J P KENNY

Deepwater Riser Fatigue Life and Standard Study
Task 1 Summary Report

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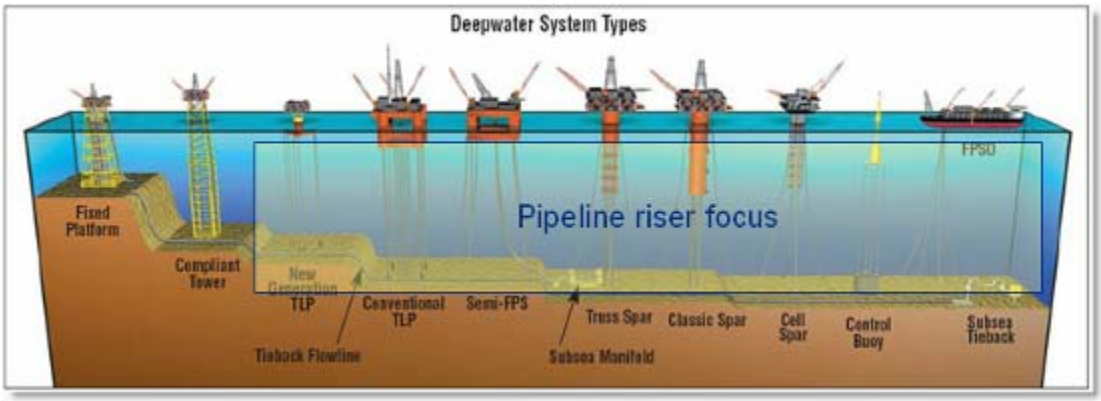
1. Study Overview

Study objective is to identify and suggest mitigations to the gaps between regulatory standards compliance and modern best practice for flexible and rigid (SCR) deepwater risers. Riser fatigue, failure consequence, designs and verification protocol will be evaluated as well as appropriate updates for regulatory guidance.

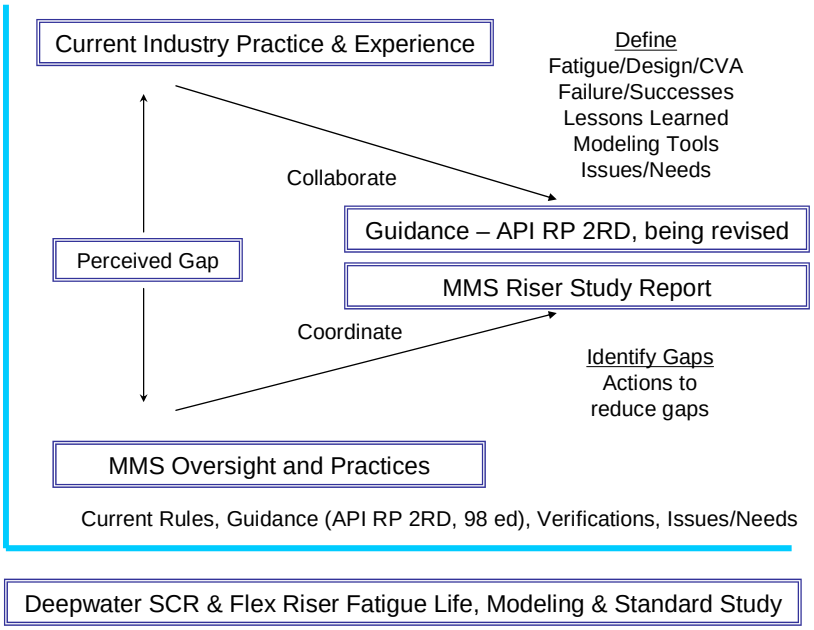


The study timeline is as depicted below.

	Jan	Feb	Mar	April	May	June	July	Aug	Sept
Task 1 - GOM riser data gather									
Task 2 - Rev operator practices									
Task 3 - Code mix / SF review									
Task 4 - FEA tool/analysis rev									
Task 5 - Edit on draft RP 2RD									
Report Prepartion									
Administration									
Workshops									

2. Study Scope

The study is comprised of five integrated tasks on SCR and flexible pipeline risers. The schematic below illustrates study scope objectives.



