


DEEPWATER DRILLING RISER INTEGRITY - FATIGUE, WEAR, INSPECTION AND MONITORING


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Introduction

- Characteristics of deepwater drilling risers
- VIV - effects and implications
- Wear - reasons for concern
- Inspection of deepwater drilling risers
- VIV and wear mitigation
- Monitoring requirements



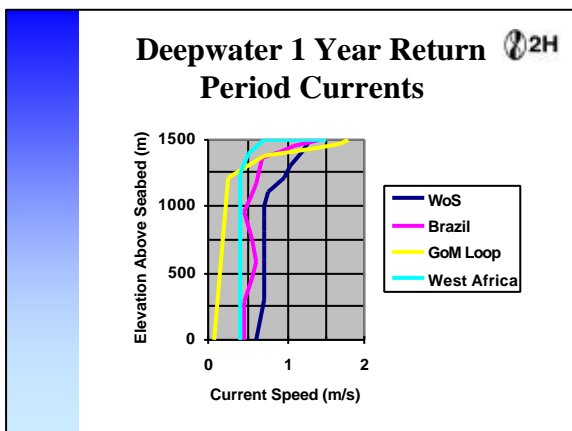

Purpose of Drilling Riser Inspection

- Detect and quantify deterioration in integrity
- Sources of deterioration:
 - fatigue damage accumulation
 - impact / handling damage
 - wear from drill string rotation
 - corrosion




Deep Water v Shallow Water

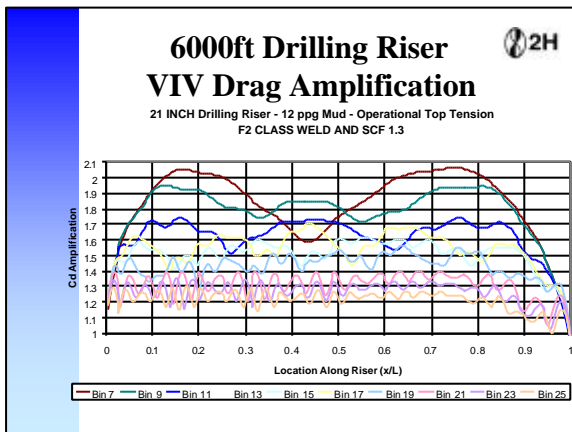
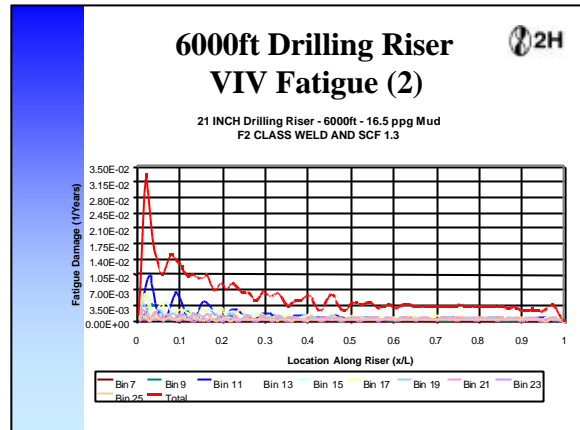
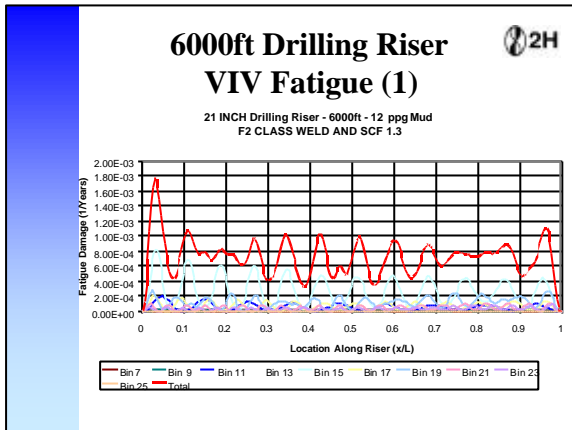
- Larger tensions
- Larger internal and external pressures
- Longer, heavier riser joints
- Exposure to severe currents
- Subject to vortex induced vibrations
- Larger curvature

Effects of VIV

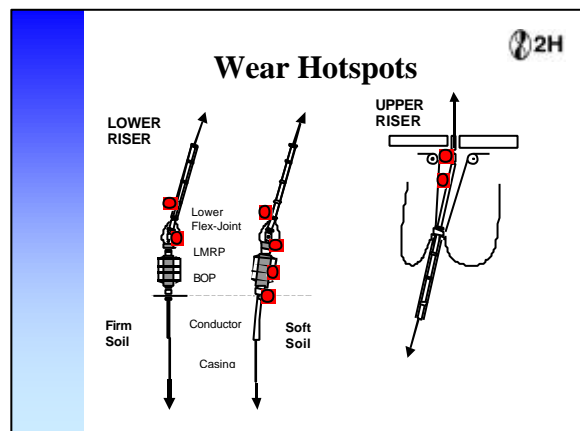
- High rates of fatigue damage
- Increased drag loading





