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is funded principally through a grant of the

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The Society gratefully acknowledges those companies that support the program by allowing their professionals to participate as Lecturers.

And special thanks to The American Institute of Mining, Metallurgical, and Petroleum Engineers (AIME) for their contribution to the program.
Risers:
A Key Challenge for Deepwater Developments

Howard Cook
December 2004
Contents

- Deepwater context
- Challenges by region
- Modelling
- Construction
- Installation
- Operation
- Future Developments
Global Reserves in deepwater

- Gulf of Mexico
- NW Europe
- Mediterranean
- Asia Pacific
- S. America
- W. Africa

Gas Oil
Depth Trend of New Developments

- N. Sea 1980
- 1995
- 2000
- 2005

Feet / Meters

0 / 0

1000 / 305

2000 / 610

3000 / 915

4000 / 1220

5000 / 1525

6000 / 1830

7000 / 2135

8000 / 2440

- Foinaven Schiehallion FPSO
- Ram/Powell TLP
- Ursa TLP
- Girrasol FPSO
- Hoover DDCV
- Thunder Horse Semi
- Atlantis & NaKika Semis

Producing Current Developments

- Pompano SS TB
- Mars TLP
- Marlin TLP
- Angola FPSO's & TLP's
- Mad Dog Spar
**Risers**

**Example**
- GoM Deepwater Semi-Sub
- 2000m water depth
- Steel Catenary Risers
- Catenary Umbilicals with Buoyancy
- Top tensioned drilling riser
- Chain-Wire Moorings

**Riser Interfaces with:**
- Hull
- Seabed
- Water column (current and waves)
- Internal Fluids
Regional Considerations

Challenges by Region

- Currents
- Harsh Environment
- Seabed Conditions
- Swell
- Hurricane and Typhoon
# Riser Configurations

<table>
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<tr>
<th>Diameter</th>
<th>Current</th>
<th>Shapes</th>
<th>Depth</th>
<th>Waves</th>
<th>Suppression</th>
<th>Lay Out</th>
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<td>Depth</td>
<td>to</td>
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### Challenges by Region
- **Wave Height**: 2’ to 72’
- **Suppression**: 1000 to 10,000 feet
Modelling

- External fluid forces
- Seabed interaction
- Internal fluid forces

High Currents + responsive slender structures
= vortex-induced vibration (VIV)

Original is a video clip

Wellhead Fatigue Failure
West of Shetland
C. 1982
External Fluid Forces

- VIV Design tools immature (5yr deepwater risers cf. 30yr jacket design)
- Response prediction models have limited calibration
- Computation Fluid Dynamics (CFD) – slow for detailed design
Model Testing to Derive Design Data

Plain cylinder
A/D rms = 0.34
U = 1.0 m/s    Re = 290,000

Straked Cylinder
(5D pitch/0.14D height)
A/D rms = 0.05
U = 1.0 m/s    Re = 290,000
Internal Fluid Forces

Multiphase flow operating map

Field measurements vs. Prediction

Field Data  _____
Simulation  _____
Construction

- Girth welds
- Coatings and insulation
- Non destructive examination (NDE)
- New materials
  - e.g. composites

Thick walled (40 mm) riser pipe for GoM
Girth Weld Fatigue Testing

- Fatigue performance confirmed for critical applications
- Resonant bend fatigue testing
- Corrosion-fatigue testing
Girth Weld Non-Destructive Examination

- Automated Ultrasonic Testing for inspection of root and weld body
- Inspection of clad pipe subject of ongoing development
Riser Insulation

- Girassol riser tower (Total operator)
- 1350m water depth

- Deepwater riser insulation
Installation

- Limited vessel fleet
- High day rates
- Landlocked developments
- Alternative methods

Water Depth (ft) vs Diameter (inch) graph with identified Significant Stretch and Major Stretch areas.
Deepwater Riser – J-Lay Installation
Novel Pipelay methods

- Floating Spiral concept
  (Eurospiral BV)
Operation

- Thermal management / Wax and Hydrates
  - Insulation, procedures and additives

- Structural management
  - Operating procedures, vessel offsets

- Integrity management
  - Corrosion monitoring
  - Inspection by Autonomous Underwater Vehicles (AUVs), Remotely Operated Vehicles (ROVs), pigs, crawlers
  - Monitoring
External and Internal Intervention

- AUVs (Autonomous Underwater Vehicles)
- Intelligent pigs
- Crawler pigs
Riser Monitoring on GoM Semisub Riser

A – Flexjoint angular deflection
B – Strain gauges for top tension
C – Accelerometer for profile
D – Strain gauges for stress
E – ADCP for upper water column
F – ADCP or LCM for lower water column
G – Topside local DA&PU
Riser Monitoring on GoM Spar Risers

Upper trace = Riser Tension
Lower trace = Riser motion relative to the SPAR
Riser Monitoring on Drilling Risers

Operation

Observed/Predicted stress ratio vs Mean Current Speed
Operation

VIV of Deepwater GoM Drilling Riser BOP

Original is a video clip of VIV movement on subsea BOP
Future Developments

- Tie backs to existing hubs
- Cost reduction
- Integrity and Reliability
- Ultra-deep fields
  - Tie-backs to shallow water
  - New riser technology (composites?)
- HPHT fields
  - Subsea High Integrity Pressure Protection Systems (HIPPS) – low pressure risers
  - Cold Flow technology – low insulation risers
Questions?
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