The first activity involves interfacing with deepwater operators and typical engineering contractors. JPK will review what they perceive as typical GoM industry practices in designing, modeling, verifying and testing deepwater risers and also review preferred VIV suppression techniques and technology used at the hang off and touch down riser locations. Opinion on internal best practices, SCR and flexible damage or problem reports, and new metaocean criteria due to hurricanes will be discussed. A direct interface with API RP 2RD subcommittee will also be established. The purpose of the interfacing is to get an overall industry consensus on working methods and indentify areas for improvement.

The next tasks will include a review of limit state design techniques in codes like DNV-OS-F201 and recent riser JIP findings relative to API RP 2RDs current approach. The purpose is to search for potentially superior and safer industry proven methods for deepwater riser design that can be incorporated into a future replacement standard. Risk of mixing different design approaches and the results on the safety factors will be addressed. Coupled analysis riser modeling methods and tools and advantages of time and frequency domain approaches will be also be reviewed.

The final task is to create a draft for a Recommended Practice that identifies best industry practices and classifies potential changes to codes to improve design, verify and protect risers. The plan is to deliver tangible guidance to regulators and operators.

3. Summary List of Task 1 - Data Gathering

Summary of tasks regarding data gathering on GoM riser practices:

1. Review reported failure data;
2. Review publications, papers, and proceedings;
3. Gather operators and contractors best practices and lessons learned. Survey and pre-workshop meetings will be conducted. Initial review of materials, VIV mitigation techniques will be done. This is in preparation for Task 2;
4. Identify and schedule meetings with relevant API, ISO and JIPs groups for interface. Focus will be API RP 2RD subcommittee members as well as export riser operators such as Williams, El Paso and Enterprise;
5. Schedule and execute workshop #1 with industry participants.

3.1 Review Reported Failure Data

The operator survey resulted in nine written, detailed responses from industry participants. The specific answers are being verified and generalized for inclusion into the final report and for use in the next set of tasks.

The MMS reports on pipeline and riser failure were reviewed since the last hurricane study reports. No specific deepwater pipeline riser failures due to fatigue were noted. However, industry participants have identified a small number of such failures that were not reported. In these cases it appears that the problems related do to the topside hand off appurtance (ie: flexible joint), the VIV suppression system (ie: strakes or fairings) and possibly some issues at the touchdown point. It was understood that these failures did not result in a release of hydrocarbons. Further investigation is ongoing and will be part of Tasks 2 – 4.

3.2 Review Publications, Papers, and Proceedings

A large number of papers and proceedings have been identified and reviewed. Many of these are being used as source material for study investigation.

The following list includes documents and publications under review.

- Draft API RP 2RD (Ch.5, 6 and 12)
- Riser Design and IM Guidance (Proprietary)
- NTL2007-G14 (Pipeline Riser CVA)
- Simulation of Riser VIV Using Fully Three Dimensional CFD Simulations
- Vortex-Induced Vibrations of Risers
- Analysis of Riser VIV

- Analysis of Vortex-Induced Vibrations of Marine Risers Based on Full-Scale Measurements
- Shear7 for Fatigue Damage
- Deepsea Riser Course - Riser Design Considerations
- Cross Section VIV Model Test for Novel Riser Geometries
- Development of SHEAR 7 Lift Curves for VIV Analysis and Application to Single Pipe
- Fatigue Life Evaluation Through the Calibration of a VIV Prediction Tool
- Freestanding Risers in Ultra-Deep Water
- Global to Local Model Interface for Deepwater Top Tensioned Risers
- Grouped SLOR
- Integrated Approach to Riser Design
- Optimization of Sensor Placement to Capture Riser VIV
- Performance Monitoring of Deepwater SCRs
- Review and Evaluation of Riser Integrity Monitoring Systems and Data Processing
- SCR Response and Monitoring
- SCR System Design and Experience
- Structural Damping Test for the BP Shah Deniz Risers
- The Need for Standardising Deepwater Riser Systems
- Steel Catenary Riser Touchdown Point Vertical Interaction Models
- VIV Applications to Deepwater Risers
- Estimating Nonlinear Coupled Analysis
- Riser Interaction Models
- CRA for Composite Drilling and Production Risers
- New Touch-Down Zone Solutions for Steel Catenary Risers
- Seafloor Interaction with Steel Catenary Risers

