Mooring System Wear

JIP Pitch
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Motivation

Wear is a common issue in offshore moorings for oil & gas

Mooring Line Failure Mechanisms

The primary degradation mechanism identified for each failure event (i.e., initial consequence) is presented in Figure 5.3. It is important to note that the term "primary" is intended to represent the mechanism thought to be the greatest contributor to degradation by the operator. Often with mooring failures, there is more than one contributing factor.

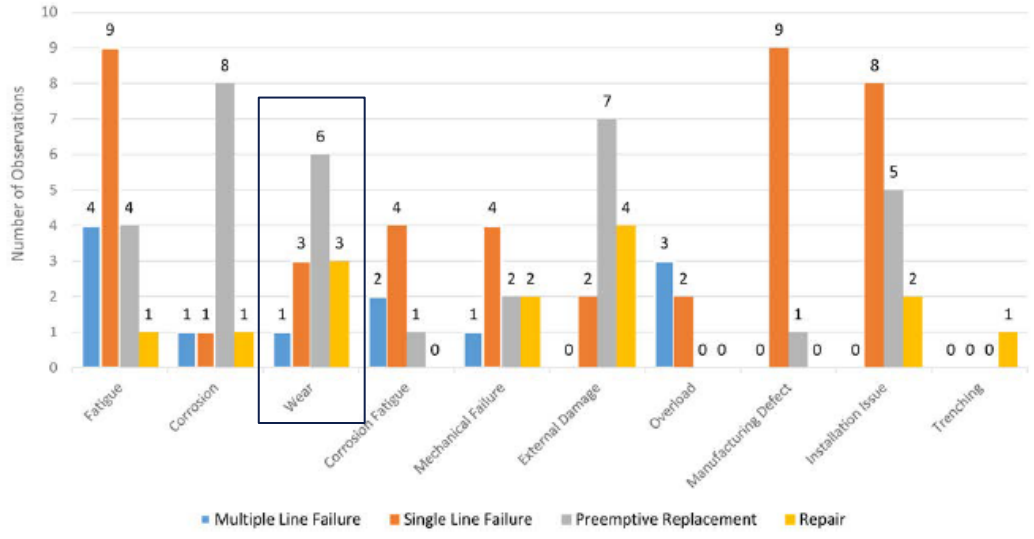
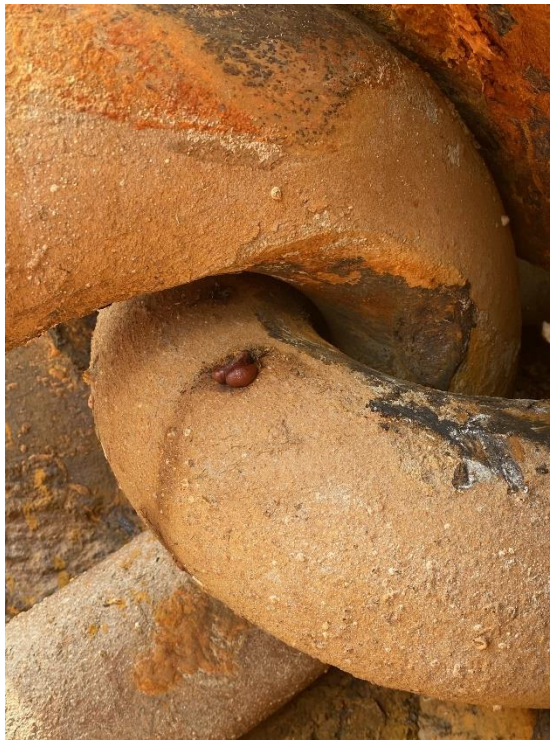


Figure 5.3—Primary Degradation Mechanisms by Consequence Failure Type Events



Mostly resulting in the pre-emptive replacement of mooring lines.

