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Integrity, Monitoring, Inspection and Maintenance of FPSO Turret Mooring Systems

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Philosophy of Asset (Turret) Integrity Management

- System versus Component Based
- Criticality - Risk Based Approach
- Implement during Concept Development / Design
- Well Documented and Structured O&M Manual
- Operator Training

Focus on Turret Integrity Key Systems

- Bearing System
- Swivel System
- Anchor Leg System

Concluding Remarks
Asset Integrity Management

Asset Integrity Management Phases

- Life Extension
- Operational Life
- Operator Training
- Commissioning / Installation
- Construction / Fabrication
- Design
- Concept Selection

Asset Integrity Management Tools

- Design Requirements
- Hazard Identification & Risk Assessment
- Data & Documentation Management
- Inspection, Monitoring & Assessments
- Maintenance & Sparing Philosophy
- Replacement or Repair Strategies
Theory to Practice!

Operating & Maintenance Manual

Training & Implementation

Keywords:
- Quantitative Instrumentation
- Performance
- Cost
- Risk
- Critical
- Reliability
- Integrity
- Reliability
- Management
- Safety
- Robustness
- Inspection
- Preventive
- Quality
- Automation
- Guidelines
- Case
- Life-Cycle
- Real-Time
- Design
- Condition
- Data
- Decision
- FMECA
- Mitigation
- Hazard
- HAZOP
- Health
- Risk-Based
Integrity, Inspection, Monitoring and Maintenance

**Integrity**
- Ability to perform a function effectively, efficiently and reliably
- Evaluated through Inspection and Monitoring, ensured through Maintenance

**Inspection**
- Periodic evaluation of component condition
- Static (snapshot) observation supporting fit-for-continued-service decisions

**Monitoring**
- (Semi) continuous evaluation of system performance
- Observation of trends and changes supporting day-to-day operational decisions

**Maintenance**
- Replenish consumables, planned or pre-emptive replacement of (sub) components
- Alterations to condition to enhance performance
Improve Inspection Efficiency in Early Design

- Consider Operational Limitations
- Identify Critical Systems and Relationships
- Create Accessibility For Inspection
- Combine Multiple Inspection Tasks Inside Isolated Areas
- Replace Manual Inspections by Automated Monitoring
- System Based O&M Manuals rather than Component Based
Key Components of a Turret Mooring System

- Piping and Valves
- Electrical & Instrumentation
- Structural
- Swivel System
- Bearing & Lubrication System
- Anchor Leg System
Bearing System – Overview

- Uplift Support Races
- Inner Race – Geostationary (Earth Fixed)
- Support Races
- Outer Race – Weathervanes (Fixed to Vessel)
- Nose Ring
- Uplift Rollers
- Axial Support Rollers
- Radial Rollers
- PAYLOAD OF RISER, UMBILICAL AND TURRET WEIGHT
Bearing System – Lubrication system
Bearing and Lubrication Systems

**Typical Inspection Points**
- Weekly visual observations of rotation
- Analyze expelled lubrication grease samples
- Measure height differential between inner and outer bearing race

**Automated monitoring possibilities**
- Lubrication flowrate
- Height differential between inner and outer bearing race
- Rotations (using DGPS, or linear encoder, or similar)

**Maintenance**
- Replace (near) empty grease drum with full one
- Clean up expelled grease
- Actively rotate FPSO when long periods of no full rotation occur
Swivel Systems – Overview
Swivel Systems

Typical Inspection Points
- Visual inspection of rotating housings, torque arm joints, piping and flange connections
- Visual inspection of hoses and electrical cables
- Visual inspection of fluid recovery and buffer systems

Automated monitoring possibilities
- Lubrication flowrate
- Pressure gauges on fluid buffer system and fluid consumption
- Swivel torque monitoring

Maintenance
- Flushing sealing system from wear debris
- Replace seals in-situ using spare seals or in-situ welded seals
- Replacement of consumable fluid barrier
- Lubrication of components, tightening of end fittings, replacement of hoses
Anchor Leg Systems - Overview
Anchor Leg Systems Integrity – Top-down Approach

Monitoring the performance of the anchor leg system
- Turret excursion monitoring using DGPS
- Combine with MRU at turret

Monitoring the performance of individual anchor legs
- Mooring catenary profile (measure angle and/or depth, calculate tension)
- Focus on line failure detection -> change in profile

Inspecting the condition of anchor leg components
- Risk based approach defines GVI or CVI per component, quantitative data requirements
- Refer to baselines from previous inspections

Maintenance of anchor leg systems and its components
- Periodic Re-tensioning (polyester stretch and OPB issues)
- Pull-in equipment readily available
Incorporate IMM philosophies early in the design stages

Take a system based approach vs component based approach & prioritize safety and production critical systems

Establish baselines during fabrication, installation & commissioning

Where possible, apply automated (remote) monitoring to reduce personnel demand

Continued IMM training of operating personnel is crucial
Thank You!

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