

OTC2017 \

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

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Presentation Outline

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

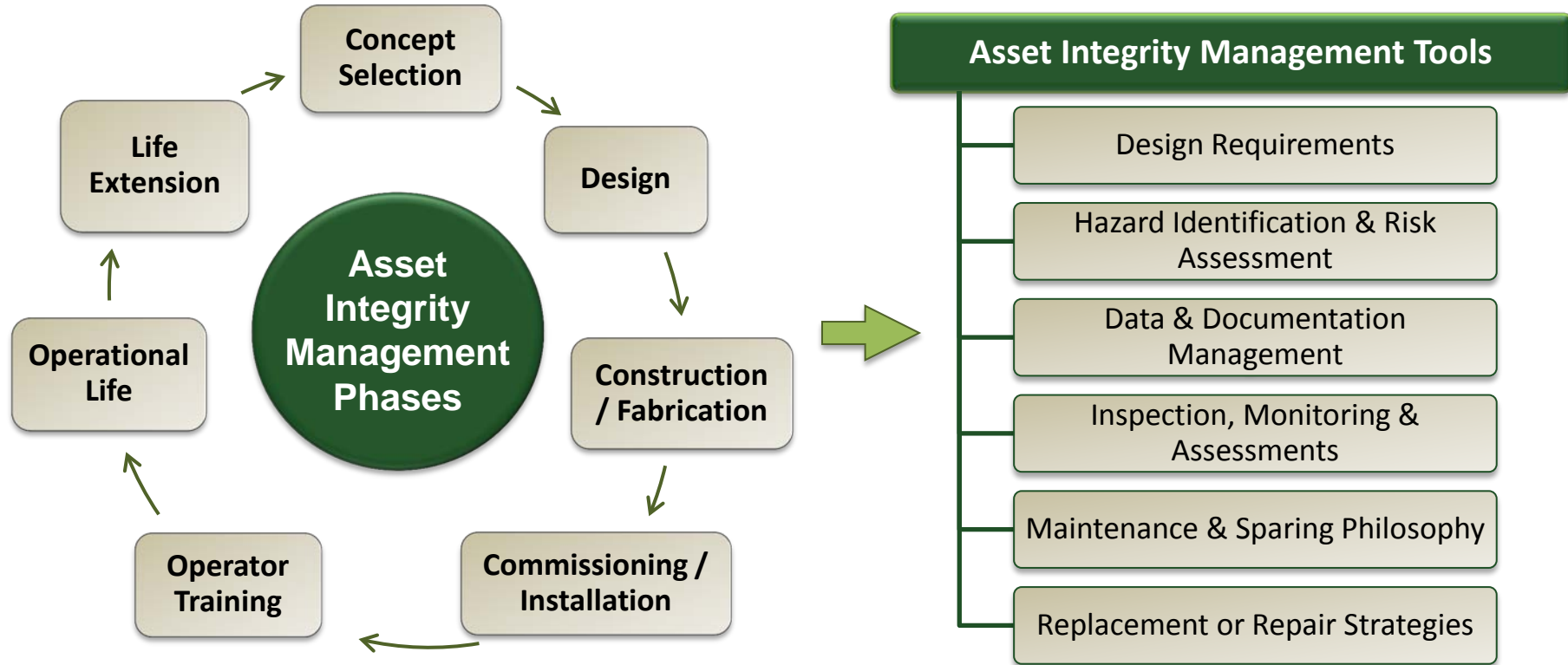
Focus on Turret Integrity Key Systems

- Bearing System
- Swivel System
- Anchor Leg System

Concluding Remarks



Asset Integrity Management



Integrity, Inspection, Monitoring and Maintenance



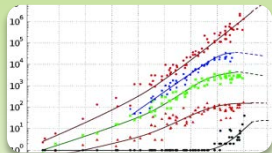
Integrity

- 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



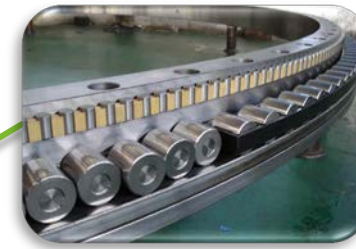
Electrical & Instrumentation



Structural



Swivel System



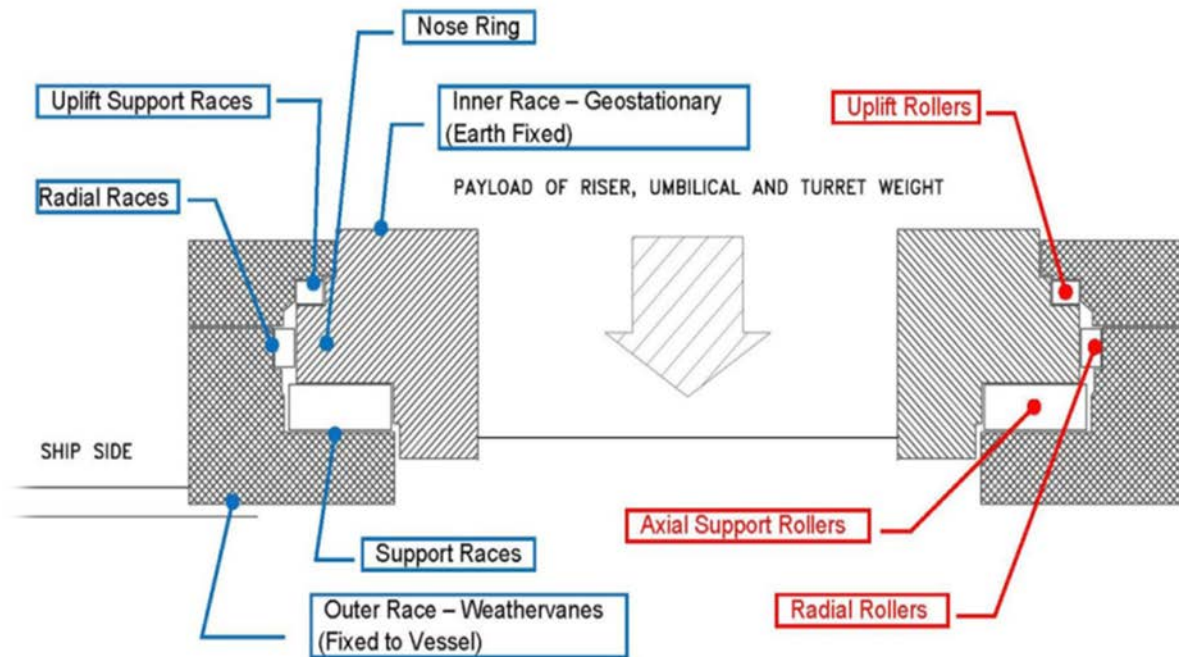
Bearing & Lubrication System