Vendors providing key components of SCR and flexible risers have also been contacted.

3.3 Operators and Contractors Best Practices and Lessons Learned

One on one interviews have been conducted to supplement the survey and workshop input. The operator's best practices and lessons learned are being narrowed down to those gathered on a number of projects. Detailed information is being worked in Task 2. The level of transparency is being negotiated with the operators (ie: whether or not to identify the specific project in regards to lessons learned or best practices that were demonstrated). The projects we have accessed include major deepwater GoM jobs by majors and independents for both infield and export SCRs and flexible water injection risers.

3.4 Identify and Interface

Purpose is to identify and interface with groups representing ROW (Right Of Way) and lease term riser systems.

The existing API RP 2RD subcommittee was contacted and JPK is a member as of March 2007. Further, by the study team involving and inviting export system operators to participate it appears that two or more will formally join the 2RD subcommittee to support the ongoing re-write.

The API RP 2RD subcommittee includes DnV, MCS, SES, and 2H which has allowed for some sharing in regard to past and ongoing JIPS relevant to the study scope.

3.5 Workshop #1 Execution

Workshop #1 was conducted on April 20, 2007 at JPK Houston offices. Direct participation included 11 company representatives in addition to JPK staff. This full day workshop had the objective of data collection – specifically gathering key experiences, lessons learned and preferences that may or may not have been shared in the written survey. See Appendix for details of the proceedings.

4. Future Tasks

Study tasks 2, 3 and 4 are being worked. Specific points and issues identified at workshop #1 will be followed up on during the next couple months. The final workshop's objective is to review summary findings and gather a final round of industry feedback in regard to the select points of guidance to offer on:

- Riser CVA (ie: verification overview, comments on new NTL2007-G14 and recommended detailed guidance example for planning and execution)
- Riser fatigue design (ie: select points of guidance)
- Fatigue suppression devices (ie: design, fabrication, installation and integrity management perspective)
- Riser monitoring (ie: overview and practical options will be identified)
- Design Approach (ie: overview of deepwater pipeline riser design with select WSD and limit state approaches that are deemed safe, good modern practice)
- Riser modeling tools (ie: overview of tools and best practices)

The results will then be compiled into Task 5 which is the final report.

APPENDIX

APPENDIX A - Workshop #1 Documents

MMS Riser Workshop 1 **Data Collection - deepwater risers**		**20 April 07 (Fri)-8:00 am to 3:45pm** JPK Houston: OPUS building, 3rd floor; 17404 Katy Freeway, Suite 350, Houston, Texas 77094 (Ph: 281 675 1000)
Workshop Team:	Project Manager: John Skinner Facilitator: Molly Atkins	Lead Riser Engineer: Lun Qiu Project Engineer/ Scribe: Geoffrey Smart
Participants:	Anadarko, BHP, BP, Enbridge, Enterprise, Exxon, Floatec, Fluor, MCS, Mentor, Repsol, Shell, SES, Technip, Williams, JP Kenny	

Agenda

Schedule	Min	Topic	By
8:00 – 8:15	15	HSSE Moment, JPK Intro, and Group Introductions	All
8:15 – 8:45	30	Study Purpose & Approach ▪ MMS study description & overview ▪ Confidentiality of Study Information ▪ Coordination & Collaboration Approach	MMS (to call-in for this item)
8:45- 9:00	15	Study Objective ▪ Study Goals ▪ Study Participants ▪ Study Schedule	PM
9:00- 9:15	15	Survey Purpose & Findings Overview	
9:15- 12:00 12:00- 1:00 1:00 - 3:15	105 60 135	Data Collection (Part 1) Lunch Data Collection (Part 2)	All
3:15 - 3:45	30	Closing & Comments	

