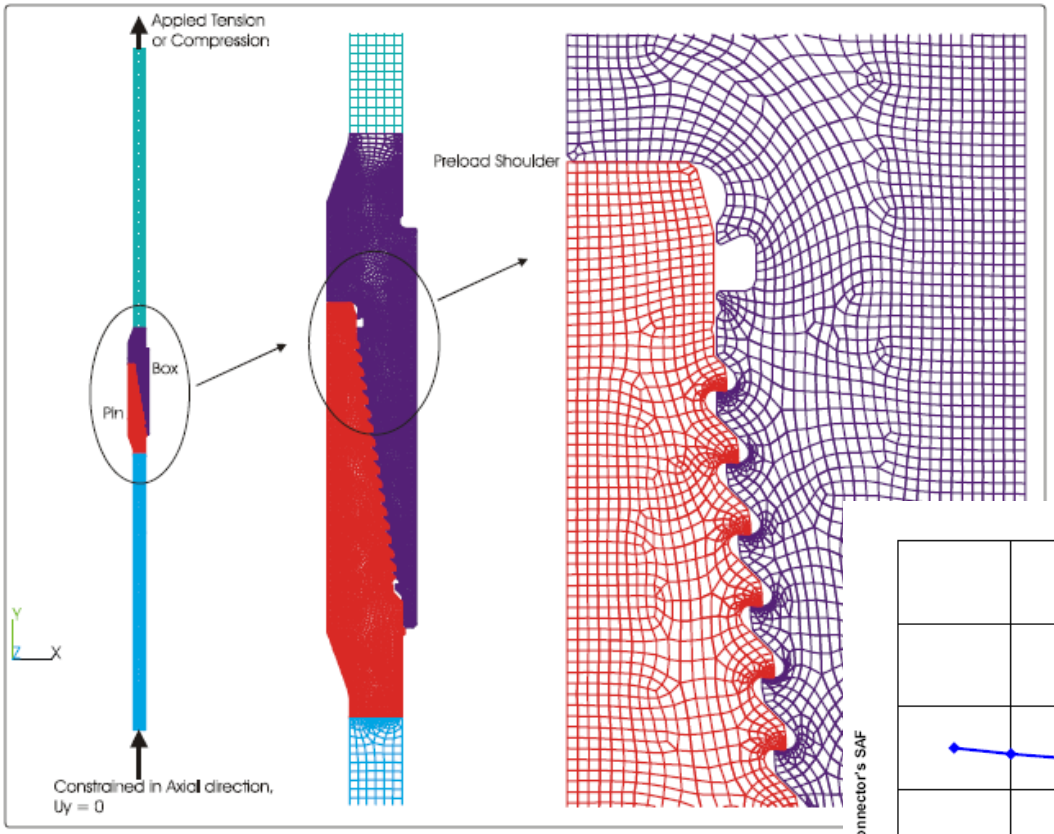
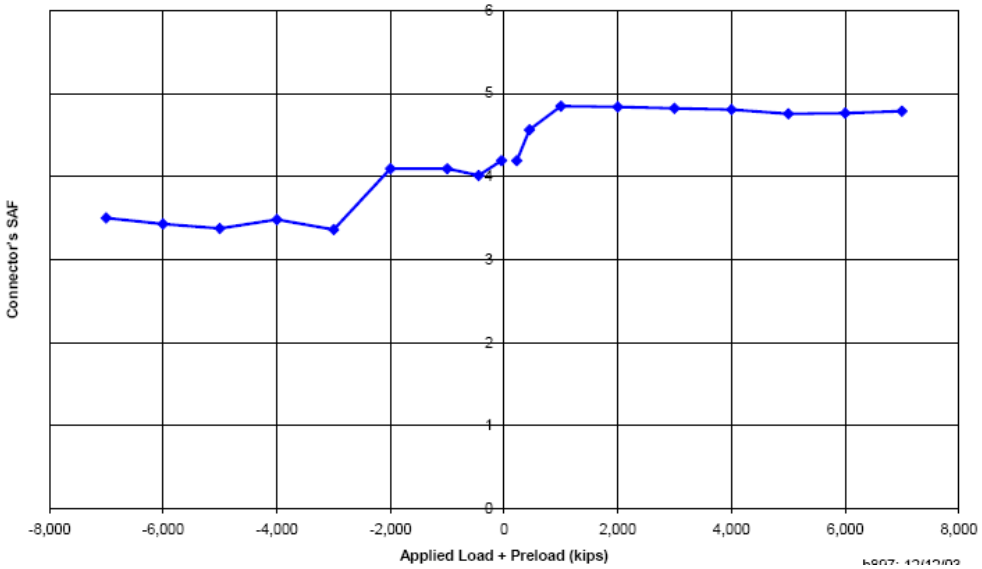
