

Input from Participants

Group 1: Physics and Information Group Leader: Scott Slocum

- Design and execute offshore field test program to provide benchmark data for realistic conditions, to gain insight into VIV in riser design conditions. Design test to challenge VIV modeling assumptions. [M. Tognarelli, S. Ward, S. Slocum, and others]
 - Pipe diameter on the order of real risers to achieve realistic Reynolds numbers
 - High length-to-diameter ratio
 - Realistic current profiles
 - Bare pipe as well as full and partial coverage with suppression devices
 - Consider covering both tension-dominated and bending-dominated response regimes [S. Swithenbank]
- Maximize learnings from existing data [C.M. Larsen]
 - Harmonize data reduction methods and data interpretation
 - Share key data sets (rigid cylinder and long flexible cylinders)
 - Form a core analysis group to ensure consistent treatment of data
- Perform high-quality, high-resolution forced motion tests at laboratory scales (low Reynolds number) including cross-flow and in-line motion [C. Williamson]
 - Acquire hydrodynamic forcing data to allow models to be validated vs lab-scale flexible cylinder response measurements
 - Gain qualitative insight into physics to guide research at higher Reynolds numbers
 - Provide a framework for designing and interpreting tests at higher Reynolds numbers
- Perform tests to expand and confirm the database of hydrodynamic coefficients at high Reynolds numbers for combined cross-flow and in-line motion
- Develop a better understanding of suppression device performance and better models for predicting the impact of suppression devices on global response, especially for risers with partial suppression coverage
- Develop a new theoretical formulation for the semi-empirical approach that will accommodate recent test observations (e.g., excitation at higher frequencies, effects of higher damping and added mass on strakes, influence of in-line motion) [S. Slocum]
- Conduct focused studies to systematically isolate and address issues/uncertainties such as [H. Lie]:
 - Effect of cylinder inclination
 - Effect of high-harmonic excitation

Input from Participants

- Support long-term development of a reliable computational flow-field model for riser analysis [S. Slocum]
 - High Reynolds number
 - High length-diameter ratio
 - Realistic current profiles
 - Coupling with flexible cylinder structural response
- Develop methods for predicting flow-induced vibration of cylinders with non-circular cross section (e.g., galloping, flutter)
- Check validity of strip theory by [C.M. Larsen]:
 - 1) measuring response at a large number of stations along a flexible cylinder undergoing VIV,
 - 2) conducting forced motion experiments on short rigid pipes with imposed motion identical to that measured in 1),
 - 3) using the forces measured in 2) to calculate the response of the flexible cylinder, and
 - 4) comparing the calculated response from 3) to the measured response from 1)
- Perform tests to better understand the effects of roughness and incident turbulence on VIV
- Develop methods for accounting for impact of waves on VIV in the wave zone (particularly for offloading lines) [W. Kim]
- Develop design methods that account for hydrodynamic interactions between individual cylinders in arrays or bundles [W. Kim]
- Use existing test and field data to quantify the variability of VIV response and develop methods for accounting for that variability in design
- Consider construction of low-temperature test facility using liquid He to allow low-cost testing at high Reynolds number [F. Hover?]

Input from Participants

Group 1: Operations

Group Leader: Hugh Howells

Monitoring and Field Tests

- High Re full scale field tests
- Reliable instrumentation
- Good current data
- Consider use of dedicated facility v existing infrastructure

VIV Suppression

- High Re testing of strakes and fairings
 - Different joint configurations in drilling risers
 - Evaluate effects of marine growth
- Don't use suppression, consider different materials

Handling

- Development and testing of:
 - Damage resistant strakes
 - Handlable and quickly deployed fairings
 - Underwater deployable strakes and fairings
- Numerous commercial efforts
- Consider provision of seed funding and testing

Input from Participants

Group 1: Prediction

Group Leader: Yiannis Constantinides

1. Development of new generation CFD tools
 - Benchmark, validation and assessment of state of the art
 - Enhancements to accurately predict VIV and handle complex problems
 - Coupling with FE structural tools
 - User guidelines and standardization of CFD setup
 - Customization for riser VIV applications to enhance productivity and ease of use
2. Empirical frequency domain tools extensions and improvements
 - Validation of existing tools
 - Enhancement and development (high harmonics, accuracy)
 - Development of calibration methods and benchmarking procedures
 - Development of calibration methods from CFD tools bridging gap from ideal and slow CFD to fast and less accurate empirical tools
 - Assessment of limitations
3. Empirical time domain tools development
 - Development of time domain empirical tools
 - Benchmark and assessment of capability versus frequency domain tools
4. Design Guidelines
 - Development of design guidelines
 - Safety factors base on reliability and software limitations
 - Development of VIV specific metocean current selection
5. Benchmark Data
 - Assembly of experimental database for benchmark and calibration
 - Flexible cylinder laboratory
 - Rigid cylinder laboratory
 - Flexible cylinder field
 - Field monitoring data
 - Assessment of error bounds and uncertainties
 - Consistent and documented data deduction procedures
 - Quality assessment of each experiment

