Floater and Riser Concept Selection

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Heat & Health

When the body is unable to cool itself by sweating, several heat-induced illnesses can occur such as heat stress or heat exhaustion and the more severe, heat stroke which can result in death.

Factors Leading to Heat Stress
High temperature and humidity; direct sun or heat; limited air movement; physical exertion; and poor physical condition.

Symptoms of Heat Exhaustion
• Headaches, dizziness, lightheadedness or fainting.
• Weakness and moist skin.
• Mood changes such as irritability or confusion.
• Upset stomach or vomiting.

Symptoms of Heat Stroke
• Dry, hot skin with no sweating.
• Mental confusion or losing consciousness.
• Seizures or convulsions.

Preventing Heat Stress
• Know signs/symptoms of heat-related illnesses; monitor yourself and coworkers.
• Block out direct sun or other heat sources.
• Use cooling fans/air-conditioning; rest regularly.
• Drink lots of water; about 1 cup every 15 minutes.
• Wear lightweight, light colored, loose-fitting clothes.
• Avoid alcohol, caffeinated drinks, or heavy meals.

What to Do for Heat Related Illness
• Call 911 (or local emergency) at once.
  While waiting for help to arrive:
• Move the worker to a cool, shaded area.
• Loosen or remove heavy clothing.
• Provide cool drinking water.
• Fan and mist the person with water.
What We Do - Business Areas

Engineering

Drilling technologies

Subsea

Umbilicals

Process systems

Mooring and loading systems

Maintenance, modifications and operations

Oilfield services and marine assets

Well intervention services
Major Components of Floating Production Systems
Experience in Floating Facilities

---|---|---|---|---|---|---
32 x H3 Semis | Veslefrikk | Snorre TLP | Heidrun TLP | Genesis Spar | Norne FPSO | Laminaria

---|---|---|---|---|---|---|---
Asgard B | Snorre B | Kristin, White Rose | Blind Faith | 2 x Aker H6e | Gjøa | Skarv FPSO | Ichthys Semi & FPSO

More than 50 floating facilities designed
Jacket / Dry tree

Mini-TLP / Dry & wet tree

Semi / Wet (Dry) tree

TLP / Wet & Dry tree

Compliant Tower / Dry tree

Spar / Wet & Dry tree

Truss Spar / Wet & Dry tree

FPDO / Wet tree
Deepwater Floater Options

- **FPSO**
  - Mild weather
    - No turret
  - Severe weather
    - Turret

- **Direct well access or independent drilling**
  - Dry trees or wet trees
  - Semi / mini TLP

- **Storage or pipeline**
  - TLP / Spar
  - Semi w. drill

- **Aasgard A**
- **Snorre A**
- **Genesis**
- **Snorre B**
- **P-51**
Production - Surface vs. Subsea Completion

- **Surface (Dry Trees)**
  - Riser type: Top Tensioned Riser (TTR)
  - Harsh environment: Low heave motion floaters, i.e. TLPs, Spar, Fixed platforms
  - Benign environment: Also possible with Semi
  - GOM: Dry Tree Semi – new concept

- **Subsea (Wet Trees)**
  - Riser type: Flexibles, metallic catenaries, Hybrid risers, etc.
  - All floater types (FPSO, TLP, Spar, Semi)
Ship-shaped FPSOs

- Storage required - No local infrastructure available
- Disconnectable turret, able to quickly evade hurricanes
- Not sensitive to topsides weight or area restrictions
- Larger motions – challenges for risers
- Faster track schedule potential for conversion-based FPSOs
TLPs

- Very low heave motions for excellent dry tree applications
- Water-depth limited (<1500m) due to tendon
- Some examples may require offshore integration
- Sensitive to topsides weight increase
Spars

- Offshore integration required
- Topsides weight and footprint challenges
- Smaller topsides to hull weight ratios
- Reduced heave motions suitable for wet or dry tree applications
- Storage possible with new belly spar concept
Semisubmersibles

- Inshore hull-deck integration
- Large deck footprint available
- Favourable hull/deck weight ratio
- Large number of risers can be accommodated
- Deep draft semis can accommodate SCRs in wet tree configuration
- Dry tree semi can accommodate TTRs for direct well access
Deepwater Floater Concept Comparison

As-built data, steel weight vs. deck load

Floater Weight Efficiency

Hull Weight (st)

Deck Operating Wt (st)

Semi
TLP
Spar

TLP
SPAR
Semi
Riser Categories

- **Top Tension Risers**
  - Marine Drilling (LP)
  - HP Drilling
  - Production

- **Flexible Risers**
  - Import/Export

- **Steel Catenary Risers**
  - Import/Export

- **Hybrid Risers**
  - Import/Export

- **Lazy Wave**
  - Import/Export
Top Tensioned Riser (TTR)

- TLP, Spar, Semi (new concept)
- Tensioner, Buoyancy Can
Production - Flexibles – Widely used but with limitations

FLEXIBLE RISER: standard dynamic application with Zeta layer

Armours
Zeta pressure vault
Pressure sheath

Anti-wear layer
Carcass

Internal Diameter

m

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<th>3000</th>
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Steel Catenary Risers (SCRs)

- Semi, TLP, Spar
- Diameter 4.5” – 24 ”
- Titanium Stress Joint, or Flexible Joint
24” Gas Export SCR Configuration (from a TLP)
Hybrid Risers

- Typical deep water solution only
  - Relative efficiency increases with water depth
  - Little effect on floater (separate buoyancy)

- Important for selection of type of hybrid
  - Options for flow assurance
  - Effective installation
Lazy Wave Riser (LWR)

