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Feasibility of Steel Lazy Wave Risers in the North Sea

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Agenda

- Risers in deepwater North Sea
- Are steel catenary risers (SCR) suitable?
- Case for steel lazy wave risers (SLWR)
- SLWR design drivers
- Case study for Large OD SLWRs
- Installation considerations
- Cost considerations
- Summary



Risers in Deepwater North Sea

- Flexibles are the preferred solution
- Relatively shallow, low pressures and temperatures
- Good strength and fatigue resistance
- Can accommodate large motions; hence used with a wide range of FPS's
- Limited to smaller size
- Not cheap
- Tendency to go with a solution that is widespread in the region







SCRs as an Alternative to Flexibles

- Mature technology
- Widespread use in GoM, Africa and Brazil
- Large ODs are feasible
- Limited by harsh environments
- Fatigue at touchdown is an issue
- Strakes needed for VIV suppression
- Installation costs can be high
- Track record in the North Sea









SLWRs

- Variation of SCR with buoyancy added
- Growing track record
- Reduced payload
- Sensitive to vessel motions at hang-off
- Buoyancy helps decouple vessel motions
- Improved strength and fatigue performance
- Large ODs are feasible
- Reduction in overall costs with use of large OD
- Higher installation costs depending on size





SLWR Design Drivers

- Offset range in extreme and survival conditions
- Vessel heave, pitch and roll motions
- Internal fluid variability
- Buoyancy length
- Payload





Case Study – Basis

- 850m Water depth
- 24" OD pipe
- Flex joint at hang-off
- Fluid: Gas and seawater
- FPS: Circular FPSO
- Top 250m straked
- Offset: 10% Extreme, 12% Survival
- Max 100yr return condition: 16m Hs
- Typical North Sea fatigue loading
- Strength and wave induced fatigue evaluated





Case Study – Selected Configuration

- Very flat configuration
 - Long step out distance
- High hang-off angle
 - Nominal 18deg
 - Near 14deg
 - Far 22deg
- Long buoyancy Section
 - 122 modules, 2m each
- Top tension 200mT





Case Study – Extreme Strength 2H

- Stresses at the hang-off and touchdown are manageable
- Start of buoyancy section is critical
- Stress primarily caused by vessel pitch and heave motions
- Moving the hang-off closer to COG helps reduce motions
- High compression at sag bend; generally acceptable







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Case Study – First Order Fatigue

- Wave fatigue is critical below the hang-off
- Higher quality weld is required
- Moving the hang-off closer to COG improves fatigue performance
- Long taper can help improve fatigue performance below hang-off
- Upset ends can be specified



DNV Curve	SCF	Target Fatigue Life (Years)	Minimum FOF Life (Years)
С	1.0		1355.37
C1	1.3	200	239.77
E	1.3		55.79

DNV Curve	SCF	Target Fatigue Life (Years)	Minimum FOF Life (Years)
C	1.0		459
C1	1.3	200	93
E	1.3		24.5



Hang-off closer to COG

Base Case Hang-off

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Case Study – Hydrotest

- Hydrotest is a known challenge for gas risers
- Buoyancy designed for gas filled case
- High pressure plugs can be used to hydrotest short sections
- Removable buoyancy modules to provide additional buoyancy during testing





STATIC ANALYSIS RESULTS - HYDROTEST CONDITION Seawater Internal Fluid - 3% Far Offset - No Load









Case Study – Pre-lay

- Pre-lay of SLWRs is important for schedule and costs
- Helps decouple FPS and riser schedule
- Riser typically installed empty
- Stresses in the riser are manageable





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Installation Consideration

- Steel risers up to 16" (18"?) can be reel laid
- J-lay or S-lay preferred method for large OD
- J-lay limited by high stresses at TDP
- J-lay for large OD is possible with high inclination J-lay towers ★
- High quality welds difficult to achieve offshore





Costs Consideration

- SLWR Cost dependent on installation method
 - Reel-lay < J-lay < S-lay
 - For large OD, J-lay costs comparable to reel-lay
 - Strakes and buoyancy modules add to installation costs
 - High quality welds done offshore adds to costs
- Flexibles vs SLWR vs Hybrid Risers
 - SLWR: Multiple wells tied back to a large OD riser reduces costs
 - Reel-lay costs: Flexibles (20-30%) > SLWR
 - Hybrid riser costs are much greater than other options

Ttom	% of the Total Cost		
Item	SCR/SLWR	Flexible	
Material cost per riser	20%	65%	
Installation and transportation	45%	20%	
Engineering, commissioning	35%	15%	



Summary

- Flexibles are preferred in the North Sea; limited by qualified size
- Large OD SLWRs provide a viable lower cost solution compared to multiple smaller flexibles
- Tying back wells to a large OD SLWR reduces costs
- Reel-lay SLWR also provides lower cost solution for smaller diameters



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