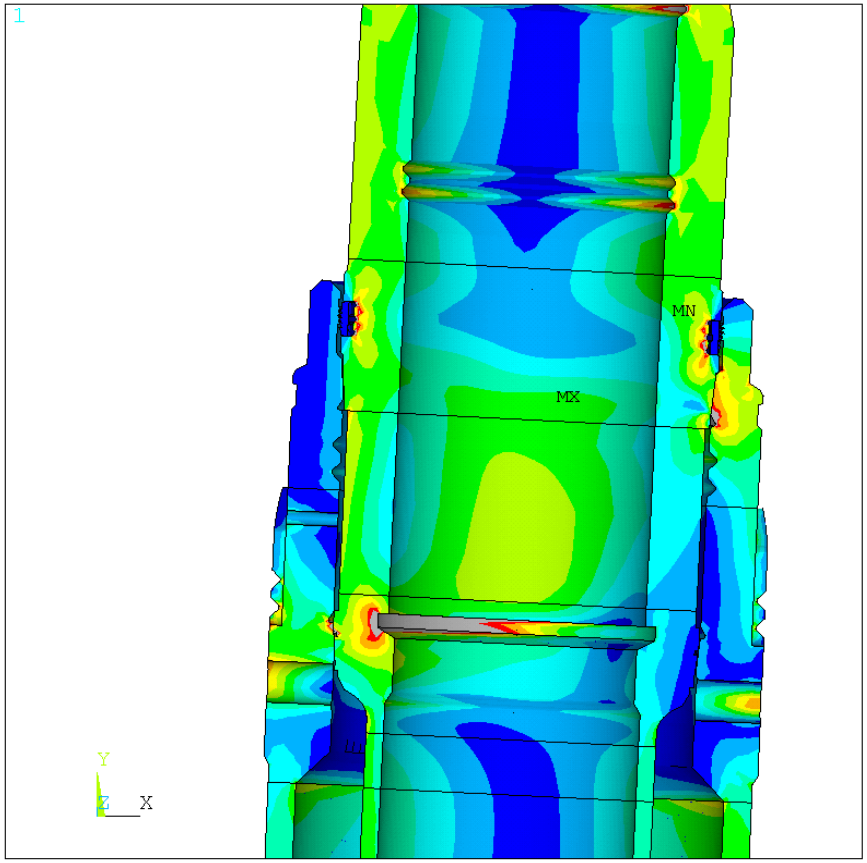
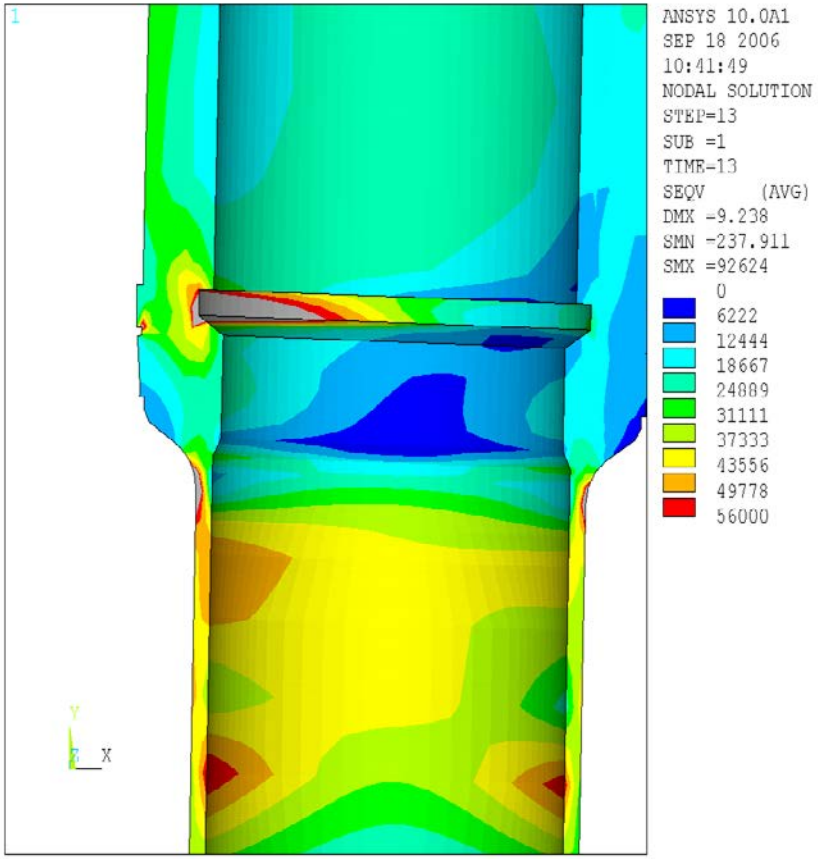
Coupling Fatigue Response



