Life Extension of Dynamic Flexible Risers A Case Study

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Outline

- Introduction
  - Current Status
  - Life Extension Overview
  - Flexible Risers
- Case Study
  - Scope
  - Methodology
  - Life Extension Assessment
- Discussion
  - Key Considerations
  - Other Possible LE Threats
- Summary and Conclusions

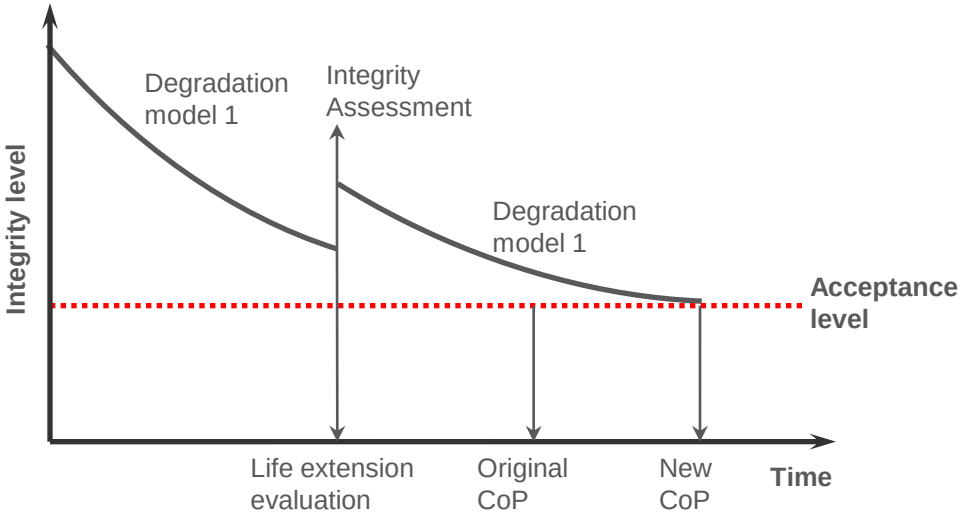
Introduction

- Current Status
  - Increasing number of pipelines in the North Sea approaching or exceeding their design life
    - May be suitable for further operation
    - Formal assessment required to confirm fitness for purpose

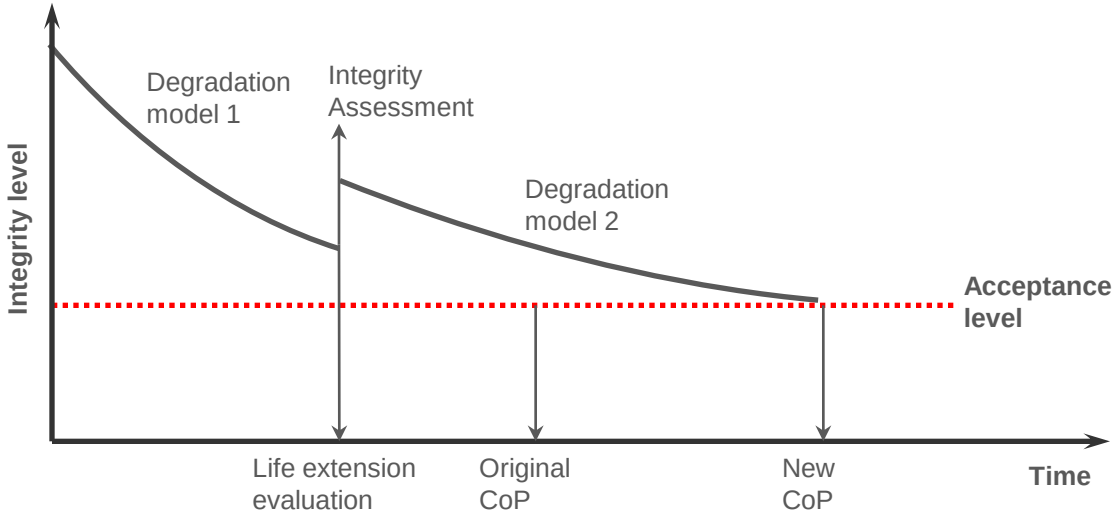
Life extension

- documented justification for operating system beyond its original design life [Norsok Y-002]
- process to evaluate if LE of a facility and its SSC is acceptable with respect to technical and operational safety [Sintef A15322]

