Deepwater Drilling Riser Technical Challenges

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Deepwater Drilling Riser Technical Challenges

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About 2H Offshore
Riser & Conductor Engineering

- Founded in 1993
- 180 highly qualified engineers
- Global standardised procedures for seamless operation
- Extensive experience in all riser types
- Practical understanding of hardware and installation
- Leaders in marine structure dynamics
- A technology driven company
- Part of the ACTEON group

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Introduction

- Present the challenges of moving to deepwater
  - Define the operational requirements of a deepwater drilling riser
  - Which of these become more difficult with deeper water

- Discuss options for overcoming these challenges
  - Modifications to conventional systems
  - Optimised well design
  - Alternative solutions

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Contents

- Drilling Riser System Overview
- Drilling Riser Operability
- Challenges of Scaling to Deeper Water
- Conventional Solutions
- Alternative Technologies

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Conventional Deepwater LP Drilling Riser
Conventional LP Drilling Risers

- Typically 21” OD marine riser
- 80ksi steel
- Range of Connector Types
- External Auxiliary Lines
- Buoyancy Modules to 10,000ft
- 18-3/4” Subsea BOP system

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Loading

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Drilling Riser Systems: Static Loading

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Flexible Joint Rotation Limits

- <2° for drilling

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Drilling Riser Systems: Operating Criteria

Flexible Joint Rotation Limits (<2° for drilling)
- Increasing top tensions increase operability

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Drilling Riser Systems: Operating Envelopes

Flex joint rotation

RISER OPERATING ENVELOPE WITH CURRENT ONLY
400kips Base Tension - Mud Filled 1.35SG - Soft Soil Profile

Vessel Offset (% of water depth) vs. Surface Current Velocity (m/s)

- Drilling
  - FJ Rotation < 2deg (mean)
  - VM / Yield Stress < 0.67

- Connected (Not Drilling)
  - FJ Rotation < 90% max
  - VM / Yield Stress < 0.8

- Survival
  - FJ Rotation < 90% max
  - VM / Yield Stress < 1.0

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Moving to Deeper Water

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Scaling to Deeper Water: Top Tension Capacity

- Increased volume of drilling mud
- Increased internal burst pressure (HP reservoirs)
- Increased external hydrostatic collapse pressure
- Increased riser pipe wall thickness
- Limited by minimum ID for drill bits & casing hangers
- Higher axial stress

- Longer riser string
- Heavier riser string

- Increased Riser Top Tension
- Increased Vessel Tensioner Requirement

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Scaling to Deeper Water: Drilling Riser Buoyancy

- External buoyancy attached to riser joints reduce the in-water mass of the riser string

- Typically made from syntactic foam
  - Glass or ceramic hollow micro spheres
  - Suspended in a polymer matrix

- External durable coating

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Scaling to Deeper Water: Buoyancy Impacts

- Greater deck space usage
- Handling difficulties
- Increased riser drag
- Reduced buoyancy effectiveness at greater depths
- Rotary table opening size limit

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Reduced buoyancy effectiveness at greater depths
Scaling to Deeper Water: Vortex Induced Vibration Fatigue

- All bodies in current flows experience forces.
- When an in-line current causes the bodies to vibrate at a natural frequency in the cross-flow direction this is called VIV.
- Constant vibration of the riser causes stress cycling, which causes fatigue damage on the riser, which can cause the riser to fail.

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Scaling to Deeper Water: Vortex Induced Vibration Fatigue

- Longer riser strings have lower natural frequencies
- So slow currents which may not excite a shallow water riser can excite the same diameter riser in deeper water
- For the same current speed higher frequencies can be excited
- These higher frequencies have greater curvatures and larger bending stress cycles

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Conventional LP Drilling Risers

- **Deepwater Issues**
  - High tension requirements (2500kips+ for 10,000ft)
  - Buoyancy becomes less efficient
  - Highly susceptible to VIV (Vortex Induced Vibration)
  - Complex Choke / Kill line interaction and sealing due to large riser deflection
  - Worldwide lack of deepwater rigs
  - High rig cost
  - Rig availability will dictate development schedule

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Solutions

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Conventional Solutions

- New larger capacity rigs
  - Greater deck capacity
  - Larger tensioner systems
  - Larger rotary tables