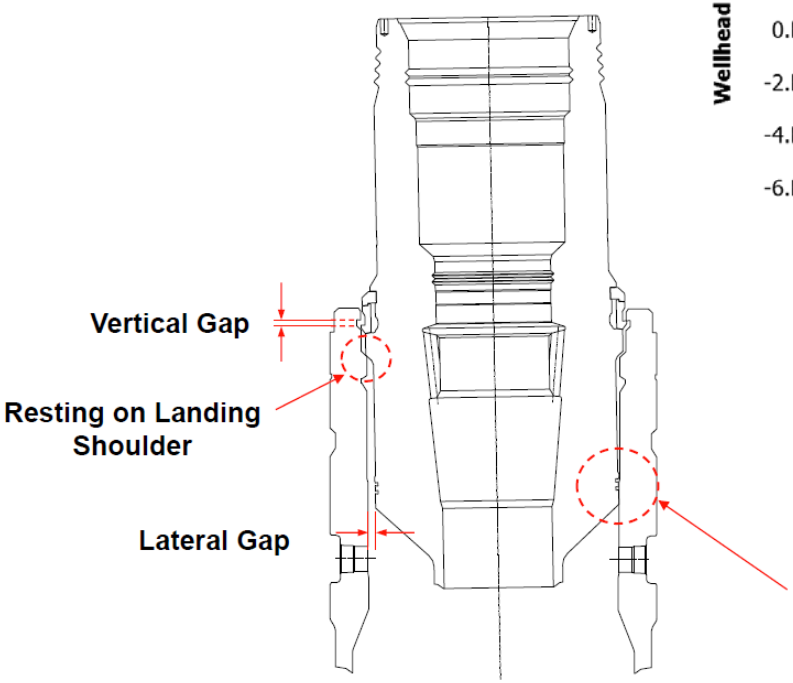


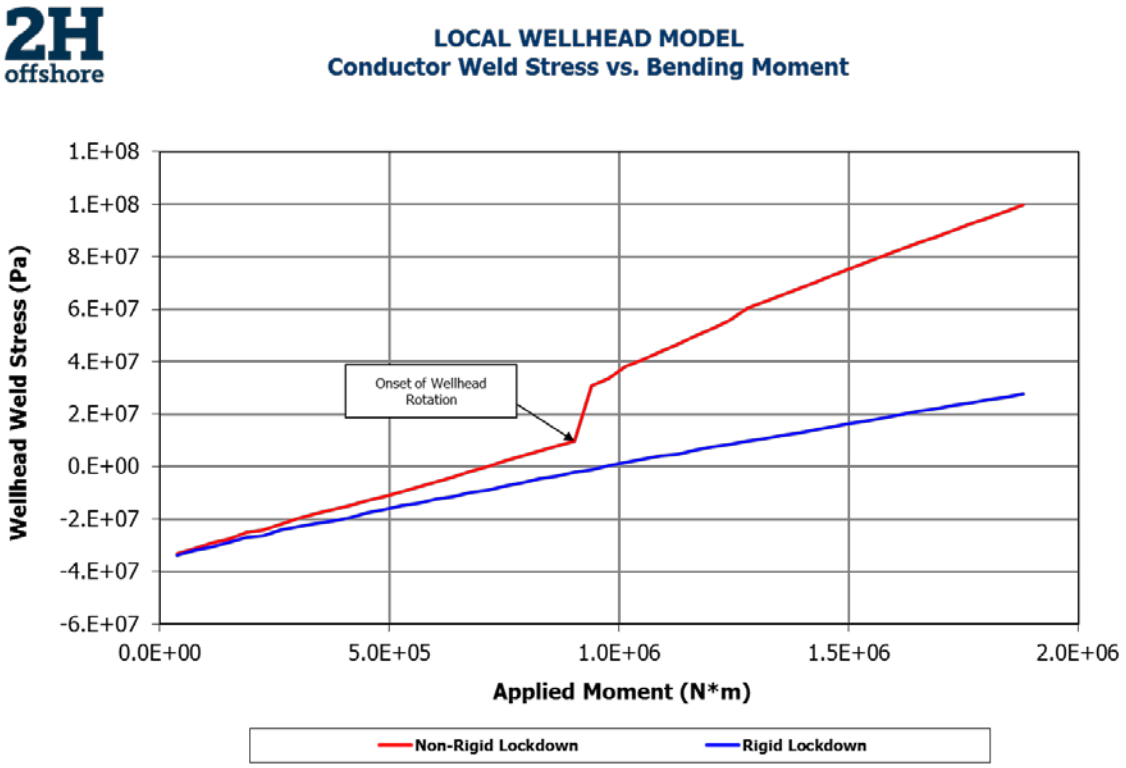
Wellhead Local Stresses and SCF's



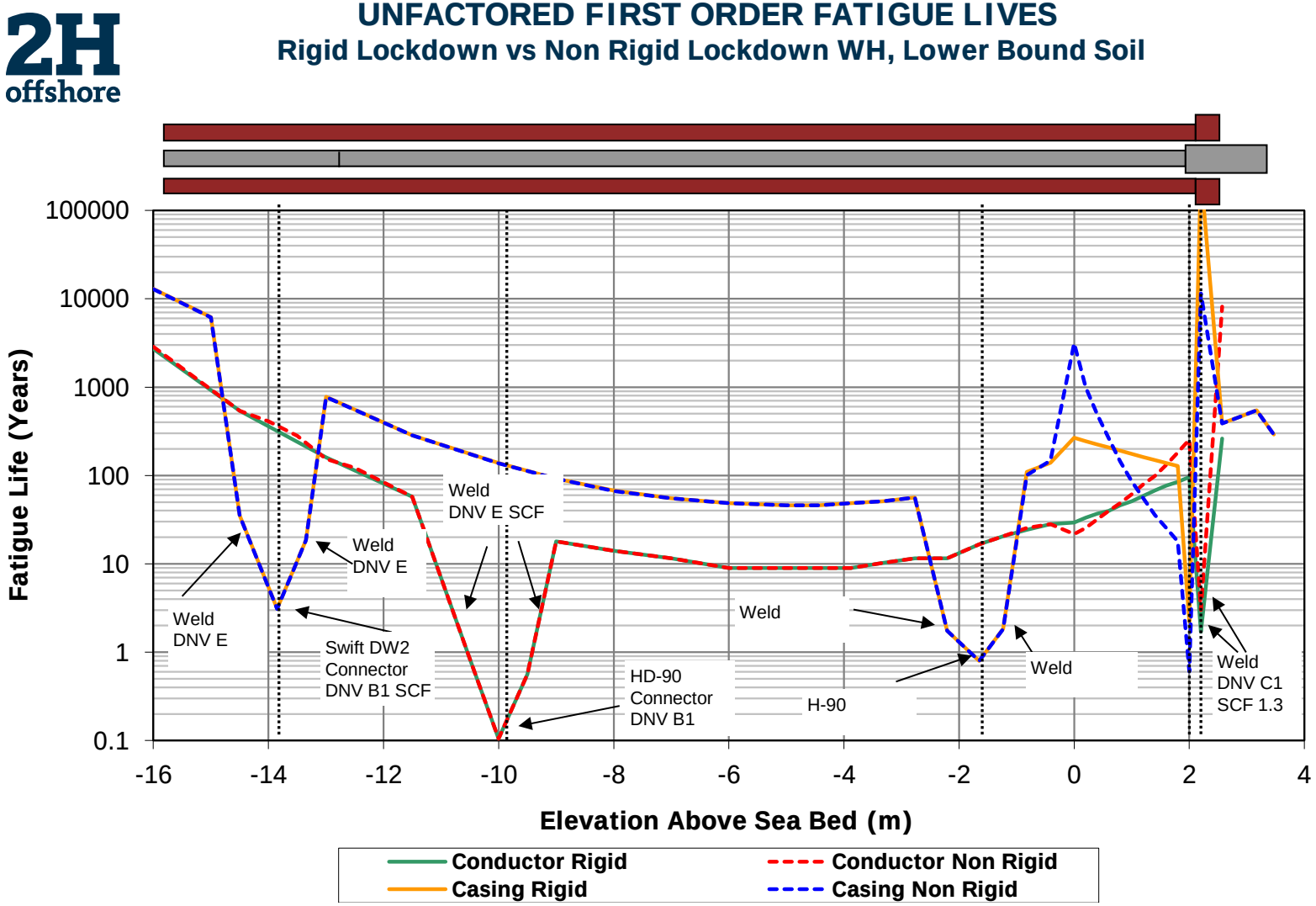


Non-rigid Lockdown Wellhead



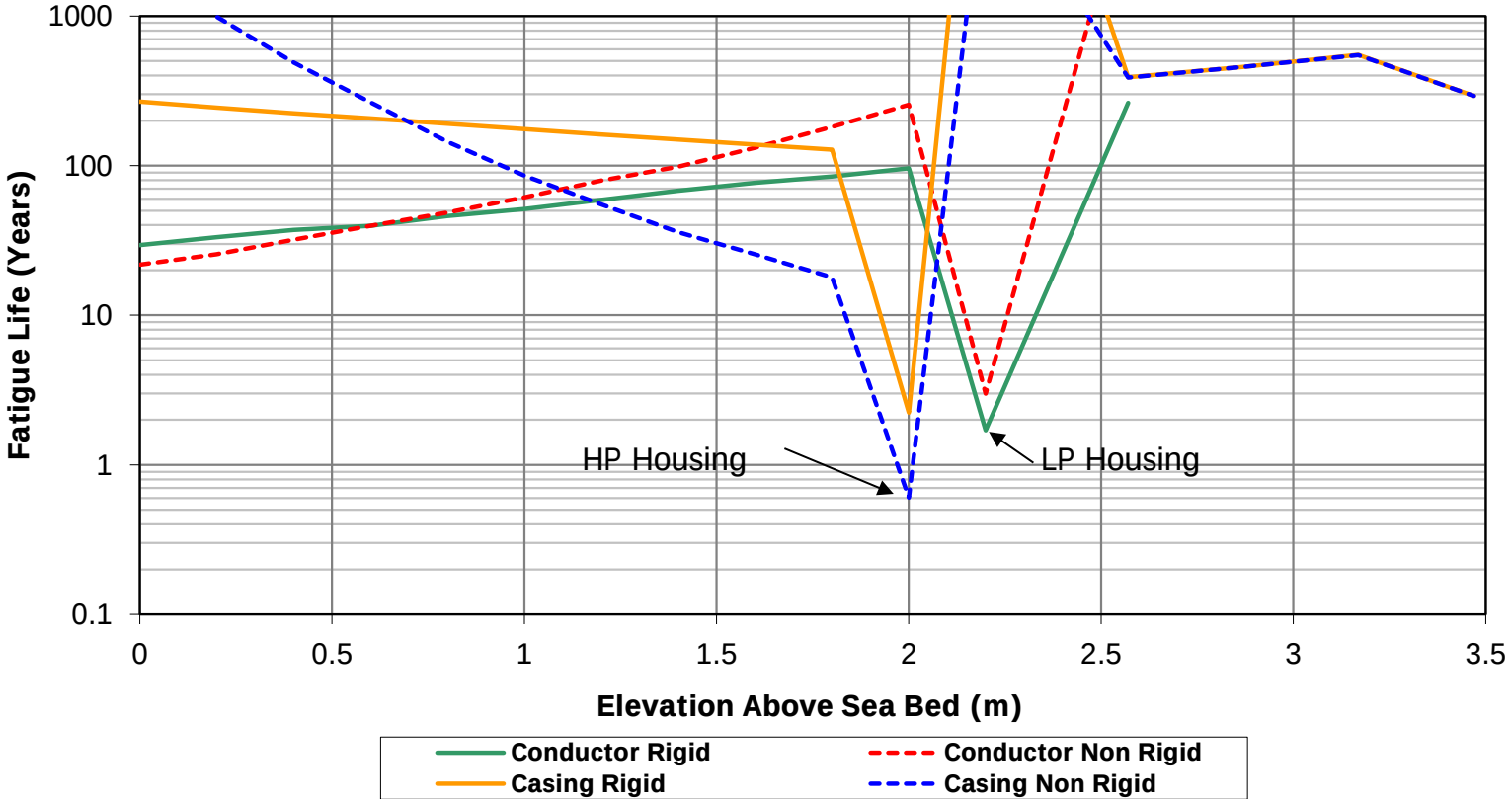