Introduction (cont'd)



LE using same degradation model and Current condition assessment
[Norsok Y-002]



LE using new degradation model (new industry practice or operating conditions)
[Norsok Y-002]

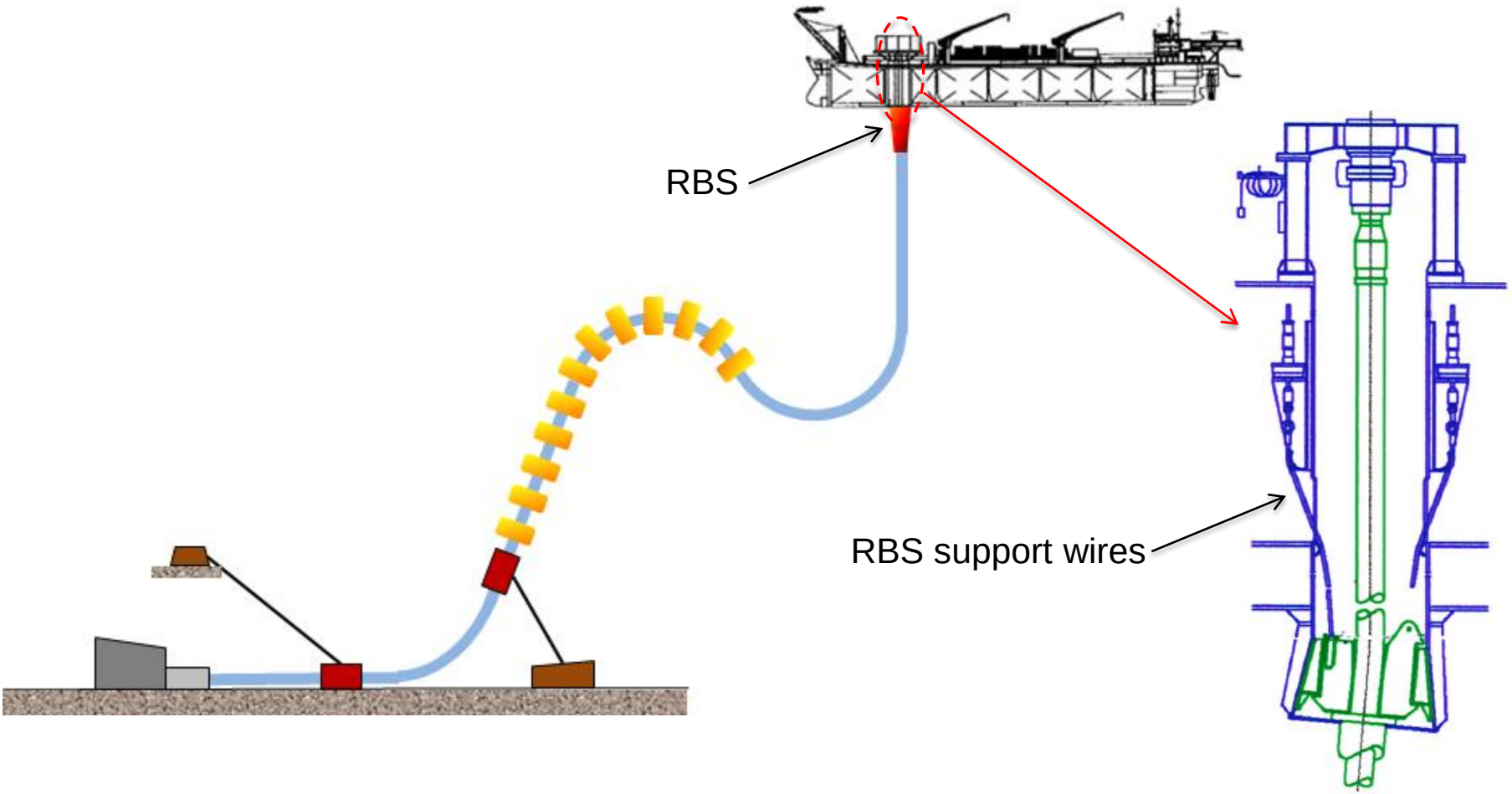
Introduction (cont'd)

