Freestanding Risers for Deepwater FPSO

K. Li

FPSO Vessel Conference
Mar. 2012
Freestanding Risers for Deepwater FPSO

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Senior Engineer
2H Offshore Engineering Ltd.

7th - 8th March 2012

Learn more at www.2hoffshore.com
Agenda

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

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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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Services

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

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An ACTEON company

ACTEON
LINKING SUBSEA SERVICES

Foundations and moorings
Risers, conductors and flowlines
Marine electronics and instrumentation
Oilfield/Subsea Services

2000 people worldwide  |  17 operating companies  |  2011: 380m turnover / £75m EBITDA

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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
- High extreme stresses
- High fatigue damage rates

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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

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Free Standing Riser Configuration

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Single Line and Bundle FSHRs

SINGLE LINE (SLOR / COR)
Kiz A & P52  Kiz B

BUNDLES (Internal) (External)
Girassol  Block 18

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BP Block 18 Riser Bundle

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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 upthrust

- Limited by:
  - Fabrication site
  - Handling / Installation restrictions

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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

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Upper Assembly - Alternatives

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Flexible Risers

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

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Base Assembly

- Rigid Base Jumper
- Taper Joint
- Flex Joint

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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

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Freestanding Riser Evaluation

Advantages

- Decoupled from vessel motions
- 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

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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

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<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>
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<td>Spread Moored FPSO</td>
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<td>2003/2005</td>
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<td>3,330 to 4,200</td>
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<td>Roncador P-52</td>
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<td>Petrobras</td>
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<td>Campos Basin</td>
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<td>8,531</td>
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*To be installed

Learn more at www.2hoffshore.com
- 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

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### Service | PSVM
---|---
Production | 1 x 10in Insulated Clad CS  
| 2 x 12in Insulated Clad CS  
Gas Lift | 1 x 8in Insulated Nominal CA  
Water Injection | 1 x 14in Non-insulated Polyethylene Lined  
Gas Injection | 1 x 10in Non-insulated Nominal CA  
Service | 1 x 10in Non-insulated Nominal CA  
| 2 x 12in Non-insulated Nominal CA  
Dynamic Umbilical | 4 x Main Control Umbilical  
| 1 x Gas Lift Control Umbilical  
| 1 x Spare Main Control Umbilical
- Project started in 2005
- 2H is responsible for...
  - Detailed component structural design
  - Detailed global analysis
  - Installation analysis
  - Procurement management

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PSVM - System Overview

- Buoyancy Tank
- Upper Riser Assembly (URA)
- Upper Rigid Riser Pipe
- Lower Rigid Riser Pipe
- Lower Riser Assembly (LRA)
- Base Foundation
- Crossover Joint
- LRA Frame
- Piping
- Lower Flexible Joint
- Ballast Box
- Upper Flexible Joint
- Upper Riser Assembly (URA)
- Driven Pile
- URA Frame
- Winch Support Frame
- URA Piping
- Crossover Joint

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PSVM - Driven Pile

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

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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

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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

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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

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PSVM - Riser Tower Installed
Alternatives – Group SLORs

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

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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

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FPSO Interfaces

- 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!

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

Questions?

Further information:

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