Deepwater Riser System Challenges and Issues

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Presentation Objectives

• Review riser system options
• Update on current industry status
• Highlight key issues
• Discuss current industry approach
• Outline alternative solutions for ultra deep water

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Dry Tree Vs Wet Tree Debate

• Dry Tree with vertical well access
  – Top Tensioned (TTR) riser
  – Motion optimised vessels (Spar/TLP)
  – High payload and wellbay design issues
  – Drilling technologies (threaded construction)
• Wet Tree
  – Catenary systems (Flexible /SCR)
  – Free standing with catenary jumpers
  – Catenary Moored vessels (Semi / FPSO)
  – Fatigue sensitivity
  – Flowline technologies (welded construction)

Status of Deepwater Risers

Top Tension Risers (Dry Trees)
• Deepest Spar – 5,600ft (Planned)
• Deepest TLP – 4,700ft (Planned)
Spar and TLP Status

Existing and Planned Dry Tree Units
(SPAR's and TLP's)

Year

- 1980
- 1985
- 1990
- 1995
- 2000
- 2005
- 2010

Water depth (ft)

0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000

- Spars (Planned)
- TLPs (Actual)
- TLPs (Planned)
- Spars (Actual)

Flexible Riser - Status

- 6inch ID Prod. – 6,200ft (Roncador P36)
- 9 1/8 inch ID – 4,900ft (Qualified)
- 11 inch Gas Export 3,500ft (P40)

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Status of Steel Catenary Risers

- Many installations to date
- Deepest – 6,300ft (Semi)
- Large Diameter Exports:
  - 20inch Gas (Na Kika)
  - 24inch Oil (Mardi Gras)
- First Pipe in Pipe Production

Hybrid Risers Status

- Girassol Bundle Riser
  - 4500ft (Prod., GL, WI)
- Single Line Offset Riser
  - Kizomba A – 3300ft (WAG)
  - Kizomba B – 4000ft (WI)
- Concentric Offset Riser
  - Kizomba B - Production

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Girassol - Bundled Free Standing Riser

Key Riser Design Issues

- Water depth
- High pressures
- High temperatures
- Thermal management
- Sour service
- Host facility performance
- Installation requirements

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Dry Tree Riser Benefits

- Efficient drilling and major workover access
- Efficient production
  - Valve and choke access
  - Wireline logging
  - Wireline and Coiled Tube access
  - No commingling of well fluids

Reduced drilling time
Reduced production downtime
Higher production rates

Top Tensioned Riser Issues

- Pressures
- Water Depth
- Materials
- No. of Casings
- RISER WEIGHT
  - Large Aircans / Tensioners
  - Vessel Impacts
  - Aircan Installation
  - Riser Costs

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Top Tensioned Riser Issues

- Vessel interfaces
  - Riser guide impact loads (Hull fatigue)
  - Compliant guide – friction stick slip (Riser fatigue)
- HP/HT flexible jumper limitations
- Increased interface loads
- Wellbay congestion
- Riser stroke (Pull over drilling)

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Dry Tree Summary

- Medium depth solution extrapolated to deep water
- Increasingly complex to tie back heavy risers in deep water
- Riser complexity being accepted and re-engineered on each application
- Alternative Tensioning Systems
  - Aircans
  - Hydro-pnuematic
- Alternative riser materials
  - Composites
  - Titanium
  - High strength steel (Threaded Connections)

storm™ - A Riser and Well Access Focused Solution

- Configuration
  - COR/SLOR risers
  - Manifolded horizontal trees
  - HP drilling riser
  - Catenary moored platform
- Features
  - Low cost drilling
  - Direct well access
  - Low cost vessel
  - Reduced riser numbers
  - Simplified interfaces
  - Fast track schedule

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Steel Catenary Risers

- Cost effective solution for subsea tie backs
- Extension of the flowline
- Suitable for wide range of diameters and water depths
- Welded construction
- Range of installation methods (J-Lay, S-Lay, Reel Lay)