Notes:	Data Collection Review is a facilitated group session to gather industry feedback on the following types of lifecycle issues: ▪ Past deepwater riser system failures/ problems ▪ SCR riser system experiences and issues ▪ Flexible riser and pipeline system experiences and issues ▪ Fatigue specific issues and concerns (ie: VIV analysis, suppression devices, integrity management) ▪ Riser design specific issues & concerns (ie: WSD & LRFD approach mix and resulting safety factors, software FEA modeling tools) ▪ Current industry quality and staff availability concerns ▪ Riser CVA (verification) rule experience and concerns	

MMS
U.S. Department of the Interior
Offshore Minerals Management
Technology Assessment & Research
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MMS - Deepwater Riser Fatigue Life, Modeling & Standard Study
Workshop #1 – Data Collection
In-line VIV of riser
DEMO TEST
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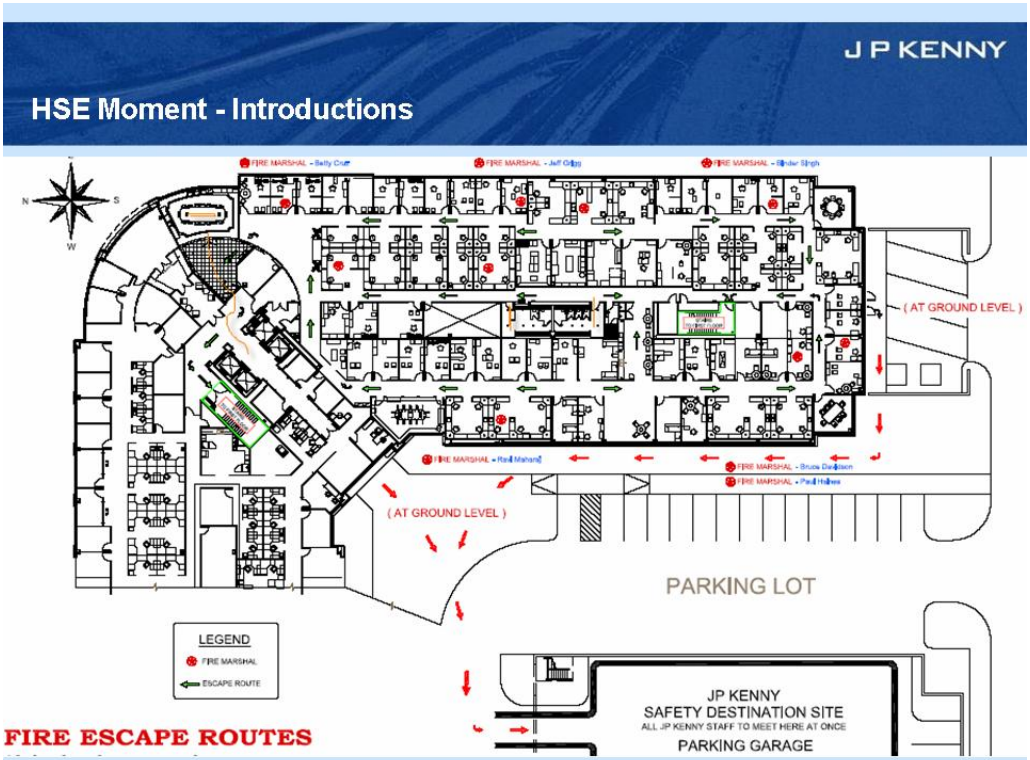
TA&R Pipelines Research Study
Contract: M07PC13013 (Project # 572)
JPK Project: 86330.01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HSE Moment - Introductions
(AT GROUND LEVEL)
(AT GROUND LEVEL)
PARKING LOT
LEGEND
FIRE MARSHAL
ESCAPE ROUTE
JP KENNY
SAFETY DESTINATION SITE
ALL JP KENNY STAFF TO MEET HERE AT ONCE
PARKING GARAGE
FIRE ESCAPE ROUTES