- Long term rig contracts

- VIV suppression
  - Strakes
  - Distributed buoyancy
  - Tension variation

- Optimised well design

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Well Construction: Design for Fatigue Resistance

- Optimise the choice of well components:
  - Conductor size
  - Conductor joint length
  - Weld quality

- Construction variables:
  - Wellhead stick-up
  - Cement shortfall

- Impact of riser design:
  - Operation mode
  - Subsea component size

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Well Construction: Design for Fatigue Resistance

- Conductor to Wellhead Girth Weld
- Extension Girth Weld
- Conductor Coupling
- Conductor to Coupling Weld

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BENDING MOMENT DISTRIBUTION ALONG CONDUCTOR
300kips Base Tension - 380 W.D. - 10 Year Current - Upper Bound Soil

Elevation above Seabed (m)

Bending Moment (kNm)

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Effects of Conductor Sizes

Generic Wellhead And Conductor Fatigue Analysis
MINIMUM UNFACTORED FATIGUE LIFE
D Class SCF 1.3

Fatigue life increased by a factor of 5 with an upgrade from 30” OD to 36” OD

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Effects of Weld Quality

Increase in fatigue life by a factor of 10 when achieving a C class weld compared to an E class

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Effects of Wellhead Stick-up

MINIMUM UNFACTORED FATIGUE LIFE
C Class SCF 1.1, Weld 0.935m Below Top of Conductor

2m Stickup 40% - 50% better than 3m Stick-up

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Effects of Cement Shortfall

No cement shortfall 50% better than 2m cement shortfall

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Effects of Operating Mode

**Drilling Mode**  
(no Subsea tree)

**Completion Mode**  
(with Subsea tree)

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Effects of Operating Mode

Completion Mode 3 times more damaging than Drilling Mode

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Well Construction Findings

- Larger LRMP & BOP stacks typical on deepwater drilling rigs have a detrimental affect on a wellhead fatigue performance
- This can be offset by:
  - Incorporating a larger diameter conductor
  - Choosing conductor joint lengths based on peak lateral load
  - Specifying better weld details
  - Using a rigid lock down wellhead
  - Ensuring a good conductor cement job
  - Ensuring a low wellhead stick-up

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Alternative Solutions

- Steel replacements
- HP surface BOP drilling riser
- Near Surface BOP Systems
- Free standing drilling riser

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Steel Replacements

- Drilling Riser Joints including Choke & Kill Lines
  - Composite
  - Aluminium
  - Titanium

- Issues
  - Lower stiffness induces greater riser deflections
  - Lower wear resistance (composite & aluminium)
  - Lower corrosion resistance (aluminium)
  - Higher production costs

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HP Surface BOP
Drilling Riser

Surface BOP
Stress Joints
Flex-Joint
Telescopic Joint
Subsea ESD
Subsea Wellhead
Tie-back connector
13-3/8” Casing (typ.)
Buoyancy Modules (Optional)

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HP Surface BOP Drilling Riser

- 13-5/8” 15ksi Surface BOP
- Typically 13-3/8” or 16” casing
- Subsea ESD for emergency disconnection
- Use of additional buoyancy dependent on vessel tension capacity and water depth
- Top configuration to suit vessel (modifications may be required)
- Casing can be re-used or run downhole on next well
- Allows lower spec / cost rigs to be used in deepwater applications

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Near Surface BOP Systems

- Elevates BOP to near surface region (100m – 250m water depth)
- Buoyancy tank used as ‘artificial seabed’
- Standard rig marine riser and BOP used to surface
- Large diameter tie-back casing (21”+) used to seabed
- System can freestand with BOP in event of disconnect
- Allows use of 3rd generation rigs for deepwater wells

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Freestanding Drilling Risers

Conventional upper riser

Upper disconnect package

Aircans to support lower riser

Conventional lower riser

LMRP and BOP

Aircan to support casing and BOP

Well casing

Tie-Back Connector

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Summary

- Scalability of conventional marine risers becomes increasingly difficult with increasing water depths.
- New purpose-built rigs overcome the majority of these challenges, but their availability is limited.
- New technologies are being championed which can allow the upgrading of older rigs for use in deeper water.
- Problems still exist such as VIV and other forms of fatigue that need to be considered in well planning.

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Thank you for your time

Questions?

Further information:

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