SCR Design Issues

- HP/HT
  - Thick wall pipes
  - Manufacturing process limits
  - Welding issues
  - Temperature de-rating of Steel
  - Vessel Payload
  - Installation vessel availability
- Material Loss
  - Corrosion / Erosion issues
  - Effect of wall thickness requirements
  - Impact on stress in extreme conditions

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SCR Design Issues

• Thermal Management
  – Prevent Hydrate Formation
  – Increases Riser Dia/Weight
  – Riser lighter in water
  – Increases stress at TDP
  – Degrades fatigue response
  – Reduces Vessel Payload
  – Pipe in Pipe consideration

• Field Layout
  – Many SCR’s and subsea equipment – installation issues
  – Vessel attachment point congestion – Topside Layout
  – Clashing / Interference Issues
  – Flowline interfaces
  – Topography

• Vessel Motions
  – Fatigue sensitive system
  – High period and low period impacts
  – Heave in excess ±10m may cause SCR compression at TDP
  – Non-linear response at TDP
  – SCR design sensitive to vessel changes

• Environmental Impacts
  – Current profiles and durations
  – Requirement for strakes

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SCR Thick Wall Welding Issues

- Control of material yield strength
- Weld consumables must ‘over match’ substrate
  - Stabilise flaw growth
- Extensive qualification testing required
- Poor weld class could be expected
- Weld quality and SCF critical
- Long weld times (2 hours+)
  - Wide bevel required
  - 20+ weld passes
  - AUT capability and duration
- Potential for excessive installation cost
- H2S susceptibility – reduce weld performance

SCR Summary

- Welded construction is the default
  - Large track record
  - High level of confidence
  - Industry preference to extrapolate shallow water technology
  - Contractor pre-investment in installation vessels
  - No alternatives offered
- SCR’s with more challenging criteria are complex riser systems

Alternative solutions

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Weld vs Threaded Connections

- High strength steel 95-110 ksi
- 13% chrome steel (for H₂S)
- Example Comparison:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Welded X65</th>
<th>Threaded P110</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wall Thickness</td>
<td>1.0</td>
<td>0.55</td>
</tr>
<tr>
<td>Top tension</td>
<td>1.0</td>
<td>0.58</td>
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<tr>
<td>Flow area</td>
<td>1.0</td>
<td>1.28</td>
</tr>
<tr>
<td>Max Riser Stress (100yr)</td>
<td>1.0</td>
<td>0.86</td>
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<tr>
<td>Fatigue Life E-1.25 vs B-3.0</td>
<td>1.0</td>
<td>2.00</td>
</tr>
</tbody>
</table>

- Threaded connections offer faster installation from Drill Rig / Q4000
- Threaded Connections for SCR – Unproven

Coupling Fatigue Qualification

DnV B SN Curve SCF 2.0
Better fatigue performance than weld

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Hybrid Riser Benefits

- Low fatigue sensitivity (Quasi-Static)
- Pre-installation feasible
- Accommodates stringent thermal requirements
- Flexible field layout
- Riser base gas lift
- Low vessel loads
- Vessel interface criticality low
- Low cost installation (Threaded Construction)
- Improved level of design confidence (margin)

Hybrid Riser Design Issues

- High pressure / temperature limitation from flexible jumpers
- Threaded construction limited to 16 inch diameter
- Threaded installation methodology yet to be proven
- Undefined contract strategies

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Conclusions

• Risers are one of the most complex aspects of deepwater
• Dry Tree vs Wet Tree decision dictates riser solution
• Increasing water depth compounds riser issues particularly installation
• Storm is an in-between solution offering many benefits important to deepwater
  – Reduce weight / Payload / Buoyancy needs
  – Minimise offshore construction
  – Faster/cheaper installation
  – Simpler interfaces
  – Well access
• Systems approach to integrate riser disciplines is critical
• Increased focus on riser issues in selecting field development solution is advocated
• Take advantage of both drilling and flowline technologies

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