MODU Installed Freestanding Riser for Deepwater Production

R. Thethi, H. Howells

Deepwater Technology Symposium
Apr. 2016
2H offshore

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MODU Installed Freestanding Riser for Deepwater Production

April 2016

Ricky Thethi & Hugh Howells

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Agenda

- Introduction  - compliant riser systems
- Conventional freestanding riser design and installation
- Alternative MODU installation
- Cost comparisons
- Summary

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Compliant Riser Systems

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Water Depths < 4,000ft

- Subsea developments
- High motion floaters – FPSOs, semis
- Flexible risers are the norm
- In deeper water depth,
  - flexible diameter limited to resist collapse pressures
  - larger collapse and tensile armor wires
  - increase cost
- Flexible long term design life uncertain

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Deepwater > 4,000ft

Freestanding hybrid riser

Steel lazy wave riser

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Freestanding Hybrid Riser

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FSHR Key Components

- Buoyancy Tank
- Buoyancy Tank Connection
- Flexible Jumper(s) to Vessel
- Steel Linepipe(s)
- Rigid Base Spool(s)
- Upper Riser Assembly
- Lower Riser Assembly
- Foundation

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## FSHRs Track Record

<table>
<thead>
<tr>
<th>Type</th>
<th>Field</th>
<th>Status</th>
<th>Owner/Field Operator</th>
<th>Yr. Installed</th>
<th>Region</th>
<th>Water Depth (ft)</th>
<th>Water Depth (m)</th>
<th>Vessel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bundle</td>
<td>Green Canyon 29/Garden Banks 388</td>
<td>De-commissioned</td>
<td>Placid Oil Company/Ensearch</td>
<td>1988/1994</td>
<td>GoM</td>
<td>1,529/2,096</td>
<td>466/639</td>
<td>Semi-Submersible</td>
</tr>
<tr>
<td></td>
<td>Girassol</td>
<td>Operating</td>
<td>Total Elf</td>
<td>2001</td>
<td>Angola</td>
<td>4,430</td>
<td>1,350</td>
<td>Spread Moored FPSO</td>
</tr>
<tr>
<td></td>
<td>Rosa</td>
<td>Operating</td>
<td>Total Elf</td>
<td>2007</td>
<td>Angola</td>
<td>4,430</td>
<td>1,350</td>
<td>Spread Moored FPSO</td>
</tr>
<tr>
<td></td>
<td>BP Greater Plutonio</td>
<td>Operating</td>
<td>BP</td>
<td>2007</td>
<td>Angola</td>
<td>4,300</td>
<td>1,311</td>
<td>Spread Moored FPSO</td>
</tr>
<tr>
<td>Single Line</td>
<td>Kizomba A &amp; B</td>
<td>Operating</td>
<td>Exxon</td>
<td>2004/2005</td>
<td>Angola</td>
<td>3,330 to 4,200</td>
<td>1,006 to 1,280</td>
<td>Spread Moored FPSO</td>
</tr>
<tr>
<td></td>
<td>Block 31 NE</td>
<td>Operating</td>
<td>BP</td>
<td>2012</td>
<td>Angola</td>
<td>6,890</td>
<td>2,100</td>
<td>Turret Moored FPSO</td>
</tr>
<tr>
<td></td>
<td>P-52</td>
<td>Operating</td>
<td>Petrobras</td>
<td>2007</td>
<td>Campos Basin</td>
<td>5,906</td>
<td>1,800</td>
<td>Semi-Submersible</td>
</tr>
<tr>
<td></td>
<td>Macando</td>
<td>De-commissioned</td>
<td>BP</td>
<td>2010</td>
<td>GoM</td>
<td>5,000</td>
<td>1,515</td>
<td>DP FPSO</td>
</tr>
<tr>
<td></td>
<td>Cascade/Chinook</td>
<td>Operating</td>
<td>Petrobras</td>
<td>2010</td>
<td>GoM</td>
<td>8,531</td>
<td>2,600</td>
<td>Turret Moored FPSO</td>
</tr>
</tbody>
</table>

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# FSHR Installation

<table>
<thead>
<tr>
<th>Field</th>
<th>Kizomba A/B Blk15</th>
<th>Cascade/Chinook Walker Ridge</th>
<th>PSVM Block31</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operator</td>
<td>ExxonMobil</td>
<td>Petrobras</td>
<td>BP</td>
</tr>
<tr>
<td>Contractor</td>
<td>Saipem</td>
<td>Technip</td>
<td>HMC</td>
</tr>
<tr>
<td>Location</td>
<td>Angola</td>
<td>GoM</td>
<td>Angola</td>
</tr>
<tr>
<td>Water Depth</td>
<td>1000-1400m</td>
<td>2600m</td>
<td>2100m</td>
</tr>
<tr>
<td>Riser Type</td>
<td>5 (5+2) SLORs / 3 CORs</td>
<td>5 FSHRs</td>
<td>9 SLHR</td>
</tr>
<tr>
<td>ODs</td>
<td>8-5/8inch</td>
<td>9-3/8inch</td>
<td>10-3/4inch</td>
</tr>
<tr>
<td></td>
<td>12-3/4inch</td>
<td>10-3/4inch</td>
<td>14inch</td>
</tr>
<tr>
<td>Specifics</td>
<td>First - PIP</td>
<td>Deepest</td>
<td>ID Overlay/liners/ Installed like tendon</td>
</tr>
<tr>
<td>Vessel</td>
<td>Saibos Field Devel. Ship (FDS)</td>
<td>Technip DeepBlue / Jumbo Fairplayer</td>
<td>HMC Balder</td>
</tr>
<tr>
<td>Crane Capacities</td>
<td>1 crane 600t @ 28m, -168msl 300t @ 55m, -410msl</td>
<td>1 crane 400t @ 18m 60t @ 55m</td>
<td>2 1000t cranes Max 5000t dual lift</td>
</tr>
<tr>
<td>Installation</td>
<td>J-Lay / Welded Riser (550t)</td>
<td>Reel Lay (wt 770t J-lay)</td>
<td>J-Lay Welding riser (1050t)</td>
</tr>
<tr>
<td>Buoyancy Tank Connection</td>
<td>Chain</td>
<td>Chain</td>
<td>Rotolatch</td>
</tr>
<tr>
<td>Jumper Installation</td>
<td>Pre-installed</td>
<td>Subsea Jumper Offtake</td>
<td>Verderg Diverless Connector</td>
</tr>
<tr>
<td>Subsea Connection</td>
<td>Rotolatch – Pulldown</td>
<td>Rotolatch – Pulldown</td>
<td>Rotolatch – Stabbed</td>
</tr>
<tr>
<td>Vessel Modifications</td>
<td>Hang-Off</td>
<td>Hang-off (Fairplayer)</td>
<td>Hang-off, rated 1000t</td>
</tr>
</tbody>
</table>

