Guidelines for Drilling Riser Joint Integrity

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ABSTRACT

The characteristics of deepwater drilling riser systems that influence integrity requirements and loss of integrity are as follows:

- Higher tensions, placing increased importance on wall thickness and which may accelerate fatigue crack growth in the riser;
- Larger curvatures, promoting the possibility of wear from drill string rotation;
- Vortex induced vibrations due to severe currents, which can generate high levels of fatigue damage in short periods of time;
- Longer drill string having increased tension, increasing wear at the top of the riser;
- Longer and heavier riser joints, more difficult to handle with increased scope for damage during riser running and retrieval;
- Greater internal pressures from mud head placing increased importance on wall thickness for hoop load resistance;
- Greater external pressures from water column, placing increased importance on wall thickness and dimensional tolerances for collapse resistance;
- Load sharing between riser tube and choke and kill lines placing increased importance on integrity of choke and kill lines for overall structural integrity.

The potentially greater rates of wear and fatigue damage accumulation and increased importance of wall thickness integrity for deepwater indicate that traditional inspection practices used for shallow water operations may need to be revised for deepwater drilling. When initiating a drilling programme in deep water or harsh environments, the riser inspection strategy must therefore be re-evaluated to take account of the severity of the operating conditions.

As part of an industry initiative for developing guidance for drilling riser usage in deepwater, 2H Offshore Inc were contracted to develop guidelines for drilling riser joint integrity. This work consisted of the following activities:

- Review of current practice for monitoring riser usage;
- VIV fatigue analysis of 2 case study drilling riser;
- Fracture analysis and inspection methods assessment;
- Requirements for riser record keeping.

The findings of this work, which form the basis of the integrity assessment guidelines being developed, are reported in this paper.
GUIDELINES FOR DRILLING
RISER JOINT INTEGRITY

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Introduction

- Characteristics of deepwater drilling risers
- VIV - effects and implications
- Wear - reasons for concern
- Deepwater drilling riser joint inspection
  - Objectives, difficulties, rationalisation
- Usage logging requirements

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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

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Deepwater 1 Year Return Period Currents

- WoS
- Brazil
- GoM Loop
- West Africa

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Effects of VIV

• High rates of fatigue damage
• Increased drag loading

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6000ft Drilling Riser
VIV Fatigue (1)

21 INCH Drilling Riser - 6000ft - 12 ppg Mud
F2 CLASS WELD AND SCF 1.3

Fatigue Damage (1/Years)

Location Along Riser (x/L)

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6000ft Drilling Riser
VIV Fatigue (2)

21 INCH Drilling Riser - 6000ft - 16.5 ppg Mud
F2 CLASS WELD AND SCF 1.3

Learn more at www.2hoffshore.com
6000ft Drilling Riser
VIV Drag Amplification

21 INCH Drilling Riser - 12 ppg Mud - Operational Top Tension
F2 CLASS WELD AND SCF 1.3

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Wear in Deep Water

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

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Wear Hotspots

- Lower Flex-Joint
- LMRP
- BOP
- Conductor
- Casing
- Firm Soil
- Soft Soil

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Wear Control

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

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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

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Purpose of Riser Joint Inspection

• Detect and quantify deterioration in integrity

• Sources of deterioration:
  – fatigue damage accumulation
  – impact / handling damage
  – wear from drill string rotation
  – corrosion

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Status of Drilling Riser Inspection

• Shallow water
  – total kip-days
  – 1 year usage

• Deep water
  – increased wear and fatigue
  – limited long term experience
  – strategies need to be defined

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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

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Riser Joint Access

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Riser Joint Rack (1)

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How to Rationalise?

• In-place inspection
  – Calipers, pigging
• On-deck inspection
  – Space, equipment, personnel
• On-deck screening
  – Magnetostrictive method
• Selective onshore inspection

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Rationalization by Selection

• Fatigue based approach:
  – Severity of operating conditions
  – Time in service
  – Inspection detail
  – Inspection frequency
  – Inspection coverage

• Wear
  – Joint position
  – Time in service

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Fatigue Crack Growth

Lower Riser - Through-Thickness Crack Growth

Crack Depth, \( a \) (mm)

Time (years)

- Initial \( a/c = 1.0 \)
- Initial \( a/c = 0.5 \)
- Initial \( a/c = 0.2 \)

\( a = t \)

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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

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VIV Fatigue at Riser Base

21 INCH Drilling Riser - 6000ft - 12 ppg Mud
F2 CLASS WELD AND SCF 1.3

Learn more at www.2hoffshore.com
Riser Joint Rack (2)

Learn more at www.2hoffshore.com
Deepwater Inspection Framework

- Use time in service approach as basis
- Account for increased wear and fatigue
- Account for operational practices
- Adjust intervals with experience

- Practice can vary from contractor to contractor and vessel to vessel

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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

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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

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Summary

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

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