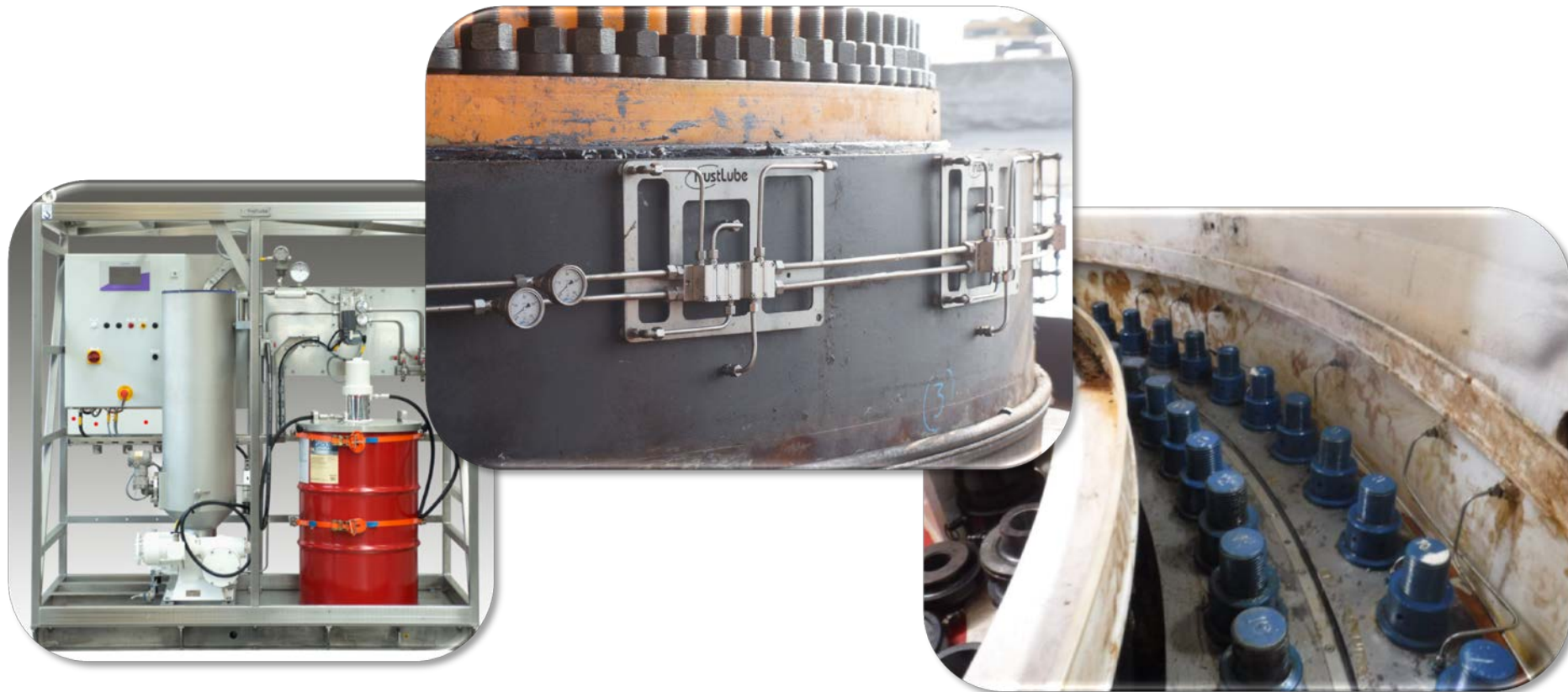
Anchor Leg System



Bearing System – Overview



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

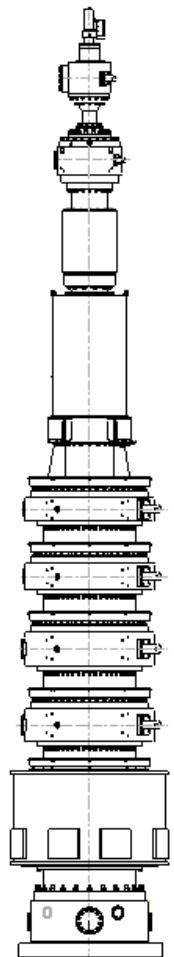
- Lubrication flowrate
- Height differential between inner and outer bearing race
- Rotations (using DGPS, or linear encoder, or similar)



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



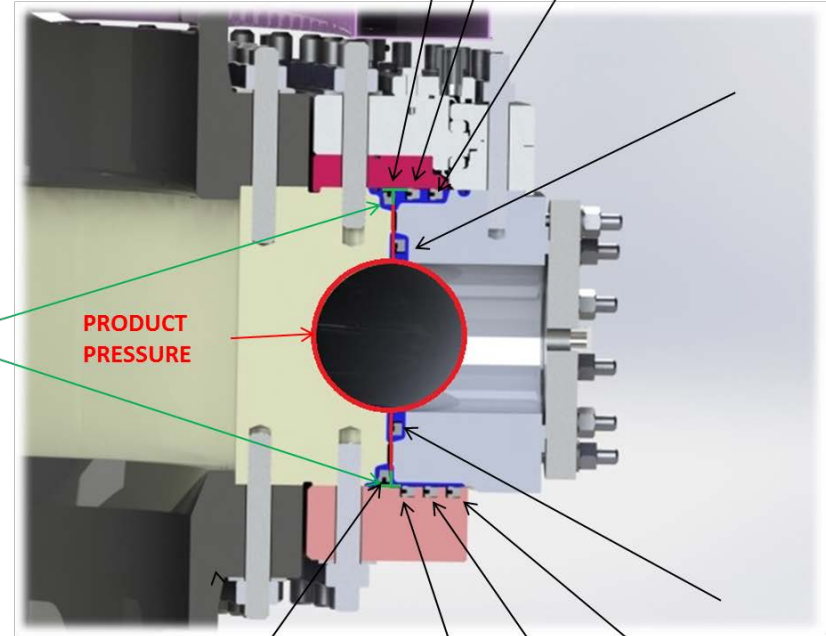
**BARRIER
PRESSURE**

**PRODUCT
PRESSURE**

BARRIER PRESSURE SEAL

PRIMARY PRESSURE SEAL

SECONDARY PRESSURE SEAL



BARRIER PRESSURE SEAL

**TERTIARY
(ENVIRONMENTAL) SEAL**

SECONDARY PRESSURE SEAL

PRIMARY PRESSURE SEAL

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

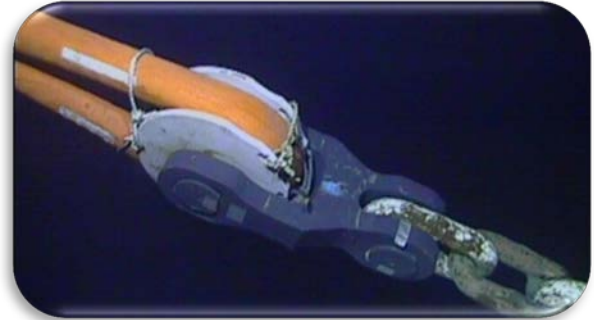
- Lubrication flowrate
- Pressure gauges on fluid buffer system and fluid consumption
- Swivel torque monitoring



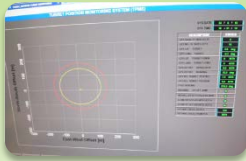
Maintenance

- 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

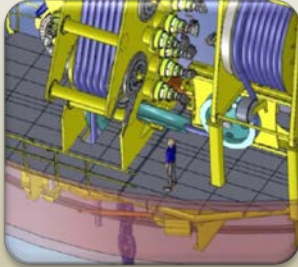
- Risk based approach defines GVI or CVI per component, quantitative data requirements
- Refer to baselines from previous inspections



Maintenance of anchor leg systems and its components

- Periodic Re-tensioning (polyester stretch and OPB issues)
- Pull-in equipment readily available

Concluding Remarks



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

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Thank You!

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