Risers for Deepwater FPSOs

J. Bob-Manuel

FPSO Vessel Conference
Mar. 2013
Risers for Deepwater FPSO’s

John Bob-Manuel
Senior Engineer
2H Offshore Engineering Ltd.

March 2013

Learn more at www.2hoffshore.com
Agenda

- 2H overview
- Challenges of Deepwater Operations
- Freestanding Riser Overview
- Riser Configurations and Component Design
- Case Study
- Alternatives

Learn more at www.2hoffshore.com
About 2H Offshore
Riser & Conductor Engineering

- Founded in 1993
- 230 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
- An independent, technology driven company
- Part of the Acteon group

Learn more at www.2hoffshore.com
Services

- Concept Design & FEED
- Detailed Engineering
- Procurement management
- Fabrication & Installation Support
- Integrity Management & Monitoring

Learn more at www.2hoffshore.com
Deepwater Riser Design Challenges

- Long unsupported lengths
- High pressures
- Design life of 20-30 years
- Environmental loading
  - Current
  - Wave
- FPSO
  - Vessel motions
  - Vessel offsets
  - Payload limitations
  - High riser tension
  - Clashing Control
- High extreme stresses
- High fatigue damage rates

“20% of the cost, 80% of the problem”

Learn more at www.2hoffshore.com
Steel Catenary Riser (SCR)

- 6-30” diameter
- 1,000 – 10,000ft water
- Sensitive to vessel and environment
  - Extreme loads
  - Fatigue motions
  - Vessel-induced motions (VIM)
  - Vortex-induced vibration (VIV)
- Payload impact on host facility
- Complex vessel interface
  - Flex joint
  - Stress joint
- Touch Down Point (TDP)
  - Fatigue
  - Compression / Buckling
  - Interaction with soil

Learn more at www.2hoffshore.com
Flexible Risers

- Compliant response
- Not fatigue sensitive
- Installation friendly
- Limitations
  - Water depth
  - Pressure
  - Diameter
  - Temperature
- Expensive
- Reliability?
- Availability?

Learn more at www.2hoffshore.com
Free Standing Riser Configuration

Learn more at www.2hoffshore.com
BP Block 18 Riser Bundle

Learn more at www.2hoffshore.com
Buoyancy Tank

- Maintain riser verticality
- Steel plate structure
- Flat or hemispherical ends
- Pressure balanced design
- Water / nitrogen filled
- Compartmentalised

Design up to:
- 40m tall
- 6m diameter
- ~700Te upthurst

Limited by:
- Fabrication site
- Handling / Installation restrictions

Learn more at www.2hoffshore.com
Upper Riser Assembly (URA)

- Tubular frame structure

- Loading interface between:
  - Top of riser pipe
  - Buoyancy tank
  - Flexible jumper

- May require:
  - Articulation connection
  - Flexible jumper pull-in
  - Intervention entry point

- Design up to:
  - 25m tall
  - 60Te

Learn more at www.2hoffshore.com
Base Assembly

- Rigid Base Jumper
- Taper Joint
- Flex Joint

Learn more at www.2hoffshore.com
Lower Riser Assembly (LRA)

- Tubular frame structure
- Loading interface between:
  - Bottom of riser pipe
  - Foundation
  - Rigid base jumper
- May require:
  - Articulation connection
  - Stress joint
  - Riser base gas lift
- Design up to:
  - 5m - 20m tall
  - 10 - 30Te

Learn more at www.2hoffshore.com
Freestanding Riser Evaluation

Advantages

- Decoupled from vessel motions
- Neat Seabed Layout
- Not sensitive to environmental loading
- Excellent fatigue performance
- Low vessel payload
- Vessel disconnect capability
- Installation flexibility
  - Vertical pipe handling
  - J lay, reel lay, threaded
  - Tow out
- Flow assurance flexibility
  - Large insulation thicknesses
  - Single pipe or Pipe-in-Pipe
- Local content
  - Piles, Buoyancy Can, Rigid jumpers
- Opportunity for design standardisation

Learn more at www.2hoffshore.com
Freestanding Riser Evaluation

Disadvantages

- High Capital Costs (CAPEX) compared to SCR
- Mechanical complexity
  - Design phase
  - Procurement phase
- Large spatial requirement
- Clearance or clashing issues
- Increased design complexity
- Installation challenges
  - Large components
  - Overall lift weight/height