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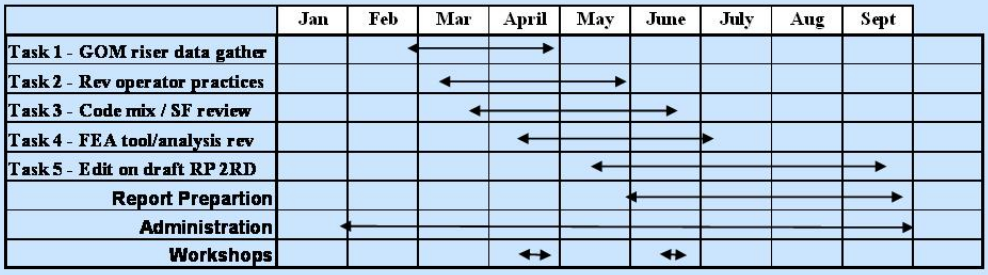
Study Schedule



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General DW riser system

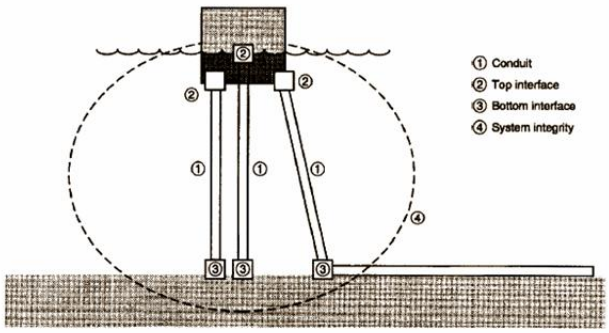

Figure 2—Essential Functional Elements of an FPS Riser System

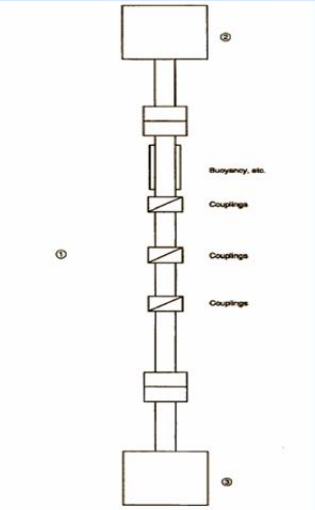

Figure 3—Elements of Complexity Enter the Basic Riser Design

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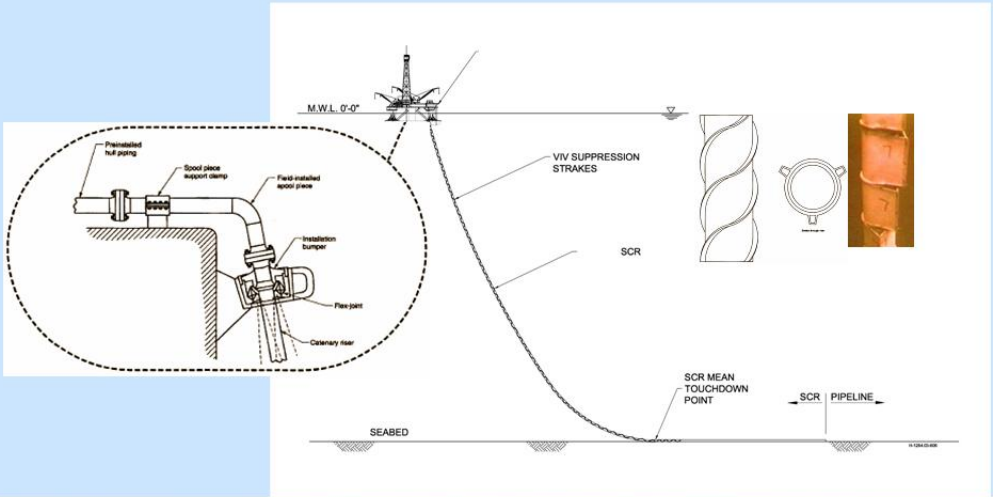
SCR Configuration