Input from Participants

Group 4: Rules and Standards

Group Leader: Hugh Thompson

- Sponsor a funded team to develop VIV guidelines through joint industry process (ex: API, Deepstar). The scope for standards development is shown on page 2 and includes riser design for VIV, hull and mooring design for VIM, and subsea component design for VIV. Four standards topic areas are proposed: Analysis, Design, Testing and Integrity Management.
- Economic Impact:

Rules and Standards will help ensure consistent application of VIV technology across the industry resulting in improved reliability of deepwater systems. Specific examples of estimated economic impact include:

- Recent spar mooring replacement due to inadequate VIM prediction: \$24,000,000
- Loss of drilling riser due to excessive VIV with no suppression: \$150,000,000
- Annual cost to run drilling riser suppression: \$100,000,000
- Riser hang-off component failure due to VIV: \$500,000,000
- Annual repair of damaged VIV suppression devices: \$100,000,000

The MMS has recently passed a new rule requiring regulatory approval of riser designs. The present lack of rules and standards creates uncertainty for both the operator and CVA and increases the cost of regulator approval.

MIT-RPSEA-Chevron VIV Forum
January 11, 2007

Input from Participants

	Analysis	Design	Testing	Integrity Management
Riser VIV * Drilling * SCRs * TTRs	<u>Met Ocean</u> - extreme event, short and long term current data etc. <u>VIV Analysis Method</u> - time vs. freq domain, cross flow, in-line <u>Structural</u> - modal characterization, SCR touch down, soil-structure interaction <u>Hydrodynamics</u> - inline, cross flow, single vs. multi mode, hyd input parameters <u>Interference</u> - wake model, integration with VIV analysis	<u>Strakes</u> - starts, pitch, height, material, attachment, length <u>Fairings</u> - long, short, attachment, length <u>Construction</u> - stake gaps due to field joints, J-lay tower grippers, etc. <u>SCR TDP</u> - Abrasion resistant strakes, CP and coating	(NO STANDARD REQUIRED)	<u>Instrumentation</u> - riser monitoring stations, data recording and retrieval, data processing and interpretation, hull wave frequency and VIM motions, current monitoring (ADCP) <u>Hull position management</u> - hull relocation to spread SCR VIV fatigue damage
Hull and Mooring VIM * Spars * Semis	<u>Met Ocean</u> - extreme event, short and long term current data, hurricane inertial currents, current profile and turbulence <u>VIM Design Parameters</u> - Reduced velocity, transverse VIM, inline VIM, drag coeff, strength criteria, short and long term fatigue <u>Mooring</u> - time vs. freq domain, <u>Hydrodynamics</u>	<u>Hull</u> - Stake pitch, height, belly side gap, structural attachment <u>Mooring</u> - bi-linear stiffness to mitigate VIM, slack vs. taut, chain vs. polyester,	<u>Model tests</u> - Reynolds number, scale effects, model degrees of freedom, mooring stiffness characteristics, appurtenance details, current direction and profile, flow turbulence, data processing, design values	<u>Instrumentation</u> - Mooring tension measurements, hull VIM and wave frequency motions, current monitoring (ADCP) <u>Mooring management</u> - fairlead link tracking, stepped line tensioning, current forecasting
Subsea Component VIV * Jumpers * Pipelines	<u>MetOcean</u> - short and long term bottom currents and directionality <u>Structural</u> - soil structure boundary interaction <u>Hydrodynamics</u> - jumper U bend strake efficiencies	<u>Jumpers</u> - unsupported length, strake coverage, buoyancy design <u>Pipelines</u> - strake coverage, mid line supports, soil interface	(NO STANDARD REQUIRED)	<u>Instrumentation</u> - pipeline monitoring stations, data recording and retrieval, data processing and interpretation

MIT-RPSEA-Chevron VIV Forum
January 11, 2007

Input from Participants