Learn more at www.2hoffshore.com
<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</th>
<th>Vessel</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(ft)</td>
<td>(m)</td>
</tr>
<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>
</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>
</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>
</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>
</tr>
<tr>
<td>Single Line</td>
<td>Kizomba A/B</td>
<td>Operating</td>
<td>Exxon</td>
<td>2003/2005</td>
<td>Angola</td>
<td>3,330 to 4,200</td>
<td>1,006 to 1,280</td>
</tr>
<tr>
<td></td>
<td>Block 31 NE</td>
<td>Installed</td>
<td>BP</td>
<td>2010</td>
<td>Angola</td>
<td>6,890</td>
<td>2,100</td>
</tr>
<tr>
<td></td>
<td>Roncador P-52</td>
<td>Operating</td>
<td>Petrobras</td>
<td>2007</td>
<td>Campos Basin</td>
<td>5,906</td>
<td>1,800</td>
</tr>
<tr>
<td></td>
<td>Containment FSH</td>
<td>Completed</td>
<td>-</td>
<td>2010</td>
<td>GoM</td>
<td>4,992</td>
<td>1,500</td>
</tr>
<tr>
<td></td>
<td>*Cascade/ Chinook</td>
<td>Detailed</td>
<td>Petrobras</td>
<td>2011</td>
<td>GoM</td>
<td>8,531</td>
<td>2,600</td>
</tr>
</tbody>
</table>

Learn more at www.2hoffshore.com
PSVM – Overview

- Block 31, offshore Angola
- Putao, Satunro, Venus and Marte fields
- 1800m to 2100m (5900ft to 6890ft) water depth
- 9 Single Leg Hybrid Risers (SLHRs) connected to an externally mounted turret moored FPSO
- Deepest SLHR in WoA
- J-lay installation using Balder

Learn more at www.2hoffshore.com
<table>
<thead>
<tr>
<th>Service</th>
<th>PSVM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Production</td>
<td>1 x 10in Insulated Clad CS</td>
</tr>
<tr>
<td></td>
<td>2 x 12in Insulated Clad CS</td>
</tr>
<tr>
<td>Gas Lift</td>
<td>1 x 8in Insulated Nominal CA</td>
</tr>
<tr>
<td>Water Injection</td>
<td>1 x 14in Non-insulated Polyethylene Lined</td>
</tr>
<tr>
<td>Gas Injection</td>
<td>1 x 10in Non-insulated Nominal CA</td>
</tr>
<tr>
<td>Service</td>
<td>1 x 10in Non-insulated Nominal CA</td>
</tr>
<tr>
<td></td>
<td>2 x 12in Non-insulated Nominal CA</td>
</tr>
<tr>
<td>Dynamic Umbilical</td>
<td>4 x Main Control Umbilical</td>
</tr>
<tr>
<td></td>
<td>1 x Gas Lift Control Umbilical</td>
</tr>
<tr>
<td></td>
<td>1 x Spare Main Control Umbilical</td>
</tr>
</tbody>
</table>
- Project started in 2005
- 2H was responsible for...
  - Detailed component structural design
  - Detailed global analysis
  - Installation analysis
  - Procurement management

Learn more at www.2hoffshore.com
PSVM - Driven Pile

- Driven pile self-penetrates into soil
- Hydraulic hammer drives the pile to required depth
- Pile length depends on soil conditions
PSVM – Ballast Module

- Mudmat (12m x 12m) provides resistance from sinking into the soil
- Ballast blocks (layers of steel plates) provides additional weight
- Total submerged weight of foundation must account for the maximum vertical loads at riser base
- Dry weight of ballast module can be up to ~300Te
PSVM - Foundation & Lower Assembly

Learn more at www.2hoffshore.com
PSVM - Upper Assembly

- Trussed frame size is 3m x 1.5m, 22.4m long
- Hollow parts must withstand hydrostatic collapse up to 250m depth
- Upper crossover joint
- Flexible joint
PSVM - Buoyancy Tank

- 5.5 m diameter
- Up to 19 compartments, 2m high each
- Max 50 tons up thrust per compartment
- Placed at 150m below sea surface

Learn more at www.2hoffshore.com
Alternatives - Group SLORs

- Grouped arrangement
- Reduced cost - top assembly optimisation
- Ease of pre-installation
- Ease of field layout and pipe routing

Learn more at www.2hoffshore.com
Alternatives - Buoyancy Supported Risers

- Concept developed in the 90’s by DeepStar for WD of 1000m
- Being developed for Guara and Lula pre-salt fields

Learn more at www.2hoffshore.com
Conclusion

- Key interfaces
  - Flexible end terminations and bend restrictors

- Key parameters affecting design
  - Turret vs spread moored
  - Position of riser hangoff
  - Space for riser end terminations
  - Maximum hang off weight
  - Vessel motions
  - Heading analysis
  - Mooring analysis

- Interface mechanism with FPSO contractor needs establishing early on!

- Selection of system required during field layout exercise. The solution will not necessarily be cost driven but the solution needs to be technically engineered.

Learn more at www.2hoffshore.com
Thank you for your time.

Questions?

Further information:

John.Bob-manuel@2hoffshore.om
www.2hoffshore.com
+44 1483 774900

Learn more at www.2hoffshore.com
Thank you

2H offshore

www.2hoffshore.com

Learn more at www.2hoffshore.com