- Flexible risers
  - Multi-layered structures
    - Different materials / specific threats
    - Bespoke ancillary equipment
    - Some operate in harsh environment
- Life Extension
  - Mainly based on design / IMR data
    - Limited inspection methods
  - Main concern internal sheath / armour wires
    - Driven by accepted degradation models

Case Study

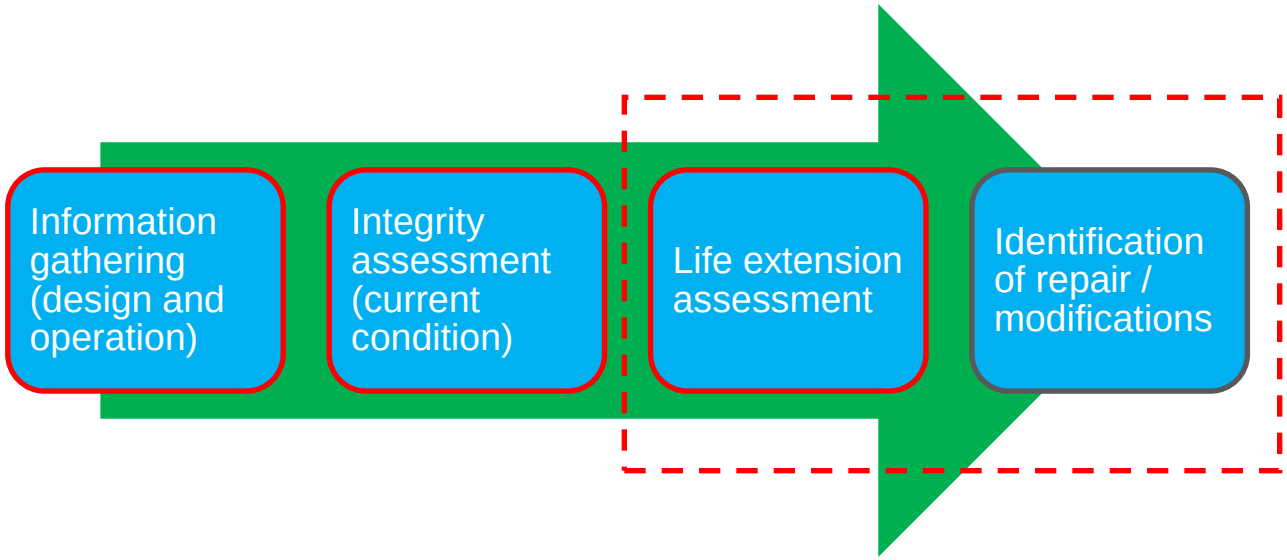
- Field Overview
  - North Sea (UKCS)
    - Deep water
  - Turret-moored FPSO with flexible risers
    - Design life 25 years
- Scope of Work
  - 10 dynamic risers approaching end of design life
    - ×1 WI, ×1 Gas, ×8 production
    - 2 of the risers replaced during first 13 years
    - 5 out of 6 prod. risers flooded (since installation)
  - Further operation period 7 years

Case Study



Case Study (cont'd)

- System break down
  - Layer by layer approach (+ end fitting)
  - Ancillary components considered separately
- Life extension
  - Long term prediction of likely degradation threats
  - Industry practice: API 17B / Sintef A15322

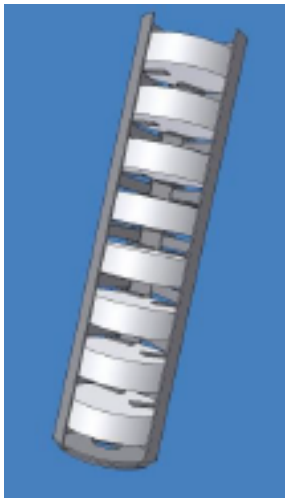


Carcass (Duplex)

