DEEP WATER RISER TECHNOLOGY, VIV & FATIGUE MANAGEMENT

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SCOPE OF PRESENTATION
- Deep Water Riser Design Issues
- AMJIG Guidelines
- Guideline Applications and Findings
- Analysis Limitations
- VIV Prediction and Effects
- Fatigue Management and Riser Monitoring

DEEP WATER ENVIRONMENTS

1 YEAR CURRENTS

DEEP WATER CHALLENGES
- Riser curvature and wear increased
- Buoyancy effectiveness reduced
- Mud pressures increased
- Collapse pressures increased
- Base/disconnect tension at BOP increased
- Hang-off deflections increased
- Running and retrieval takes longer
- Fatigue damage increased

AMJIG - Deep Water Drilling Riser Integrity Management Guidelines
- Extension NOT replacement for existing guidance
- Emphasis on system approach:
  * All components - riser, wellhead, conductor
  * All operations - riser installation, operations, monitoring, inspection
<table>
<thead>
<tr>
<th>AMJIG RISER GUIDELINE DEVELOPMENT</th>
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<tbody>
<tr>
<td>Directed by BP, Shell and Elf</td>
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<tr>
<td>Reviewed by operators, drilling contractors and analysis consultants</td>
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<tr>
<td>Guidelines in 3 Parts:</td>
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<tr>
<td>- Analysis</td>
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<td>- Operations</td>
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<td>- Inspection</td>
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<td>Completion and well test operations</td>
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<td>Riser VIV</td>
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<td>Riser-wellhead-conductor interaction</td>
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<td>Recoil and hang-off</td>
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<td>Riser, casing and conductor installation</td>
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<th>PART II - RISER OPERATIONS</th>
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<td>Tension and tension variation</td>
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<td>Installation and retrieval envelopes</td>
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<td>Drilling and survival envelopes</td>
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<td>Monitoring operating conditions</td>
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<td>Recording riser operations</td>
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<td>Recording riser usage</td>
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<td>- Inspection types and frequency</td>
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<td>- Provision for inspection</td>
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<td>Components to be Inspected</td>
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<td>Inspection Procedures by OCTG</td>
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<th>GUIDELINE APPLICATIONS</th>
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<tr>
<td>Assess fitness-for-purpose</td>
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<tr>
<td>Optimise riser configuration</td>
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<td>Predict downtime</td>
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<td>Provide input to operating procedures</td>
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<td>Predict inspection requirements</td>
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<th>DEEP WATER RISER FINDINGS</th>
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<td>Need thicker walls for internal and external pressures and tension</td>
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<td>Hang-off requires bare lower riser</td>
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<td>Soft soils improve LFJ and WH response</td>
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<td>Retainer valves needed for disconnect</td>
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<td>High VIV fatigue damage = increased inspection and/or suppression</td>
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ANALYSIS LIMITATIONS

- Only as good as input assumptions:
  - Currents
  - Drag coefficients
  - Uncertainty in effects of drill string tension
  - Requires margin of conservatism
  - Can be costly - VIV

VOXET INDUCED VIBRATIONS

- Still subject to research
- Analysis methods relatively new
- Do VIV’s really happen?
- What are the effects?
- How good/bad are our predictions?
- How are VIV’s best managed?

VIV ANALYSIS METHODS

- DnV Rules
  - Uniform risers in uniform, planar current
- SHEAR7
  - Uniform top tensioned risers
  - Sheared, planar, monotonic current profile
- VIVA
  - Variable riser properties along the length

VIV ANALYSIS APPROACH

- Analyses conducted with several current profiles
- Current profiles of varying severity, typically based on exceedence level
- Fatigue damage factored according to duration of profile
- More refined selection of profiles at more severe currents

VIV FATIGUE

VIV DRAG AMPLIFICATION

[Graphs and charts related to VIV analysis and drag amplification]
VIV UNCERTAINTIES
- Current profile and direction
- Slick and buoyant joints
- Choke and kill lines
- Drill string tension
- Damping of multi-string system
- Conductor interaction

DRILL STRING TENSION
- No drill string tension
- 100% drill string tension

IMPLICATIONS OF VIV FATIGUE
- Resistance:
  - Change tension/buoyancy
  - Higher quality fatigue details in riser and wellhead/conductor
  - More frequent inspection
- Suppression:
  - Fairings - expensive but reduce drag
  - Strakes - cheaper but increase drag

VIV FATIGUE MANAGEMENT
- Objectives
  - Minimise conservatism
  - Account for actual environment
  - Reduce modelling uncertainties
- Options
  - Entirely predictive
  - Analysis predictions used in conjunction with measured environment
  - Monitored environment and response
**ENTIRELY PREDICTIVE**

- Fatigue Damage
  - 0.0005
  - 0.001
  - 0.0015
  - 0.002
- Location along Riser (x/L)
- 0.2 m/s Current
- 0.4 m/s Current
- 0.6 m/s Current
- 0.8 m/s Current
- 1.0 m/s Current
- 1.2 m/s Current
- 1.4 m/s Current
- Total Damage

**PARTLY PREDICTIVE**

- VIV Damage Along Riser
- VIV Fatigue Damage Accumulation
- 1.00E-08
- 1.00E-07
- 1.00E-06
- 1.00E-05
- 1.00E-04
- 1.00E-03
- 1.00E-02
- 1.00E-01

**MOSTLY MONITORED**

- Stress or displacement amplitudes and frequencies
- Used with predictions to give fatigue damage distribution over riser length
- Used with current measurements to calibrate predictions
- Removes environmental and modelling uncertainties

**RESPONSE MONITORING APPROACHES**

- On-Line System
  - Hardwired
    - Increased installation time, cable damage
  - Signal transmitted by telemetry
    - Large batteries, expensive
- Passive System
  - Run with riser, or ROV installed
  - Data processed after unit retrieval
  - Low cost

**PASSIVE MONITORING EXAMPLES**

- BP Schiehallion Drilling Riser
  - 360m water depth, 3 monitoring locations
  - VIV up to mode 4 observed
  - Response being evaluated
- NDP
  - 500-1400m, 5 monitoring locations
  - 3 Fields, Nyk, High, Vema and Helland Hansen
  - Small responses

**CONCLUSIONS**

- Deep water presents many challenges
- AMJIG Guidelines needed to supplement existing codes
- VIV fatigue significant
  - Analysis may overestimate damage
  - Inspection requirements based on analysis may be overly conservative and costly
  - Monitoring provides more rational approach to fatigue management