Fatigue Hot Spots – Rigid vs. Non-Rigid Lockdown

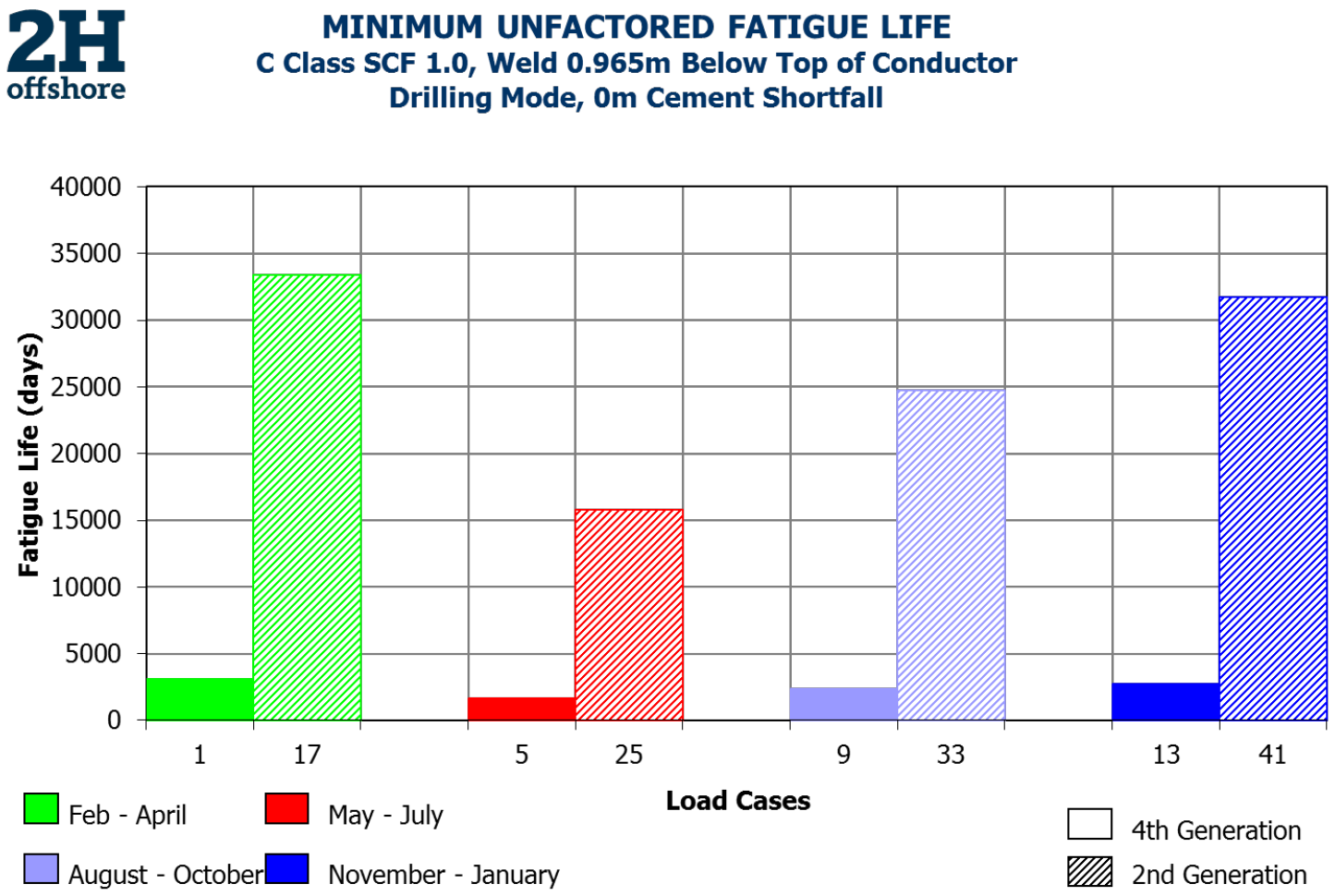


Fatigue Hot Spots – Rigid vs. Non-Rigid Lockdown

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

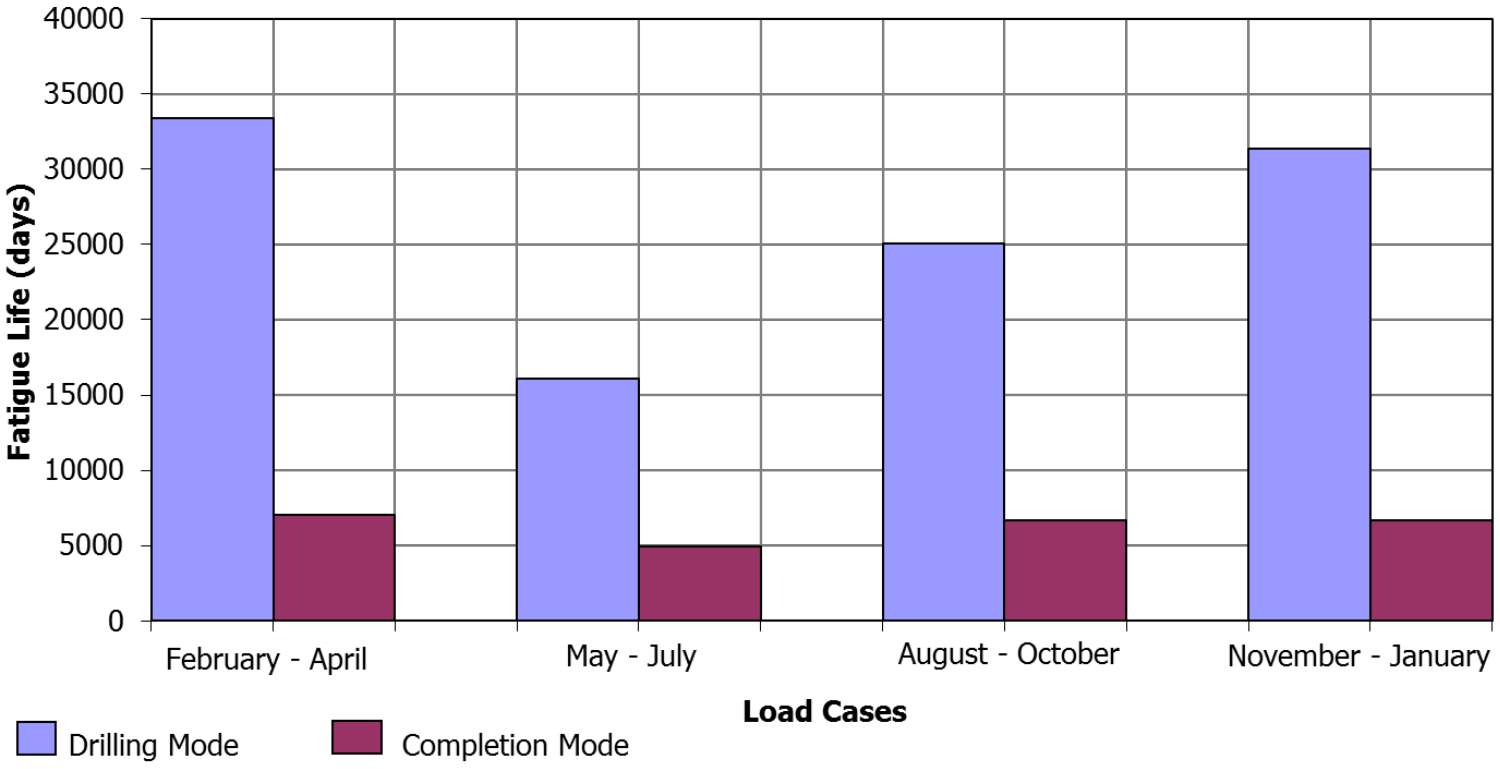


