Innovative inspection, monitoring, and analysis techniques to provide integrity assurance

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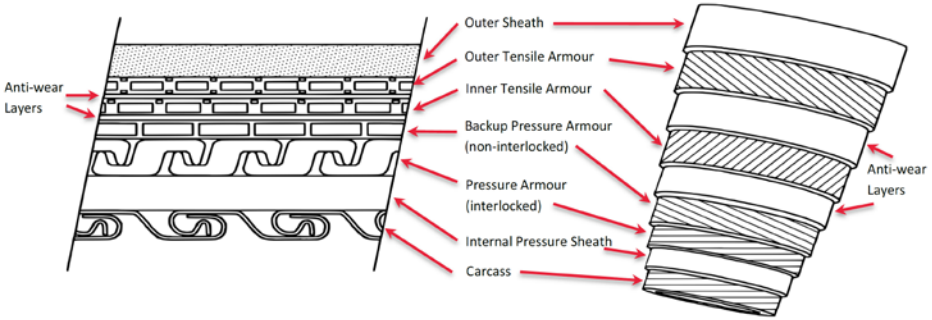
Ian MacLeod	Wood	Engineering Manager
Toby Rider	CNRI	Technical Integrity Team Leader

Overview

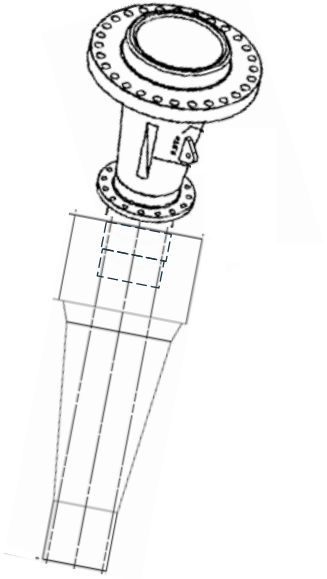
- Background – Example Riser Configuration
- Riser Assurance Activities
- Advanced FE analysis
  - Confirm ongoing risk management
- Monitoring / inspection program
  - Various techniques
- Pipe inspection / dissection

Background – Example Riser Configuration

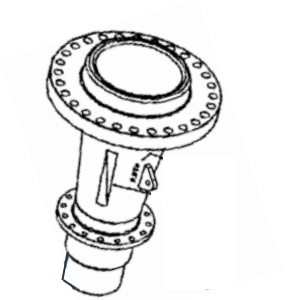
Riser Structure (Ref. API RP 17B)



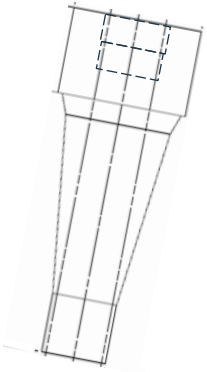
Combined Bend Stiffener & Anchor



Bend Stiffener Anchor (steel)



Riser Bend Stiffener (PU)



Riser Assurance Activities

Objective: validate armour wire integrity on all risers

Pressure testing tends to be considered:

- Flexible pipe structure redundancy in armour wires
  - ~150 tensile armour wires with code utilisation 0.67
- Early breaks / initiation may not be identified using this method

BHGE MAPS® inspection

- Can identify **any** unloaded (broken) wire within scan range

Assurance Methods - Inspection

MAPS inspection

- Seeks to identify % armour wire breakage on a flexible riser

Where issues exist, options are:

- Repeat MAPS inspection to verify data
- Consider access restrictions
- Physical inspection
  - Look for physical displacement
  - Hang-off deck, rope access, drone deployment
- Monitoring System
- Verify potential failure mechanisms / risks

Drone / UAV inspection

Easy to Perform on **Opportunistic Basis**

- Best quality / resolution versus previous approaches

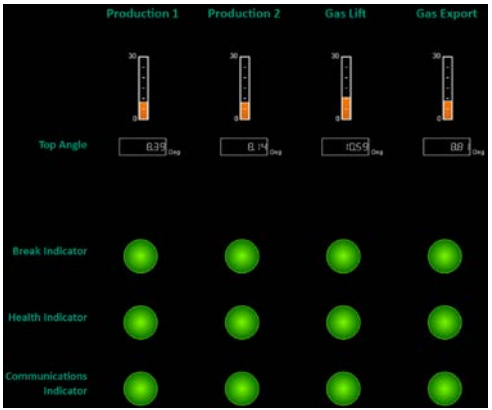
Previous Approaches Used:

- Rope Access Inspection
  - Circumstances may mean additional risk (and restrictive mitigations)
  - Personnel / time / cost implications
- Inspection from deck above
  - Poor quality survey due to sub-optimal view

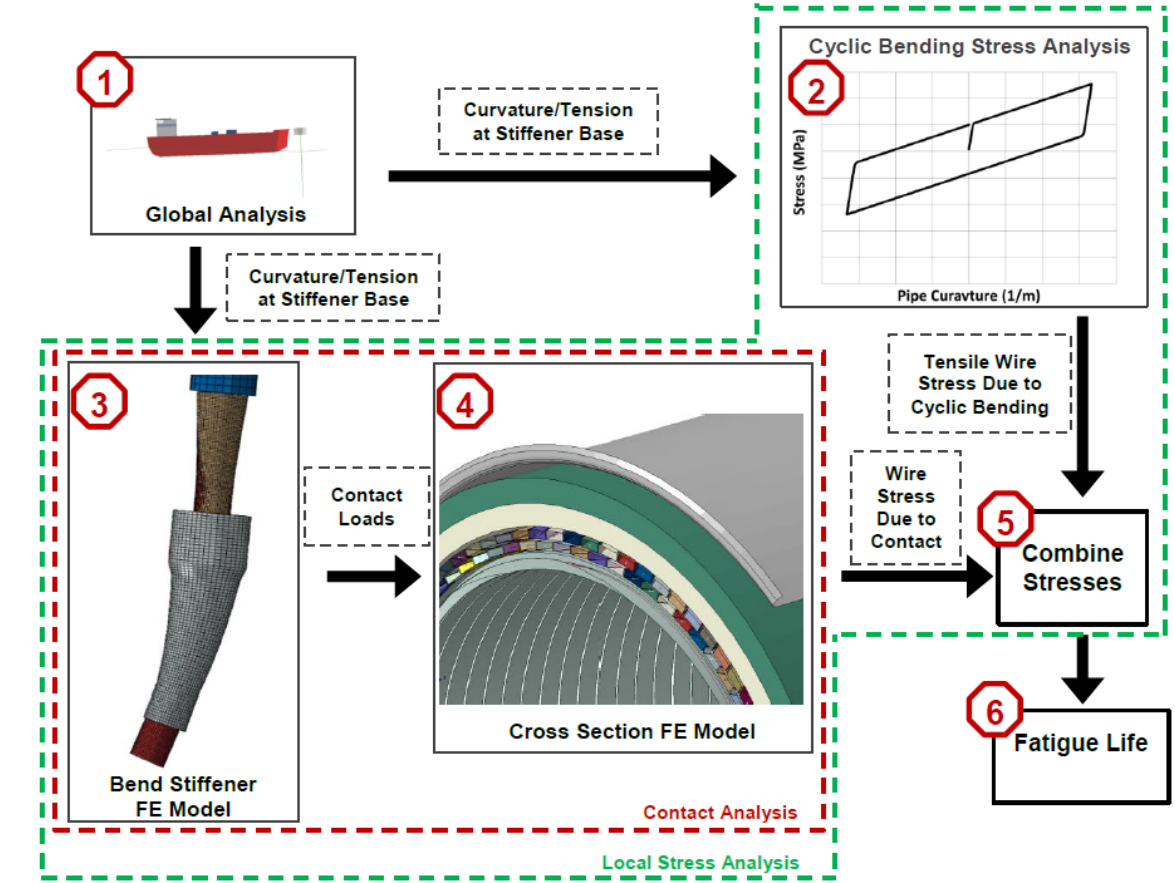
Drone / UAV inspection

Potential Wire Break Detection / Monitoring

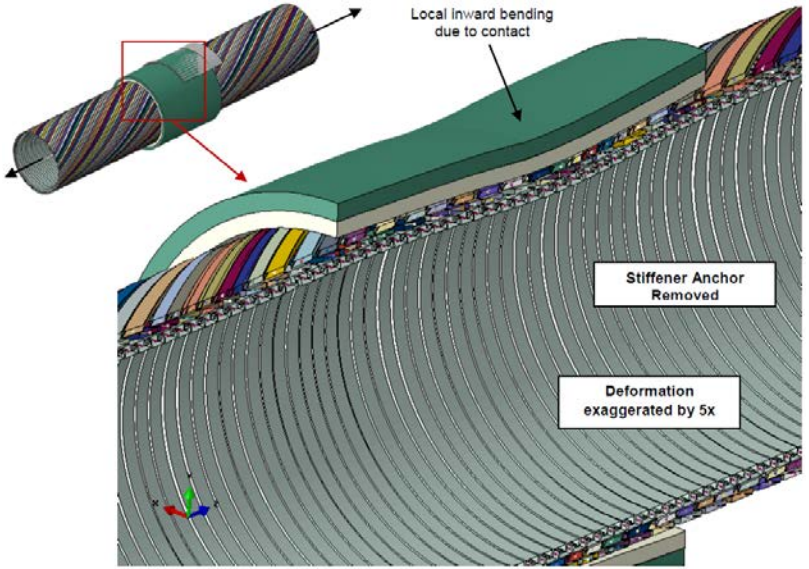
- Detection of potential wire break events
