Challenges in Shallow Water Riser Design

G. Gardner – 2H

IMechE Offshore Engineering
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Challenges in Shallow Water Riser Design

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Gilles Gardner

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Agenda

- Introduction
- Preliminary Project Survey
- Configuration Assessment Methodology
- Configuration Assessment
- Conclusions and Recommendations

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Introduction

- Tubarão Martelo Field (Waikiki)
- Campos Basin - Brazil
- 95km from Rio de Janeiro
- Water Depth 110m

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Introduction

- Challenge of Selecting Design Concept
- Fixed Platform - Lack of Infrastructure
- Water Depth too Shallow for Spar or TLP
- Floating Production Storage and Offloading
- Flexible Risers

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Introduction

OSX-3 External Turret

- Production (6)
- Gas (8)
- Water Injection (1)
- Control Umbilical (8)

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Introduction - Challenges

- Quantity of Risers Selected for Field
- Relatively Light Weight of Flexible Lines
- Geometrical Limitations Shallow Water Depth
- Dynamic Vessel Response Under Harsh Environmental Conditions

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Preliminary FPSO Survey

FPSO Challis Venture
Australia
WD: 100 m
SALM
26 Risers
1989 - 2011

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**Preliminary FPSO Survey**

**Water Depth (m) vs Number of Risers**

- **FPSO Alvheim**
  - Norway
  - WD: 120 m
  - Turret-Moored
  - 14 Risers with 3 MWAs
  - 2008 - Present

- **Etame**
  - Gabon
  - Spread Moored

- **Challis/Cassini**
  - AUS
  - SALM

- **Okono/Okooho**
  - NIG
  - Spread Moored

- **OSX-3**

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Configuration Assessment Methodology

Preliminary Analysis

Acceptable?

Yes

Extreme Storm Analysis

Acceptable?

Yes

Interference Analysis

Acceptable?

Yes

End

No

No

No

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Configuration Assessment
Methodology

Four Configurations Considered:

1. Free Hanging
2. Lazy Wave
3. Tethered Lazy Wave
4. Lazy S

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Configuration Assessment

- **Preliminary Analysis**
  - No
  - Acceptable?
  - Yes
  - No
  - Extreme Storm Analysis
    - No
    - Acceptable?
    - Yes
    - No
    - Interference Analysis
      - No
      - Acceptable?
      - Yes
      - No
      - End

- **Quasi-static Analysis**:
  - 100 Year Return Period Current
  - Maximum Accidental Vessel Offset

- **Acceptance Criteria**:
  - Minimum Bend Radius of Risers
  - Maximum Hog-Bend Elevation
  - Minimum Sag-Bend Elevation

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Configuration Assessment

- Dynamic Analysis:
  - Regular Wave Approach
  - Total of 256 Load Cases
  - 2 Internal Fluid Densities (min & max)
  - 2 Vessel Drafts (full & empty)
  - 8 Loading Directions
  - 8 Loading Combinations

Learning directions

- Quart 1
- Quart 2
- Quart 3
- Quart 4
- Transverse
- Near
- Far
- Near

End

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Configuration Assessment

- Marine Growth
- Abnormal Condition:
  - 25° Vessel List
  - 1 Year Return Current and Wave Loadings
- Acceptance Criteria:
  - Same as Preliminary Analysis
  - Maximum Allowable Compression

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Configuration Assessment

- Quasi-static and Dynamic Analysis:
  - 100 Year Return Period Current
  - 10 Year Return Period Wave
  - Maximum Accidental Vessel Offset

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Configuration Assessment

• Clearance Assessed for all Risers
• Interference - Risers, Hull or Mooring Line
• Acceptance Criteria:
  • Minimum Clearance Shall be Larger Than the Sum of Their Outer Diameters

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Configuration Assessment

• Free-hanging Catenary Configuration is NOT Feasible

• Lazy-wave Configuration NOT Feasible with Large Number of Risers

• Tethered Lazy-wave Configuration Selected as the Lateral Motions are Restrained at the Touch Down Point

• Lazy S Configuration Selected as Risers Lateral Motion Controlled Over Arches

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Sensitivity Study Varying Several Parameters:
- Net Buoyancy
- Length of Buoyant Section
- Suspended Length
- Tether Positioning

Target Turret Departure Angle: 9°

- Light Risers → Large Departure Angles
- Heavy Risers → Small Departure Angles

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Tethered Lazy-Wave Configuration Assessment

- Interference Between Adjacent Riser Pairs Conducted
- Close to 60% of the Riser Pairs Clash Due to Harsh Environmental Conditions

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Lazy-S Configuration Assessment

Mid-Water Arch (MWA)

Tethers

Subsea Buoyancy Tank Assembly

Gravity Base

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Lazy-S Configuration Assessment

Main advantages:

- More Room Between Mooring Lines and Adjacent Risers
- Risers Clamped to Arch in Gutters – Reduce Risk of Overbending

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Lazy-S Configuration Assessment

Sensitivity Study Varying Several Parameters:
- MWA Position (Vertical and Arc Spacing)
- Minimum Bend Radius Along Sagbend for Selected Loading Conditions
- Ballast Modules Included Along Subsea Section for Lighter Pipe
Measures adopted to minimize interference issues:

- Different positions for adjacent MWAs
- Ballast modules at selected jumpers

Main Issues that Proved Challenging:

- Clashing Between Risers and Mooring Lines
- Clashing Between Risers, Tethers and Adjacent MWAs
- Ensuring Risers Have Enough Uplift from MWAs

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Conclusions and Recommendations

Never Before Has Such a Large Number of Risers Been Used in Shallow Waters With a Turret Moored FPSO

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<th>Configuration Type</th>
<th>Preliminary</th>
<th>Extreme Storm</th>
<th>Interference</th>
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The Lazy-S Configuration was Recommended for the Project

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Questions?

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