Effect of Vessel on Fatigue Life



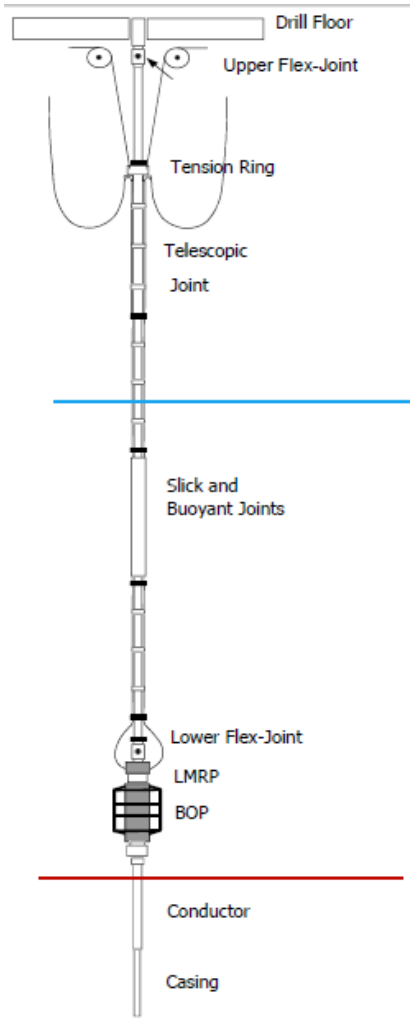
Effect of Operation Mode

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



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



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