  - Acoustic and accelerometer based system (Pulse)
- Need to consider baselining any new monitoring system
  - establishing of thresholds and known/baseline
- If monitoring system identifies wire break event
  - Verification by MAPS inspection and enact response
- No confirmed breaks to date

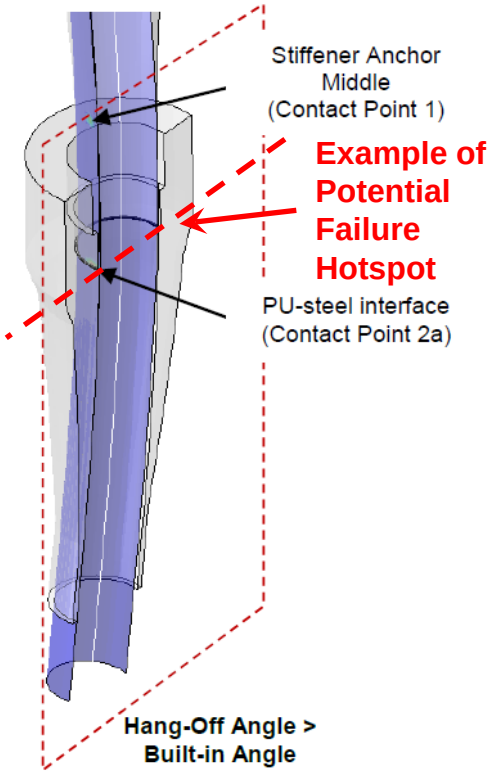


Advanced FE Analysis Methods



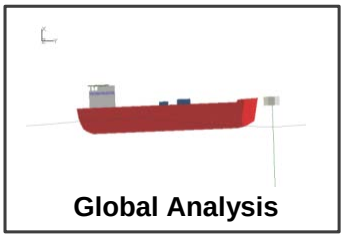
Advanced FE Analysis – Fatigue Assessment





