MODU Mooring Design and Inspection Practice

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MODU Mooring Environmental Criteria

(1) **US – American Petroleum Institute**

API RP 2P – MODU (1984, 1987)

- Design Environment: 1-year

API RP 2SK – MODU and FPS (1997, 2005)

- Design Environment: 5-year (away from other structures)
  10-year (close to other structures)
- The 1997 Revision was Based on Mooring Code Calibration JIP (1995)

(2) **International Standard Organization (ISO 19901-7)**

- API criteria adopted
- Norwegian annex: 10-year design environment

Tension Limits and Safety Factors

	Analysis Method	Tension Limit (Percent of MBS)	Equivalent Factor of Safety
Intact	Quasi-static	50	2.0
Intact	Dynamic	60	1.67
Damaged	Quasi-static	70	1.43
Damaged	Dynamic	80	1.25

Chain for MODU and Permanent Moorings

Typical 3 in MODU Chain

6 in Chain for Permanent Moorings

Overview of Recent 2SK Revision

- Revision Began in 2002 and Completed in 2004
- To be Issued in 2005
- Major Revisions

  MODU and Permanent Mooring
  - Add Pile and Plate Anchor FOS and Design Guide
  - Allow Higher Uplift Angle for Drag Anchors
  - Add Clearance Criteria
  - Revise Mooring Proof Load
  - Add Mooring Hardware Section
  - Revise Dynamic Positioning Section
  - No Change in Environmental Criteria

  Permanent Mooring
  - Revise Chain Fatigue Design Curves
  - Add Global Analysis Guidelines
  - Add Spar VIM Design Guide
  - Add Discussion on Mooring Strength Reliability
  - Provide NPD and API Wind Spectrum

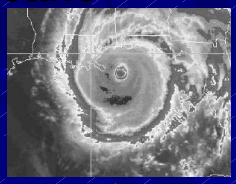
Comparison of MODU Mooring Practice

- Gulf of Mexico
  - Evacuate Drilling and Production Facilities
  - Recent Total Failures: Andrew 2 (1992), Lili 1 (2002), Ivan 4 (2004)
  - There were also Partial Failures
  - Primary Cause: Overloading
- North Sea and Other Areas
  - Manned Facilities
  - Partial Failures
  - Primary Cause: Overloading, Fatigue, Faulty Components

DeepStar 4404 (2001) - Mooring Reliability Study for Permanent Moorings

	GOM	North Sea	W. Africa
H_s (100 yr/10 yr)	1.5	1.15	1.18
V_w (100 yr/10 yr)	1.5	1.14	1.18
Operation Procedure	Evacuate	Manned	Manned

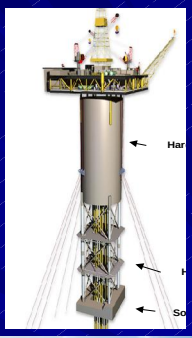
Comparison of GOM Hurricane Environments



	10-year, MODU Mooring Design	100-year, Permanent Mooring Design	Ivan
Sig. Hs (ft)	26	40	45 - 52
Wind Speed (1 minute, knot)	70	95	95 - 105
Current Speed (knot)	1.8	3.0	4

GOM Operations
Changes in the Last 10-15 Years

- More Floating and Subsea Installations
- More Permanent Deepwater Operations with Higher Production Rates
- More Deepwater MODUs with Taut Leg/Pile Mooring Versus Catenary/Drag Anchor Mooring Years ago
- Some MODUs Stay on One Location for Much Longer Period
- Bigger MODUs
- More Metocean Information



Some Fundamental Questions

- Have the Changes in GOM Operations Increased the Risk Sufficiently to Warrant Another Change of 2SK MODU Mooring Criteria?

- If the Answer is Yes:
  - What Level Of Change is Appropriate?
  - What is the impact of the Change on the Industry?

Long Term Plan for API RP 2SK

- Reactivate the 2SK WG to address GOM MODU mooring issue
- 2SK WG will work with OOC/industry to initiate a JIP to study the MODU mooring reliability and provide a first draft commentary
- The 2SK WG will finalize the commentary and seek API approval and publication (2006/2007)
- After 3-5 years industry practice, the commentary will be incorporated in the 4th edition of 2SK (2010)

Commentary on GOM MODU Mooring Practice Potential Topics

- Basic considerations
- Current design and operation practice
- Historical GOM operation experience
- Risk assessment of current and future operations
- Comments on the use of 2SK environmental criteria for GOM MODU mooring
- Strategy to minimize mooring failure and damage to surrounding structures
- Indicative GOM extreme environments

Revision of API RP 2I Mooring Inspection

Current API RP 2I

- Developed about 15 years ago
- Address inspection of mooring chain, wire rope, and connecting hardware mainly for MODUs

On-Going Revision

- Add Fiber Rope Inspection Guidelines
- Add Permanent Steel Mooring Inspection Guidelines
- Revise MODU Mooring Inspection Guidelines
- Schedule for Completion: Mid 2006