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History

- First SCR
- 1994; 12" Export SCRs; Auger TLP; GB 426; 2860 ft
- First SCR on FPSO
- 2005; 12"Bonga; West Africa; 3300 ft
- First SCR on Semi submersible; GoM
- 2003; 6"-20"; Na Kika; MC 474; 6378 ft
- First SCR in less than 1500 ft
- 2001; 12" Export SCRs; Prince TLP; EW 1003; 1492 ft
- Deep SCR
- 2007; 8"-14"; Independence Hub Semi; MC 920; 8000 ft

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Design Drivers

- Fatigue (VIV, Wave-, Vessel Motion-, Vessel Heave-Induced)
- $1 / \Sigma (S_i D_i) \geq$ Design Life
- S-N Curve; ECA
- Strength (Installation, Hydrotest, Operating, Extreme, Survival)
- Stresses/Strains < Allowable
- WSD; LSD
- Clashing
- Min Clearance > Specified Distance
- Wake Effect
- Installation
- Feasible; Collapse

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Codes, Guides, Software

- Codes/Guides/Regulation
- API RP 2RD, DNV OS F-201, ASME B31.8, API 1111, Etc.
- Operator's Guidelines
- Code of Federal Regulation
- Software
- WIF, Strength, Clashing: ABAQUS, ANSYS, Riflex, Flexcom, Orcaflex
- VIV: Shear7, VIVA, VIVANA, Etc.
- SCR Model
- Mesh Size
- Pipe-Soil Interaction

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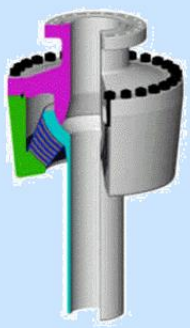
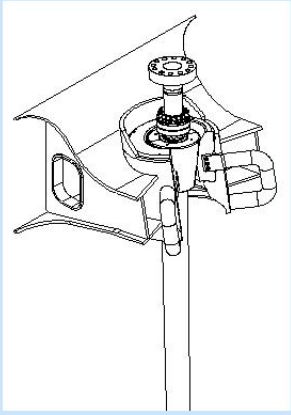
SCR-Hull Interface

Flexible Joint



Stress Joint



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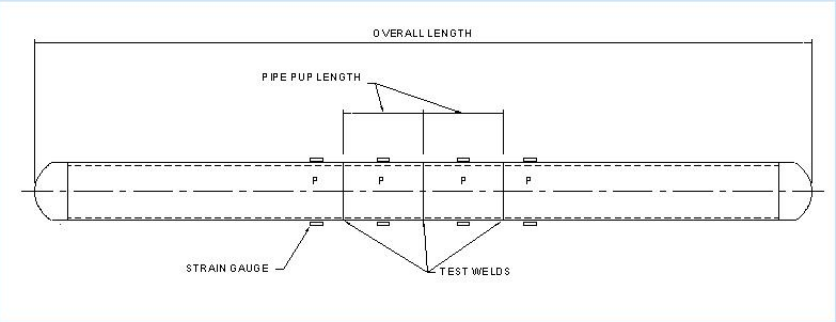
Fatigue Test Program

- **Per Weld Type/Material**
- **N Tests X M Stress Ranges**
- **Passing Limits**



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Engineering Critical Assessment

- **BS 7910**
- **Appropriate Level**
- **Critical and Allowable Flaw Sizes**
- **Surface Flaws/Buried Flaws**
- **Safety Factor**

