Considerations for the Design of a Deep Sea Mining Vertical Transport System

F. Lim

Deep Sea Mining Summit
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Considerations for the Design of a Deepsea Mining Vertical Transport System

Frank Lim

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Overview

- 2H Offshore
- Project Experience
- Mining Riser Design Considerations
  - Pump
  - Configuration
  - Pipe
  - Connector
- Deepwater Challenges
- Ultra-Deep Water Depth
- Questions

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About 2H Offshore
Riser & Conductor Engineering

- Founded in 1993
- 150+ highly qualified engineers
- Standard global procedures for seamless operations
- Extensive experience in all riser types
- Practical understanding of hardware & installation
- Leader in marine structure dynamics
- Independent, technology driven company
- Part of the ACTEON group

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Offices Worldwide

Houston
Aberdeen
London
Beijing
Rio de Janiero
Kuala Lumpur
Perth

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Areas of Expertise

Drilling, Completion & Workover

- Marine drilling risers
- Jack-up risers
- Subsea well conductors
- Completion & workover risers

Surface BOP drilling risers
- FPS dry tree production risers
- Fixed platform well conductors
- Jack-up production risers

Production & Export

- Steel catenary risers
- Free-standing hybrid risers
- Flexible risers
- Umbilicals

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Services

- Concept Design & FEED
- Detailed Engineering
- Procurement Management
- Fabrication & Installation Support
- Integrity Management & Monitoring

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An ACTEON Company

OPERATING AREAS

- RISER SERVICES
- MOORING & INSTALLATION
- FOUNDATION SERVICES
- SURVEY & MONITORING SERVICES
- ENGINEERING MANPOWER

ACTEON COMPANIES

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Full Lifecycle Subsea Services

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Oil & Gas
Production Risers

- Conduit for fluid transportation to and from well
- Well control/pressure containment

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Oil & Gas
Drilling Risers

- Conduit for drilling into well, passage of drilling tools and well casings
- Carry BOP control umbilical and auxiliary lines
- Run and retrieve BOP in free hanging mode

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Mining Riser Design Experience

- Offshore Papua New Guinea - Riser and Lifting System Concept Design and Verification
- Black Sea Seabed Mining Production Riser Feasibility Study
- Generic Mining Riser Feasibility Study for 5,000m Water Depth
- European Union Blue Mining Joint Industry Project
- South Indian Ocean Mining Trial - Configuration and Handling Studies of Flexible Transport Riser System in 6,000m Water Depth
- Deployment Analysis and Safety Assessment of a Circulation Test Riser System in 500m Water Depth

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Typical Mining Riser Configuration
Pump Selection

Positive Displacement

- High pressure difference
- Low flow rate
- Pulsating flow (requires multiple chambers and tuning to smooth out pulsations)
- Located at the bottom of riser string
- Easier to recover entire unit to surface for maintenance and repair, leaving riser in water

Picture Courtesy of GE

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Pump Selection

Centrifugal

- Low pressure difference (may require several units to relay up deep water column)
- High flow rate
- Continuous flow
- Located at multiple elevations along the riser
- Mid-water intervention for maintenance and repair, as riser recovery is undesirable

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Riser Configuration Options - Wave Catenary

Steep Wave Riser

Multiple Steep Wave Riser

Lazy Wave Riser

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Riser Configuration Option – Vertical Hanging

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Comparison of Configurations

**Wave Catenary**
- Continuous riser from Vessel to Miner
- Pump located on Miner
- Steep Wave preferable to Lazy Wave because it does not present a sag bend that collects residue during shut-down
- Pipe wear in bends
- Restraining loads on Miner, highest in Steep Wave configuration
- Limited pipe material choices

**Vertical Hanging**
- Separate pump free hangs underneath long vertical riser
- Pump hovers above seabed
- Wave shaped jumper connects Miner to pump
- Allows Miner to move freely with little restraint
- Less power required to manoeuvre lighter Miner
- Long vertical riser section opens to many material choices including steel pipes
- Steel riser can carry different pump types

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Unbonded Flexible Pipe

- Compliant response
- Not fatigue sensitive
- Installation friendly from reel
- Continuous construction
- Water depth / pressure / diameter limitations
- External sheath susceptible to damage
- Steel armour wire corrosion
- Costs $/m

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Pipe Selection

**Bonded Hose**
- Good wear resistance
- Reel installation of made-up sections
- Lack tensile strength
- Pressure limitation
- Weak end fittings
- Suitable for short jumpers

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Pipe Selection

Steel Pipes

- Well established technology
- Extensive knowledge and experience
- Track record in deepwater drilling
- Large diameter
- Mechanical connections
- Installation from derrick, 75ft (~23m) sections
- Wear liner required
- Welding quality critical

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Riser Design Engineering Scope

- Design basis preparation
- Concept and configuration selection
- Wall thickness definition
- Operability (static/dynamic) analysis
- First order fatigue analysis
- VIV fatigue analysis
- Handling and installation study
- Installation analysis
- Interference analysis
- System and component design
- Wear liner design

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Deepwater Challenges

- High riser payload
- Large deck space for storing riser joints
- Long time to deploy and retrieve riser
- Uncertain metocean conditions
- Vortex induced vibrations
- Weld and connector fatigue

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Cross flow vibration of risers caused by presence of severe currents

- Riser vibrates at high frequency
- High Frequency Stress Reversals
- High Rates of Fatigue Damage Accumulation

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VI V Suppression Devices

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Special Issue for Ultra-Deep

AXIAL RESONANCE!

Leading to extreme stresses, snatch loading, or possibly fatigue failure

When riser is mining

- A suspended spring-mass system with axial natural period falling within range of exciting wave periods

During deployment

- A suspended spring-mass system going through various length-dependent natural periods

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Mitigating Axial Resonance

When riser is mining

- Adjust riser hang-off stiffness and damping characteristics to reduce exciting loads on riser
- Add in-line motion compensators to ‘de-tune’ the riser axial natural period
- Add tuned mass dampers to ‘cancel’ vertical riser motions

During deployment

- In-line motion compensators
- Tuned mass dampers
- Compensated drawworks
- Compensated drill floor

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Concluding Remarks

- Risers are not commodity items
- Challenging component of a mining system
- Deepwater riser experience is improving
- Technologies transferrable from Oil & Gas
- Materials and riser weight driven
- Early engineering & assessment critical
Thank you for your time.

Questions......

Further information:

2H Offshore Engineering
www.2hoffshore.com
+44 1483 774900

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