But some line losses have been reported

Motivation

Wear is expected to become a significant issue for floating offshore wind due to more challenging conditions than oil & gas:

- Higher dynamic motions and mean load than O&G systems
- Scalability of FOWT (multiple units in farms- risk of systemic fault) vs oil & gas (few large moored assets)
- Focus in reducing mooring systems complexity
- Current costly/inadequate wear design strategies:
  - Accounting for spares
  - Inspection and replacement operations
  - Requirement for topside facilities to support in-situ replacement

Operational Experience

- Several cases of excessive wear above estimations, leading to midlife preemptive replacement, redesigns and rebuilds.
- Some systems presenting very high wear after a single storm situation.

Interlink wear in mooring chains

Bushings- Lug bearings

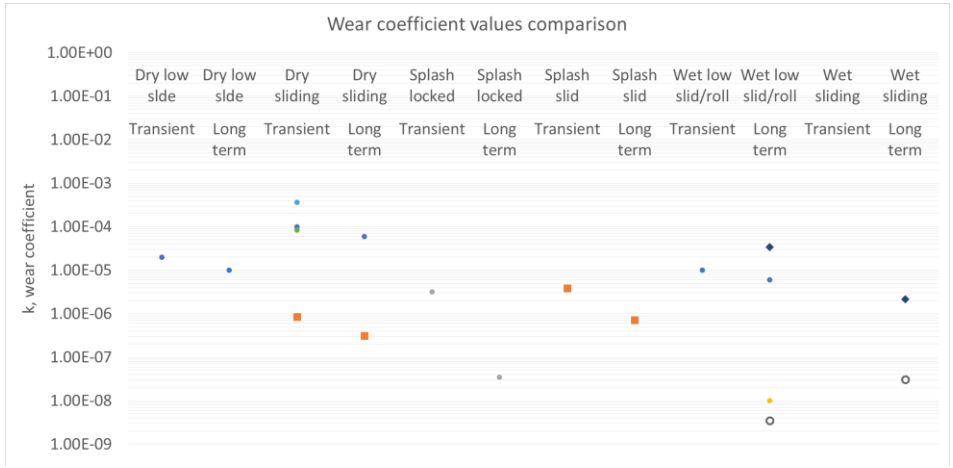
Knowledge Status

In the previous JIP it was not possible to continue to full testing and qualification of fully submerged interlink wear.

Calculations have been performed using several different theories (analytical and numerical) with differing results without sufficient demonstrated accuracy.

Estimation accuracy is impaired by:

- Need for Mooring analysis dedicated results. Need to generate mooring line angle and tension time-series with adequate conservatism.
- Excessive scatter of published theoretical and experimental results.
- Accuracy of contact surface and wear volume shape estimation.



Knowledge Gap

Initial knowledge gaps observed:

- Need to updated wet contact wear coefficient- with adequate understanding of expectable in-service tension load ranges / mean loads.
- Need to improve other calculation parameters accuracy e.g. contact surface and wear volume shape estimation.
- Establish a calibrated calculation procedure- guideline.

DNV and AMOG Track Record

- DNV own and operate a chain testing rig perfectly suited for wear testing
- AMOG led the initial ground-breaking research into chain wear during the SCORCH JIP including full-scale chain wear tests
- Both organisations have provided expertise and advice to operators on real-world chain wear issues

JIP- Proposal

Investigation into chain interlink wear in submerged conditions and bearing in mooring system conditions:

Phase 1: State-of-the-art and gap analysis and Development plan

Review of the state-of-the-art in terms of:

- Testing results.

- Applicable theoretical base.

- Excessive wear cases .

Define a theoretical and testing development program.

Phase 2: Development

- Theoretical/numerical/analytical studies. Calibration based on actual cases and testing.

- Testing.

Phase 3: Proposal of wear estimation guideline

Potential Plan Details

Physical Testing

- Testing of mooring chain in wet conditions
  - Small and large chain tests
- Testing of lug bearings in wet conditions – mooring system typical load/movement conditions
  - Bearing types/materials/specs to be further detailed
- Consider influence of parameters such as:
  - Chain material/grade
  - Tension
  - Variation of angle ranges
  - Angle ranges
  - Angular velocity
  - Transient loading / wear regimes / evolution of wear geometry
- Document wear progression for evaluation of worn chain link geometry