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

Fatigue Improvement – VIV Suppression Devices

- Strakes
- Fins
- Fairings

Fabrication Considerations

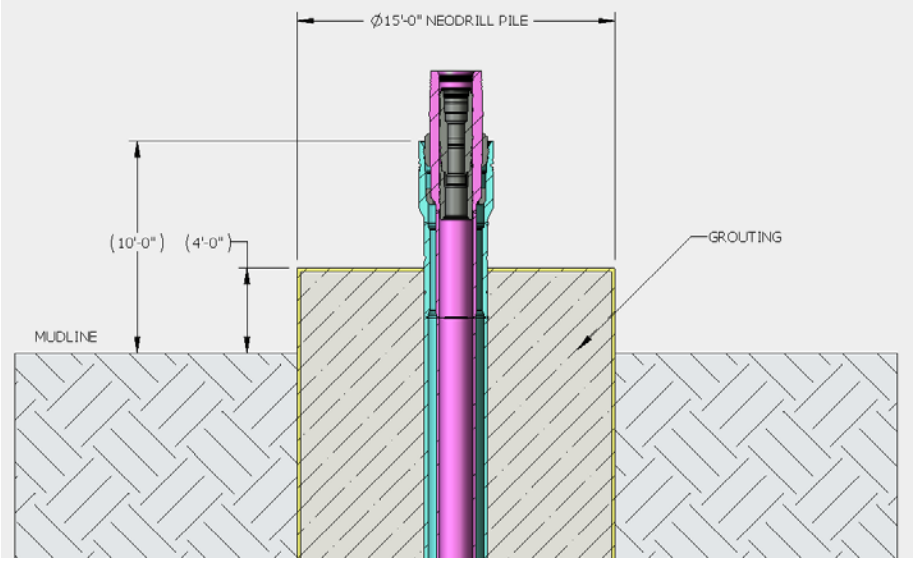
- Need to achieve high quality
- Welding to get good quality fatigue details with high grade steels is not simple
- Effort spent on qualifying and obtaining good quality fabrication is generally a good value
  - Pipe dimensional control, welding, coating

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

Fatigue Mitigation Developments

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



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?

Thank you

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