Advanced FE analysis – Individual Wire Breaks

Environmental Conditions
Internal Fluid
Vessel Offset

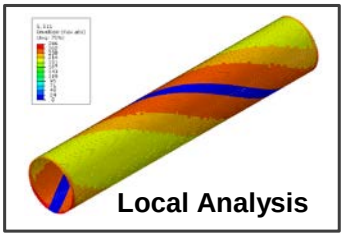


Global Analysis

Effective Tension at Hang-off

Internal Pressure

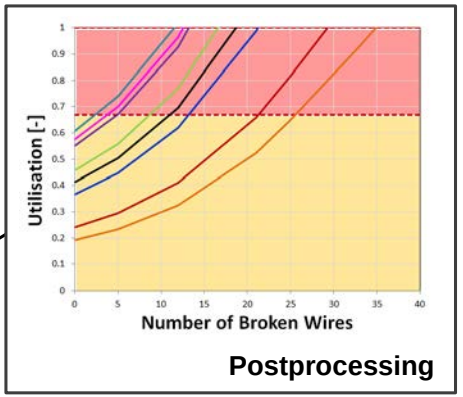
True-Wall Tension



Local Analysis

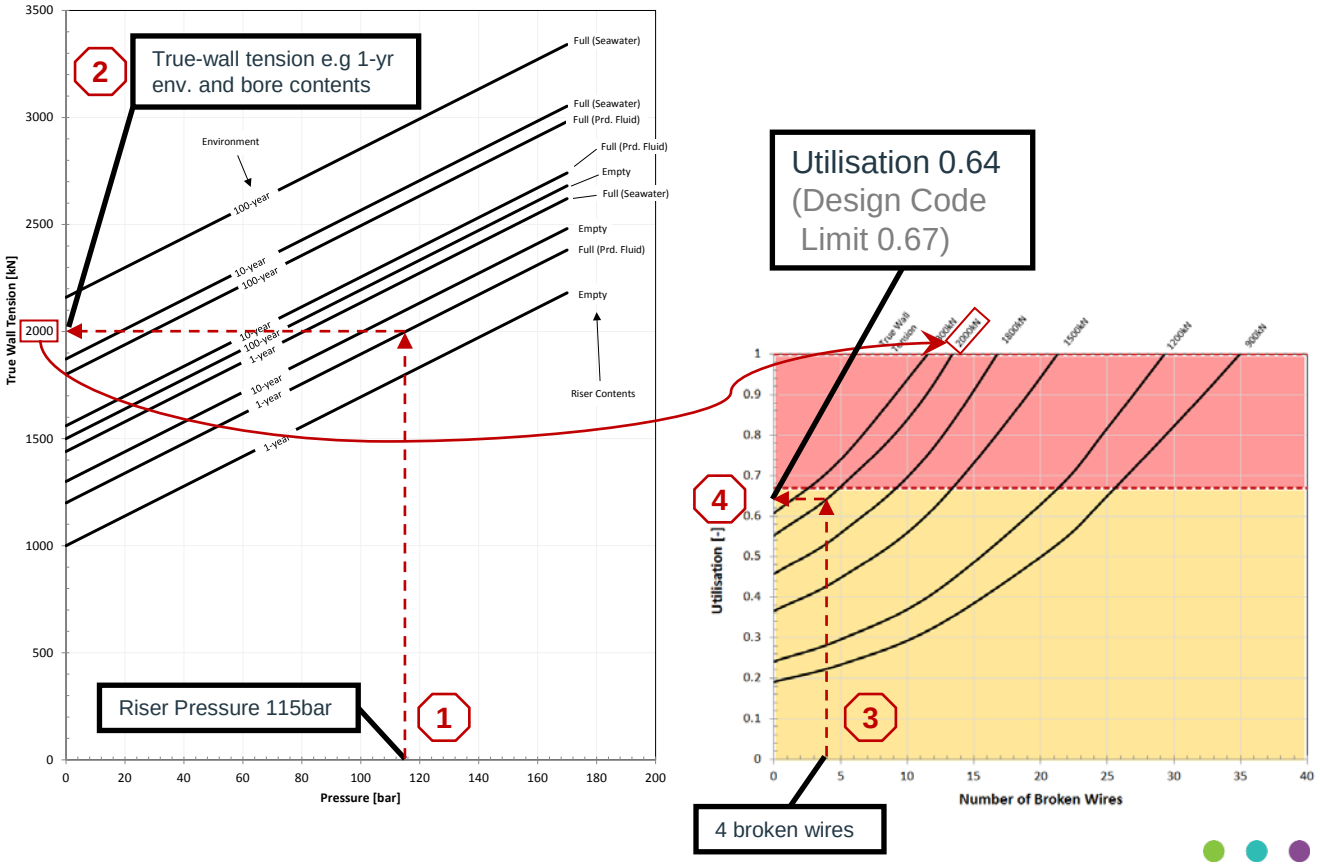
Number of Wires Broken

Wire Stress for Various Riser Operating Scenarios



Postprocessing

Advanced FE Analysis Output **Example**



Finite Element Analysis Summary

- When contact stresses are excluded from model:
  - Fatigue life effectively infinite
  - Aligned with original design approach / results
- When local interface contact stresses included
  - Calculated life can be reduced by **orders of magnitude**
- In a non-operating production riser application
  - For example stabilised crude versus gas lifted production
    - Hang-off loads will increase
  - Further reduction in calculated life by factor of ~4
- With limited wire breaks, risk may be managed

Pipe inspection / dissection

- Sample flexible riser section obtained

- Further development activities:
  - Blind testing
    - Various inspection techniques applied by vendor with zero knowledge of wire condition in sample
  - Dissection, further validate;
    - mechanism / in-service inspection / blind testing

Conclusions

- Consider operating conditions in fatigue design
- Ensure all local interfaces are assessed in design
- Ensure assurance measures mitigate specific threats
  - i.e. not generic / “off the shelf”
- Where risks justify, investigate and deploy inspection / monitoring techniques
  - early identification of degradation prior to a failure
  - consider alternative / novel inspection
  - limited previous drone inspection of flexible risers

Canadian Natural

wood.

Thank you.

Questions?