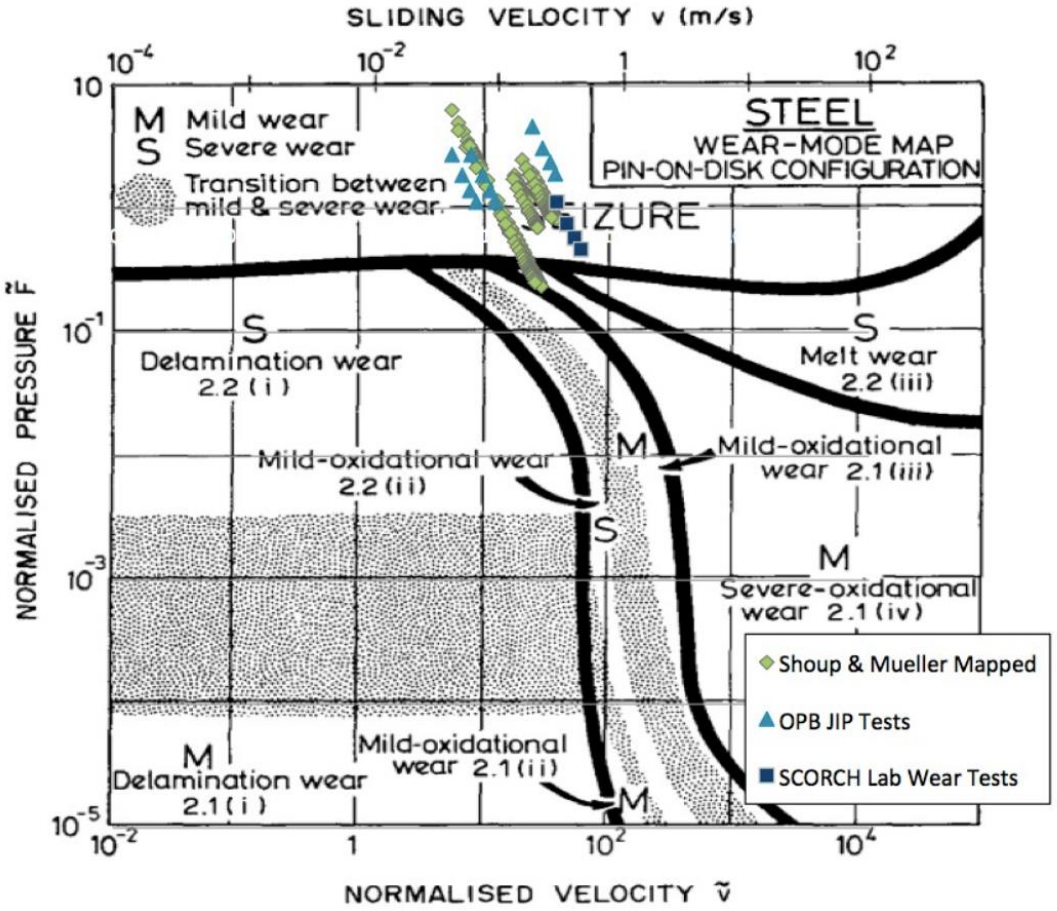
Potential Plan Details

Numerical/analytical studies:

- Comparison of wear theories/models
- Analysis of rolling/sliding threshold
- Calibration with in-service cases applying test results

Analysis of different wear regimes based on pressure and sliding velocity

- Develop a wear mode map specific to chain link contact
- Analysis of worn geometry – development of wear over time, how does it evolve?
- Analysis of test data vs in-field data
  - Industry collaboration: seek in-field data involving significant chain wear issues
  - 3D scanning, material tests of recovered chain



Pin on disk wear mode map

Expected Budget and Proposed plan

Minimum required funds: $1.5M USD (Minimum set of testing- lower range of chains diam.)

Yearly or milestone-based fee

Expected to obtain the interest of:

- Mobile offshore unit operators
- Permanent mooring installations
- FOWT stakeholders

Plan Estimate

- Potential kick-off: Mid 2024
- Phase 1: End of 2024
- Phase 2: 1 year- 2025
- Phase 3: Wear estimation guideline: Mid 2026

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Welcoming your comments!

Thank you for your attention

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