Design Exercise for the Modification of a MODU to a FPU Semisubmersible

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Agenda

• Background
• Design differences drilling semi vs FPU
• Main design changes required for converting MODU
• Design case – A5000 to FPU
• Qualitative feasibility evaluation
Background

• For FPSOs conversion of tankers typically account for close to 2/3\textsuperscript{rd}s

• Conversion economically attractive for FPSOs

• Conversion of MODU (drillships, semis or jack-ups) to production rare the last 15 years (some in Brazil)

• Industry downturn has resulted in a dramatic reduction in fleet utilization for MODUs
  • Approx. 75% floater utilisation per January 2016\textsuperscript{1}

\textsuperscript{1} – Source: ClarksonsPlatou Offshore
Background

- Number of units stacked continues to rise
- Projects are delayed, postponed or cancelled:
  - Focus on increased confidence in reservoir and production profiles
  - Large investments postponed if possible
  - Early production facilities more interesting to some
- Continued strong focus on reducing CAPEX
  - Standardisation
  - Simplification
Background

• Drivers for MODU to FPU semi-submersible conversion:
  • Early production facility
  • Minimum processing facility
  • Full production facility
    • May not be feasible for harsh environment areas
Design differences MODU vs FPU

• Semi-submersible MODU
  • Typically subject to class renewal and inspection (dry-docking) every 5 years
  • Operation in multiple locations
  • Mooring/station keeping
    • Pre-laid or on-board mooring
    • POSMOOR:
      • Dynamically positioned
      • “Thruster assisted” mooring
  • Drilling utilities often integrated in hull structure
    • Mud, brine and powder tanks etc.
  • Transit speed generally a design requirement
  • Variable deck load (VDL) is the main design parameter
Design differences MODU vs FPU

• Semi-submersible floating production unit
  • Topsides weight and footprint main design driver
  • Typ. one location for entire design life
  • No dry-docking
  • Additional riser loads
  • Can have both production and drilling
  • Typically less integration of topsides utilities in hull
Design changes required for converting MODU to FPU

• Topsides
  • Major conversion
  • With drilling capabilities
    • Complete layout redesign to accommodate production
    • Typical minimum processing facility
  • Without drilling capabilities
    • Removal of drilling equipment
    • Design of new processing modules for installation
    • Check and verification of global structure for new loads
• Review and eventually upgrade utilities
  • Power generation
  • Cooling water
  • Fuel storage
Design changes required for converting MODU to FPU

• Hull
  • Verify payload limitations and stability
    • Limits maximum topsides weight and CoG
  • Assess hydrodynamic characteristics with regards to
    • Air gap requirements
    • Process system constraints
    • Riser system
  • Assess mooring system arrangement with regards to hull
    • Chain lockers (volume and structural capacity)
    • Chain jacks (replacement or additional units)
    • Fairleads (replacement or additional units)
  • Assess riser interface on hull
    • Riser hang off
    • Riser loads
Design changes required for converting MODU to FPU

• Hull
  • Hull structure and arrangement
    • Utility tanks may be repurposed
    • Check and verify fatigue life of fatigue sensitive details (i.e. bracings, pontoon – column transition, column top)
    • Evaluate installation of transverse pontoons and removal of bracings
    • Check ballast capacity and tank arrangement to ensure possibility to trim platform to even keel at operational draft
    • Check hull systems design for compliance with FPU requirements

• Lifetime extension
  • Verify accumulated fatigue damage
  • Establish inspection regime and acceptance criteria in lieu of dry-docking and class renewal inspections including risk based inspection
A5000 semi-submersible MODU to FPU
A5000 semi to FPU

• A5000 MODU
  • Main Particulars

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
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<tbody>
<tr>
<td>Square Column Width</td>
<td>15.50 m</td>
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<tr>
<td>Number of Columns</td>
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<tr>
<td>Pontoon Width</td>
<td>16.50 m</td>
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<tr>
<td>Pontoon Height</td>
<td>10.05 m</td>
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<td>Operational Draught</td>
<td>17.50 m</td>
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<tr>
<td>Elevation Underside Deck Box</td>
<td>29.55 m</td>
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<tr>
<td>Overall Width</td>
<td>70.50 m</td>
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<tr>
<td>Overall Length</td>
<td>104.50 m</td>
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<tr>
<td>Deck Box Height</td>
<td>8 m</td>
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<tr>
<td>Deck Area</td>
<td>5 812 m²</td>
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<tr>
<td><strong>Displacement (approx.)</strong></td>
<td><strong>40 800 tonnes</strong></td>
</tr>
</tbody>
</table>

• Lightship weight                25 500 tonnes @ VCG 26.5m
• Variable deck load              5000 tonnes
A5000 semi to FPU

• A5000 FPU
  • Identical hull particulars as the MODU as base case
  • Weight budget:

<table>
<thead>
<tr>
<th>Item</th>
<th>Weight</th>
<th>VCG</th>
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<tbody>
<tr>
<td>Hull Weight (Including Riser and Mooring Forces)</td>
<td>22 100 tonnes</td>
<td>11 m</td>
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<tr>
<td>Topsides Dry Weight</td>
<td>11 000 tonnes</td>
<td>44 m</td>
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<tr>
<td>Fluids &amp; Consumables (ex. Ballast)</td>
<td>3 700 tonnes</td>
<td>17 m</td>
</tr>
<tr>
<td>Margin</td>
<td>2 000 tonnes</td>
<td>29 m</td>
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<tr>
<td>Ballast</td>
<td>2 000 tonnes</td>
<td>6 m</td>
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<tr>
<td><strong>Total</strong></td>
<td><strong>40 800 tonnes</strong></td>
<td><strong>21 m</strong></td>
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• Topsides payload capacity can be increased by relatively minor modifications
A5000 semi to FPU

• A5000 potential hull modifications:
  • Blisters and sponsons
    • Offers improved stability and additional topsides payload
    • Will influence motion characteristics
    • Relatively minor modification
  • Replace bracings with transverse pontoon
    • Requires modifications to areas subject to high stresses
    • Offers significantly increased topsides payload (order of magnitude 5000 tonnes)
    • May be positive with regards to service life compared to bracings
  • Transverse pontoon + blisters and sponsons
    • Relatively large modification
    • Offers significantly improved stability and additional topsides payload
Qualitative Feasibility Evaluation

• Technical feasibility
  • Challenges:
    • Lifetime extension and fatigue sensitive areas
      • Pontoon/bracing configuration
    • Payload capacity for integrated production and drilling, and for full production facilities
    • Riser interface and hang-off
    • Mooring arrangement
    • Air gap can limit the operational areas
  • Opportunities
    • Upgrade and life extension of aging units are well known in the industry (i.e. Aker H3 rigs from the 1970s still operating, some as deepwater units)
    • Steel replacement/renewal also well known in the industry
Qualitative Feasibility Evaluation

• Commercial feasibility
  • Challenges:
    • Cost of upgrade/renewal scope
    • Topside facility integration
    • Suitable fields
      • Infrastructure
      • Environmental conditions (e.g. wind and wave loading)
      • Reservoir characteristics
  • Opportunities
    • Lease and operate models
    • Reduced CAPEX – Lower hull cost, reduced topsides cost?