A New Thermoplastic Composite Riser for Deepwater Application

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Challenges

Requirement to move to deeper waters whilst extending life time increases demands on production risers:

- Weight optimization is necessity
- Total system complexity increase risks
- Fatigue resistance and chemical resistance requires improvement
- More high pressure & high temperature applications
Solution

1. Thermoplastic Composite Pipe Technology
2. Integrated Development Approach including pipe design and global riser system analysis
3. Technology Acceptance Plan
Thermoplastic Composite Pipe Technology

“One material” concept:
- Reinforcing a thermoplastic liner with melt-fused fibre-tapes
- Same thermoplastic compound in liner, tapes and coating
- Fully bonded, solid wall tubular
Thermoplastic Composite Pipe Technology

- One-solid wall, supporting pipe in all load cases: fail-safe design
- High allowable strain: spoolable without fatigue and without cracks
- Higher ductility resulting in unsurpassed toughness, impact resistance and residual strength
- No annulus
- Smooth bore in a collapse resistant pipe
Global and Local Analysis

• Integrated approach of pipe design and dynamic riser response analysis
• TCR Design based on laminate theory:
  – Visco-elastic behaviour of the material
  – Failure modes for fibre, polymer and matrix
  – Single and combined load cases
• Global riser design incorporating specific pipe weights and stiffnesses
• Materials selection based on proven track-records
Global Analysis

- Water depths 400 – 3500 meters
- Configurations FHC, lazy wave, steep wave, multibore hybrid riser and TTR
- Environments benign to harsh
- Floater type FPSO to low-motion floater
- Comparison against Flexible Pipe and SCR solutions
Riser Configuration Design - TCR

- Configuration design for composites:
  - Design for low weight
  - For high drag-to-weight ratio, low terminal velocity
  - High rotations, large lateral motions

- Riser Weight-in-Water Examples
  - 4-inch ID; flexible pipe vs TCR
    - 36 kgf/m vs 11 kgf/m (TCR)
  - 10-inch ID; flexible pipe vs TCR
    - 220 kgf/m vs 19.8 kgf/m
    - 10-inch TCR buoyant when empty
TCR Configuration Solutions

• Leads us to utilise configurations that build tension in the riser
  – Steep Wave / Tethered Wave solutions
  – Top tensioned risers (TTRs)
  – Hybrid riser towers

• Add weight modules along sag catenary sections

• Utilise tapered TCR sections to avoid bend stiffeners
Steep Wave Riser Solution

- 2000 m WD
- GoM, WoA and Brazil
- TCR vs Flexible Pipe

**Results:**
- 55% reduction in hang-off tension (even with weight modules added)
- 65%-75% reduction in buoyancy
TCR: Results

- Flexible
- TCR-empty
- TCR-full

Apparent weight

Curvilinear distance along riser

Reduced buoyancy length

Weight modules around sag bend

Strong reduction in buoyancy

Around sag bend
Steep Wave Configuration Results

-1200 -1000 -800 -600 -400 -200 0 200 400 0 500 1000 1500 2000 2500

Apparent Weight (kg/m)

Curvilinear Distance Along Riser (m)

Flexible TCR Fluid Filled TCR Empty Weight Modules

Hog Bend Buoyancy Section One

Weighted Modules

Sag Bend Buoyancy Section Two

Vessel Hang Off PLEM

Buoyancy Section Two

Weight Modules

Flexible TCR Fluid Filled TCR Empty Weight Modules
Results – TTR & Hybrid Riser

• Top Tensioned Riser (2000m GoM)
  – Pipe-in-pipe configuration with production tubing and outer casing
  – 90% reduction in top tensions compared with steel case
  – Implies much reduced top tensioner ratings or smaller buoyancy cans

• Hybrid Riser in 2200m WD
  – Multi-bore hybrid riser with composite production lines
  – Expecting much reduced buoyancy can requirements
Global Analysis – Summary
Conclusions

✓ Solutions found to 3500+ meter water depth
✓ Top tension reduction (>60%)
✓ Dynamic stability critical: focus on tensioned solutions / reducing compression
✓ Strong reduction in buoyancy requirements
✓ Depending on size, environment and configuration limited additional weight required
Global Analysis – Summary Conclusions

✓ Choice of PA/PVDF and Glass Fibre creates optimal weight to strength ratio
✓ Drag to apparent weight ratio ranges from 5-16, depending on size and materials used
✓ Optimum found in bending stiffness, weight and Minimum Bending Radius
✓ Global system design essential for optimal solution
Technology Acceptance (I)

- Create technology pull: JIP “Cost-Effective Thermoplastic Composite Riser”
- Sponsored by BP, Statoil, Chevron, Shell, Total, Petrobras, BG Group and SBM Offshore
- Consortium with MCS Kenny and OTM Consulting, initiated through ITF - Aberdeen
- Aim: to prove the feasibility of the TCR in dynamic riser applications
Technology Acceptance (II)

- Qualification strategy
  - DNV RP A203 Qualification Procedures for New Technologies
  - DNV OS C501 composite components
  - DNV OS F201 dynamic riser
  - DNV RP F202 recommended practice for composite riser

- Full qualification product approval
Technology Acceptance (III)

• Walking – then running:
  – Service Intervention Line
  – Pipeline Downlines
  – Composite Coiled Tubing

• Repair
Conclusions

• 60% top tension reduction with dynamically stable system achievable with Thermoplastic Composite Riser system
• Reduced requirement for buoyancy
• Solutions found to 3500+ meters water depth
• Dynamic stability as critical issue addressed through integrated approach of local and global design
Repair

- Procedure for field repair
- Same strength as before damage
Connectors and End-fittings

- Proven clamping mechanism
- No termination of individual layers
- Bend strain relief
- MCI fits on ANSI, API, Grayloc etc
Thank you