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FSHR Pros and Cons

- Design decouples riser from vessel 1st order motions
- Not highly sensitive to environmental loading
- Good fatigue performance (F class weld offshore)
- Low vessel payload – good for FPSO turret loads and tieback to existing host
- Pre-installable ahead of production host vessel
- Installation flexibility pre or post laying of subsea flowlines and pipelines
- Flow assurance flexibility
  - Large insulation thicknesses
  - Pipe-in-Pipe
  - Can use corrosion resistant alloy lined pipe
- High cost – $60-80MM per installed riser versus $20-25MM for steel lazy wave risers

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MODU Installed FSHR

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- MODU installed design very similar to spar top tensioned riser components
- Riser joint made up with mechanical connectors
- Latched to foundation pile using a wellhead connector
- Surface flexible jumper pre or post installed
- AirCan designed to be within the BOP size envelope (20ft dia. x 40ft height)
- Use foam buoyancy as needed to reduce AirCan tension requirements

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BP Macondo FSHR for Containment
Key Installation Steps

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FSHR Connection Options

- Single pipe or PIP
- T95/C110 casing pipe with non-welded threaded and coupled
- X65/X70 line pipe with:
  - weld on threaded pin and box
  - weld on concentrically grooved pin and box
  - weld on high fatigue resistant flange

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Mechanical Connector Track Record (dry and wet tree)

- 15 dry tree Spar developments
  - 150 riser systems (dual or single)
  - 240 riser strings

- 24 dry tree TLP development
  - 430 riser systems (dual or single)
  - 540 riser strings

- Shell Perdido Spar subsea tree import TTRs

- Exxon Marimba subsea tree tie back to Kizomba A TLP using an import TTR

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Design & Application Advantages

- Significantly lower installed cost
- Minimize riser induced dynamic movements and fatigue at base jumper
  - Use of tapered stress joints versus flex-joint
- Use high strength steel (T95/C110 vs. X65/X70)
  - Lower tension requirements by more than 30%
  - Reduce aircan size
- Readily retrieval and relocatable
  - EPS
  - Poor performing field

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MODU Installed FSHR Costing – 4,500ft Water Depth

- 1500ft, 7-in bore flexible: $3.0MM
- Buoyancy can, 700 kips tension: $3.0MM
- Upper riser assembly with flex-joint rotolatch: $1.5MM
- 10-3/4” 10ksi T95 insulated riser joints: $2.5MM
- Lower stress joint, 45ft: $1.0MM
- Lower riser assembly: $0.5MM
- Wellhead connector: $1.0MM
- Conductor pile foundation: $1.0MM
- Riser base spool/jumper: $1.5MM
- Spares and ancillary equipment: $5.0MM
- MODU Installation (10 days): $5.0MM
- MSV support (10 days + mob/demob): $5.0MM

- Total installed cost per riser $30.0MM

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Cost Comparison, 4500ft WD

- Conventional steel lazy risers:
  - 5 off 10-3/4” x 1.0-in risers - $125MM
  - Riser payload – 2,250 kips

- Conventional FSHRs:
  - 5 off 10-3/4” risers - $300MM
  - Riser payload – 800 kips

- MODU installed FSHRs:
  - 5 off 10-3/4” risers - $150MM
  - Riser payload – 800 kips

- MODU installed FSHR
  - Significantly less cost than conventionally installed
  - Comparable cost to steel LWRs
  - Less payload on turret = cost savings on turret

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Barriers to Implementation

- Operator led contracting strategy of using a MODU drilling in the field to install a production riser
  - EPCI approach may be difficult with a drilling contractor, use TLP/Spar model
  - Rig installed production risers are the norm on dry tree platforms
  - MODU rates are now cheaper and no mobilization cost

- Long term sealing reliability concerns of mechanical connectors
  - PIP configuration used on Perdido and Marimba subsea tree developments and operating for many years (2010 and 2007 respectively)
  - Single pipe configuration provides weight and tension advantages

- Extensive operating history with dry tree single casing TTRs with no reported leakages or failures in approx. 50,000 riser joint threaded connectors

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SUMMARY
Summary

- FSHR now has an extensive track record since 2001
- FSHR offers key advantages with payload, fatigue, installation flexibility and compact spatial layout
- Cost reduction required based on recent project history
- MODU installed approach can reduce FSHR costs by approx. 50%
- Installation proven with Macondo containment riser and implemented into oil spill response equipment
- A non-EPCI operator led contracting strategy is required similar to the TLP/Spar model

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