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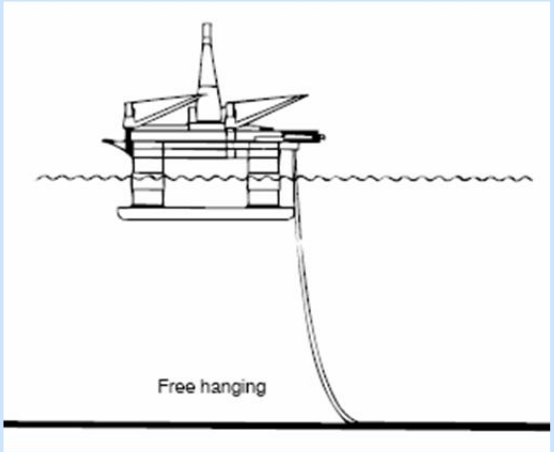
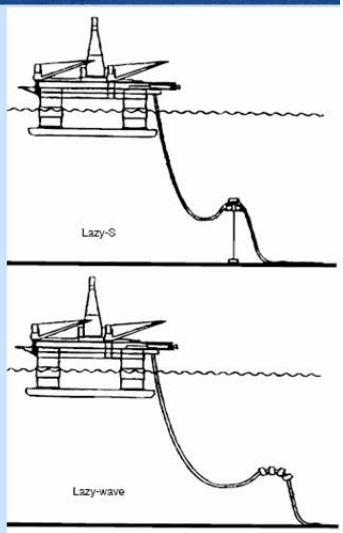
Flexible riser- example configurations





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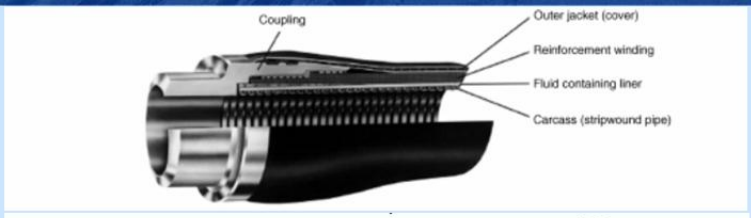
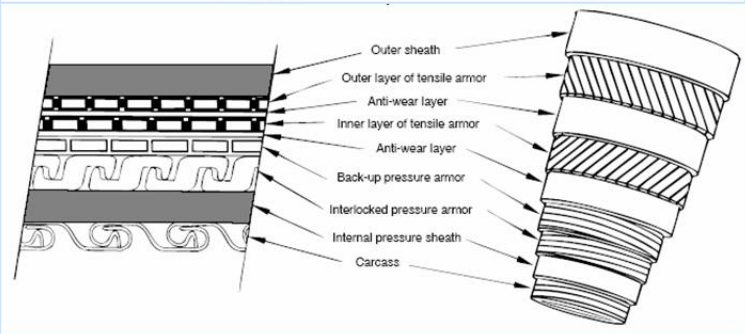
Type

- **Bonded**



- **Unbonded**



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Design Drivers

- Fatigue (VIV, Wave-, Vessel Motion-, Vessel Heave-Induced)
- $1 / \Sigma (S_i D_i) \geq$ Design Life; S-N Curve
- Strength (Installation, Hydrotest, Operating, Extreme, Survival)
- MBR/Stresses/Strains < Allowable; Collapse (Birdcaging)
- Clashing
- Min Clearance > Specified Distance; Wake Effect
- Flow Assurance
- Single/PIP; Wet Insulation
- Thermal/Chemical Degradation; Wear; Corrosion
- Material; Temperature; Fluid
- Installation
- Feasible; Collapse

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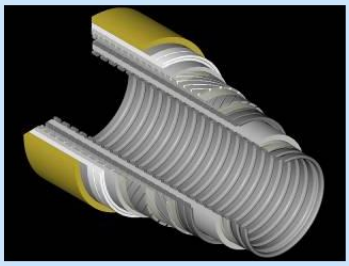
Flexible riser- design challenges

Design Challenges:

- High Temp / High Pressure w/ large ID
- Fatigue life
- Material suitability for trace H2S
- End Fittings
- Prototype testing within lo-float timetable



