

## DEEP WATER RISER TECHNOLOGY, VIV & FATIGUE MANAGEMENT

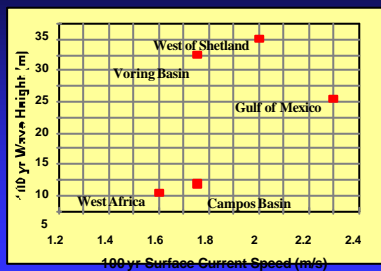
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2H Offshore Engineering Limited

Slender Well Workshop  
Aberdeen, March 1999

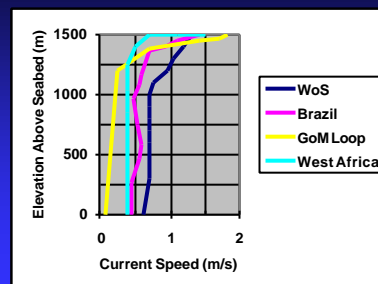
## SCOPE OF PRESENTATION

- 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

## AMJIG RISER GUIDELINE DEVELOPMENT

- Directed by BP, Shell and Elf
- Reviewed by operators, drilling contractors and analysis consultants
- Guidelines in 3 Parts:
  - ◆ Analysis
  - ◆ Operations
  - ◆ Inspection

## PART I - RISER ANALYSIS

- Riser configuration
- Drilling and survival limits
- Completion and well test operations
- Riser VIV
- Riser-wellhead-conductor interaction
- Recoil and hang-off
- Riser, casing and conductor installation

## PART II - RISER OPERATIONS

- Tension and tension variation
- Installation and retrieval envelopes
- Drilling and survival envelopes
- Monitoring operating conditions
- Recording riser operations
- Recording riser usage

## PART III - INSPECTION

- Inspection Assessment
  - ◆ Service category
  - ◆ Usage history
  - ◆ Inspection types and frequency
  - ◆ Acceptance criteria
  - ◆ Provision for inspection
- Components to be Inspected
- Inspection Procedures by OCTG

## GUIDELINE APPLICATIONS

- Assess fitness-for-purpose
- Optimise riser configuration
- Predict downtime
- Provide input to operating procedures
- Predict inspection requirements

## DEEP WATER RISER FINDINGS

- Need thicker walls for internal and external pressures and tension
- Hang-off requires bare lower riser
- Soft soils improve LFJ and WH response
- Retainer valves needed for disconnect
- High VIV fatigue damage = increased inspection and/or suppression

## 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

## VORTEX 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?

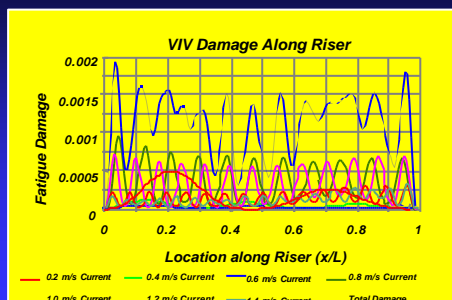
## VIV ANALYSIS METHODS

- 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

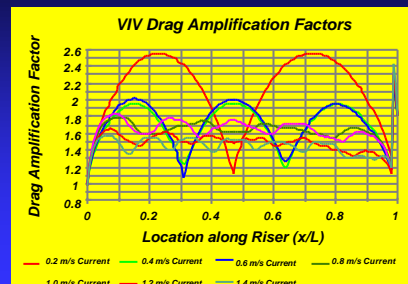
## VIV ANALYSIS APPROACH

- 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



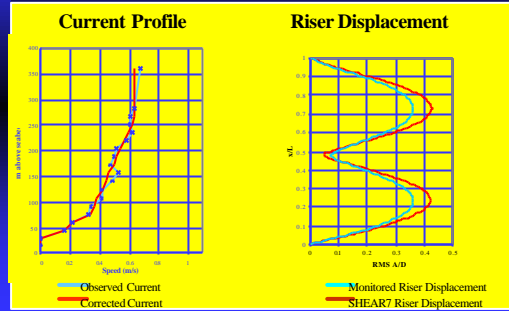
## VIV DRAG AMPLIFICATION



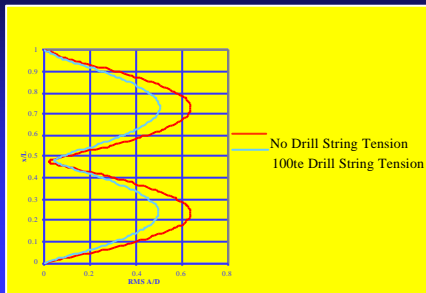
## VIV UNCERTAINTIES

- Current profile and direction
- Slick and buoyant joints
- Choke and kill lines
- Drill string tension
- Damping of multi-string system
- Conductor interaction

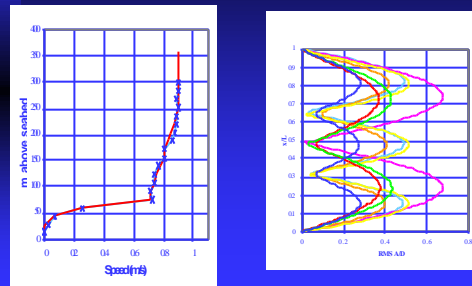
## VIV - ACTUAL v PREDICTED



## DRILL STRING TENSION



## MODELLING UNCERTAINTIES



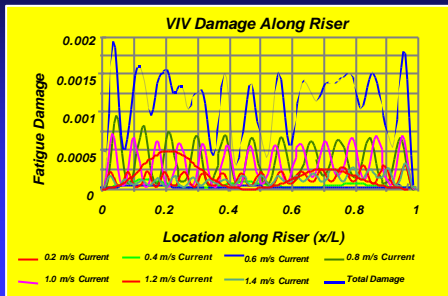
## IMPLICATIONS OF VIV FATIGUE

- 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

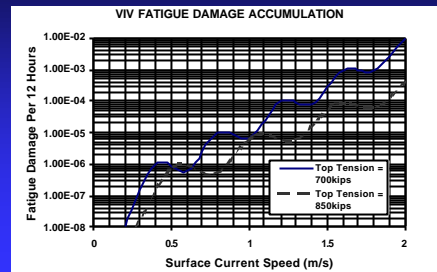
## VIV FATIGUE MANAGEMENT

- 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



## PARTLY PREDICTIVE



## 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