- Conventional Draft Semi may potentially be utilized
- LWR effective in further reducing VIM fatigue damage
- Reduced fatigue damage in TDZ
- Potential to eliminate cladding in Sour Service conditions
Miscellaneous Riser Configurations

- Steep Wave
- Lazy Wave
- Simple Catenary (SCR)
- Steep S
- Lazy S
- Chinese Lantern
- U-Shape
- Fixed S
- Camel S
- Tethered Wave
- Tethered S
- Offset Steel Catenary Riser (OSCR)
Production – Subsea Completion – Flexible/Compliant

Limits on combination of:
- diameter
- water depth
- temperature

![Graph showing limits on combination of diameter, water depth, and temperature for Steel Catenaries, Titanium Catenaries, and Flexibles.](image-url)
Risers – challenges (1)

- Floater motions
  - From wind & waves
  - From current (oscillations; vortex induced motion)
  - => dynamic motions of risers

- Remedies:
  - Flexibles in “shallow” water
  - SCRs
  -SCRs with tailored dynamics
  - Titanium Catenary?
  - Riser towers (bundles or single)
Risers – challenges (2)

- Requirement for disconnect?
  - Quick disconnect only reasonable
  - FPSO with turret: proven!
  - Others solutions: on concept level
Risers – challenges (3)

- Insulation of riser
  - Increases complexity of riser system

- Remedies:
  - Externally insulated -> gets light
  - Pipe-in-pipe -> gets heavy

- Sour service:
  - Welding & material challenge
  - Reduces fatigue capacity considerable

- Remedy:
  - Need less dynamic exposure of riser
Risers – challenges (4)

- Installation
  
  - Weight in deep waters -> few vessels / high cost, for
    - Large diameter (exports)
    - Pipe-in-pipe
  
  - In field welding quality for dynamic risers
  
  - Sensitive to bending/contact pressure during S-lay
    - Externally Insulated Risers (SCRs) – syntactic foam
    - Application of strakes (for avoiding riser VIV)
Building Blocks for Concept Screening Methodology

- Subsea Systems
- Risers & Umbilicals
- Station-keeping (Mooring)
- Hull
- Topsides
Field Options Generator Methodology

Approximately 150 Cases, 7 Families Identified

Options selectively chosen and combined

Seven (7) criteria for qualitative evaluation:
- Mobility
- Functionality
- Adaptability
- Technology
- Cost
- Schedule
- Execution

Criteria scored 1 to 10 on an equally weighted qualitative basis

Five “Building Blocks” identified

<table>
<thead>
<tr>
<th>Toolbox Options for each “Building Block”</th>
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<td>A</td>
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<tr>
<th>Transfer System Tool Box</th>
<th>Production Facility Tool Box</th>
<th>Station Keeping Tool Box</th>
<th>Oil Storage/Offloading Tool Box</th>
<th>Gas Export System Tool Box</th>
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<tbody>
<tr>
<td>A SCR (Ship Shape)</td>
<td>1 FPPS - Ship Shape</td>
<td>1 Spread moored - Non Turtled</td>
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<tr>
<td>B Free Standing Hybrid Riser (SLOR)</td>
<td>2 Semisubmersible</td>
<td>2 DP</td>
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<tr>
<td>C Bundled Hybrid Riser</td>
<td>3 FPPS - Non Ship Shape</td>
<td>3 CALM with soft connection</td>
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<td>D TTR</td>
<td>4 FPU - Ship Shape</td>
<td>4 SLM with soft connection</td>
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<td>E Flexible Risers</td>
<td>5 Spar</td>
<td>5 Turret moored - disconnectable</td>
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<tr>
<td>F Offset SCRs (OSCRs)</td>
<td>6 FPPS - Spar Shape</td>
<td>6 Turret moored - non-disconnectable with Thruster Assist</td>
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<td>G SCRs with SIB</td>
<td>7 TLFP</td>
<td>7 TLP</td>
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<tr>
<th>Oil Storage/Offloading Tool Box</th>
<th>Gas Export System Tool Box</th>
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<tr>
<td>a) Shutles Only (Tandem Offloading)</td>
<td>SCRs</td>
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<tr>
<td>b) PSO &amp; Shuttles (Tandem Offloading)</td>
<td>Free Standing Hybrid Riser (SLOR)</td>
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<td>Bundled Hybrid Riser</td>
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<td>TTRs</td>
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<td>Flexible Risers</td>
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<td>Offset SCRs (OSCRs)</td>
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16 Cases, 4 Families Short-listed
SKARV - Concept Selection and Definition Process

45 Concepts:
- FPSO
- SEMI_D
- TLP
- SEMI
- FPDSO
- SEMO
- Tie-back to Heidrun

8 Concepts:
- FPSO
- SEMI_D
- TLP
- SEMI

2 Concepts:
- FPSO
- SEMI

1 Concept:
- FPSO
GOM Floaters – Water Depth vs. Topsides Weight

The graph illustrates the relationship between water depth and topsides weight for various offshore installations. Each point on the graph represents a different installation, with different symbols and colors indicating different types of floaters (e.g., Semi, Spar, TLP, FPSO, MinDOC). The x-axis represents water depth in feet, while the y-axis represents topside weight in short tons. The graph includes a note indicating the current offshore single lift limit and the maximum water depth for current TLPs.
Blind Faith

Client: Chevron
- 2,000 m water depth
- 9,000 Ton Topsides
- 45mbopd, 45mmcfgpd
- Steel Catenary Risers with Titanium Stress Joints
- Polyester mooring (8 lines)

Aker Solutions Scope:
- Hull & mooring EPC
- Riser design
- Installation
Steel Catenary Risers

- 7” and 14” SCRs
- Weight coating
- Strakes for VIV
- Titanium Stress Joints
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