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CVA – GoM risers - Overview

- MMS issued a new rule under 30CFR250 subpart (i) on August 19, 2005. It affects deepwater project works associated with API RP…
  2RD (risers)… 2SK (station keeping)… 2T (TLPs)… 2FPS (FPSOs)… and 14J (DWOP HAZOP+) as well as flex lines and underwater welding
- For the first time, Gulf of Mexico deepwater riser systems must be verified.
- The verification for risers in particular must be done by a company nominated and MMS approved CVA (certified verification agent).
- The riser CVA scope of work must include:
  - specific design,
  - fabrication and
  - installation aspects

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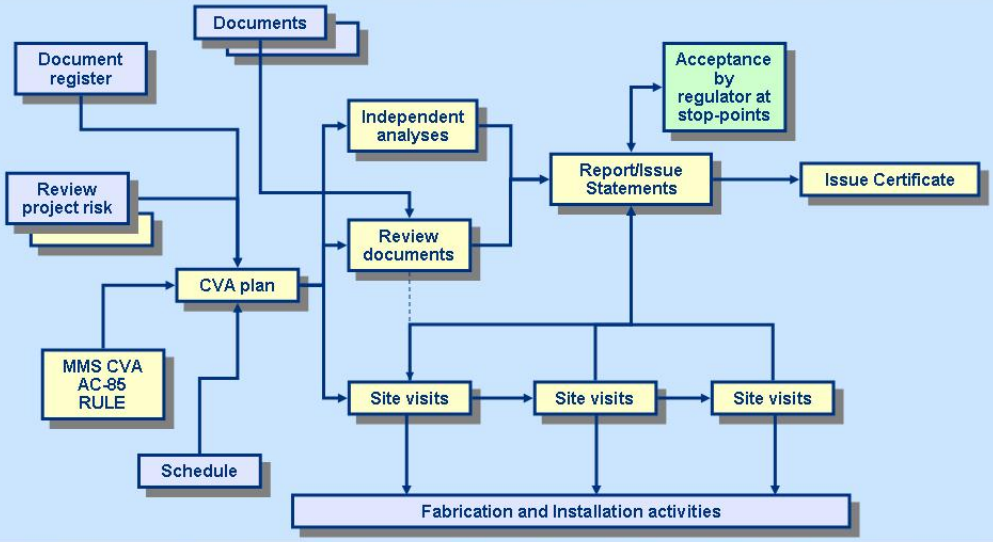
Certified Verification Agent (CVA) - Approach



Company | CVA | Regulator

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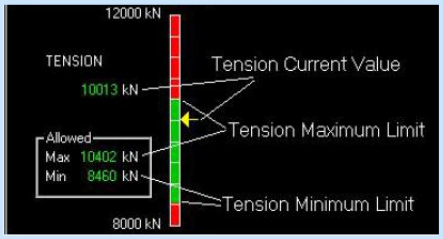
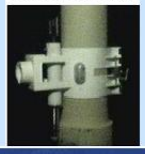
Integrity management – Monitoring

***IRIS-RMS* sensor inputs**

- IRIS-RMS data inputs are typically a combination of
- existing sensors and RMS-specific additional sensors.
- Typical sensors are:
  - •Strain Gauges
  - •Riser tension & Stroke
  - •Riser top and bottom angles
  - •Vessel Position (from GPS or transponders)
  - •Surface current and wind speed



Standalone data loggers



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Case study – monitored SCR

Full Scale Riser Monitoring - Allegheny

- 12" diameter simple catenary gas export riser
- 3300ft (1005m) GoM
- Atlantia Seastar mini TLP
- ADCP current data to 650m
- Wall thickness of 0.688" (17.48 mm)
- Departure angle of 12º
- Hang-off position at 25 m below MWL
- Strake fitted along the top 580 ft of the riser
- Strake height 0.16 D, pitch of 15 D
- Instrumented in August 1999 - 13 loggers
- Low cost (<$250k)

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