- ### Implications of VIV
- High rates of fatigue damage
 - Increased top tension
 - Increased vessel and base loading
 - Suppression devices
 - Increased drag loading
 - Increased curvature
 - More wear
 - More downtime

- ### Wear in Deep Water
- Larger mean angles
 - Larger tensions
 - 2667/4445psi at 6,000/10,000ft
 - Higher external pressures
 - 4393/7321psi 14ppg mud, 6,000/10,000ft
 - Higher internal pressures
 - 4393/7321psi 14ppg mud, 6,000/10,000ft
 - Integrity of wall more important



Wear Control



- Flex joint angle limits
 - 2 degrees mean, 4 degree max (API)
- Criteria based on historical performance
- Deepwater limits?
 - 0.5 to 1 degree mean used by some drilling contractors

Deepwater Integrity Issues



- Increased fatigue damage from severe currents
- Increased wear from riser curvature
- Increased susceptibility to handling damage from the use of longer, heavier riser joints
- Increased wall thickness integrity required to accommodate higher tensions and pressures

Status of Drilling Riser Inspection



- Shallow water
 - total kip-days
 - 1 year usage approach
- Deep water
 - increased wear and fatigue
 - limited long term experience
 - strategies need to be defined

Deepwater Inspection Difficulties

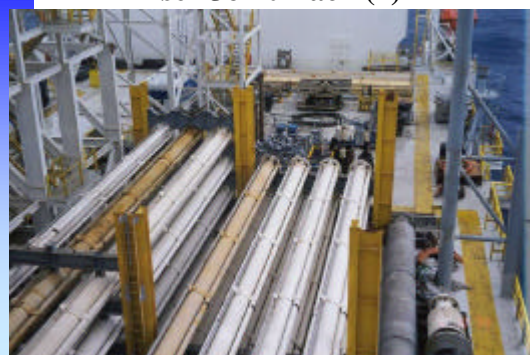


- Joint length - 75-90ft
- Joint weight - 60-70kips
- Difficult to handle - damage to buoyancy
- More remote - longer turn around
- More joints
- More expensive
- Need to rationalise

Riser in Rack



Riser Joint Rack (1)



Deepwater Inspection Difficulties



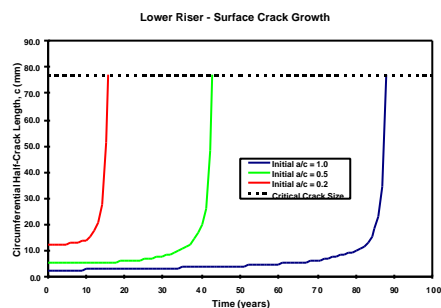
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How to Rationalise?



- Fatigue based approach:
 - Severity of operating conditions
 - Time in service
 - Inspection detail
 - Inspection frequency
 - Inspection coverage
- Wear
 - Joint position
 - Time in service

Fatigue Crack Growth



How to Rationalise?



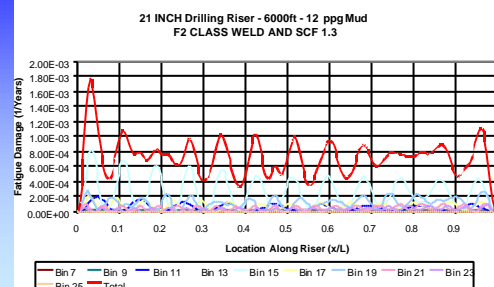
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- Wear
 - Joint position
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Influence of Operational Practices



- Tension and tension variation
 - reduced VIV, vessel capacity may limit, increased wellhead loading
- Joint rotation
 - spread fatigue damage
 - scope may be limited
- Flex-joint angle limits
 - reduced limits give less wear
 - more downtime

VIV Fatigue at Riser Base



Riser Joint Rack (2)



Deepwater Inspection Strategy



- Use current time based approach as basis
- Account for increased wear and fatigue
- Account for operational practices

Variables to Accommodate



- Drilling in different water depths
- Different usage of different joints
 - lower rated joints used more often
- Actual operating conditions
 - may be more or less severe than predicted
- Requires rigorous usage logging

Usage Logging Requirements



- Operations log
 - riser history
- Riser stack-ups
 - joint position and dates
 - basis for selective inspection
- Operating conditions
 - tension, mud-weight, drill string tension, current and wave
 - verify operation and identify extreme events

Summary



- Current inspection practices must be extended for long term deepwater drilling
- Rationalisation dependent on:
 - depth and environmental conditions
 - time each joint in service
 - operational practices
- Logging necessary to verify correct operation and enable selective coverage
- Experience will enable refinement