- Credible life extension threats
  - Pitting (H_2S)
  - Thinning (erosion)
- PoF
  - Low (prod/gas, no carcass in WI)
    - H_2S < material limits, dry gas
    - Sand levels < design limits
    - Jumper dissection OK
- Recommendations
  - Ongoing IMR
  - Erosion calculations (target rate) to confirm when thickness will reach minimum allowable

Pressure Sheath (PA-11, HDPE)

- Credible life extension threats
  - Ageing embrittlement
    - PA-11 (prod/gas): physical + chemical ageing
    - HDPE (WI): physical ageing only
- PoF
  - Low for prod/gas
    - Low operating *t,* 17TR2 analysis >100 years
    - Jumper dissection showed no concerns
  - Medium for WI (no coupons)
- Recommendations
  - Ongoing IMR
    - Ensure enough coupons until new CoP
  - Ageing validation for HDPE



Armour Wires (Carbon Steel)

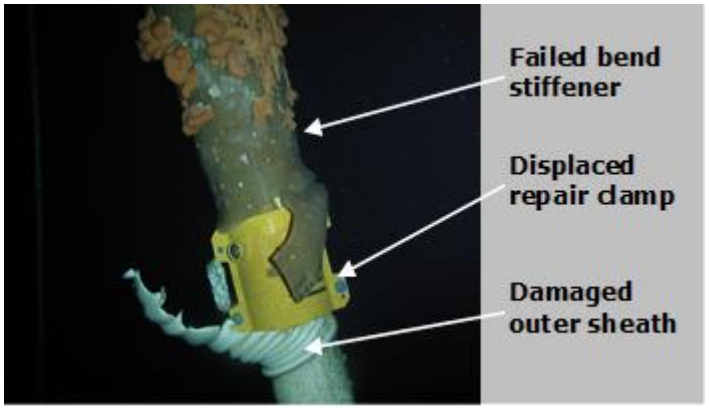
- Credible life extension threats
  - Fatigue (dry), C-F (flooded)
- PoF
  - Low (dry)
    - Fatigue life > 100 years
  - Medium (flooded)
    - C-F life = original CoP + 9 years
    - Known damage locations clamped
    - Minimal general wall loss expected (CI)
- Recommendations
  - Ongoing IMR (inc. repair clamps)
    - Remove redundant shackles
  - CP assessment

Anti Wear Tapes (PA-11)

- Credible life extension threats
  - Wear
  - Embrittlement (cracking)
- PoF
  - Low (>100 years)
    - Based on pressure sheath
    - Worst case flooded risers
    - Low operating bore *t*
    - Dissections showed wear not a concern
- Recommendations
  - Ongoing IMR

Outer Sheath (PA-11)

- Credible life extension threats
  - Rupture (inadequate venting)
  - Ancillary equipment failure
- PoF
  - Low (prod/gas, venting)
    - Regular RAVT / vent system CVI
    - Assuming shackles removed
  - Medium (all, ancillary equipment)
    - See ancillary equipment
- Recommendations
  - Ongoing IMR
    - Riser + ancillary equipment!

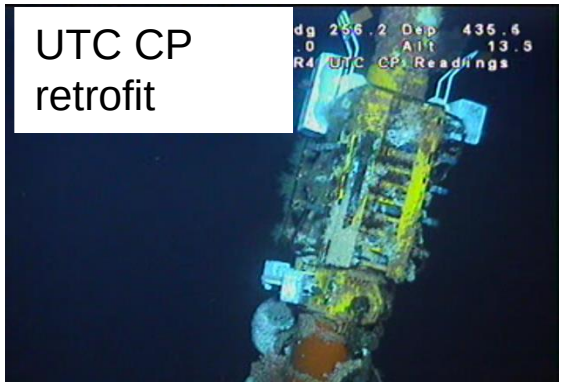


End-fitting

- Credible life extension threats
  - Marine corrosion
- PoF
  - Low
    - Ni-based coatings have proven to be effective
    - Industry experience shows no concerns
    - Dissections showed no concerns
- Recommendations
  - Ongoing IMR

Ancillary Equipment

- Credible life extension threats
  - Corrosion / fatigue
- PoF
  - Medium (hold down/back system)
    - Historical CP issues (all rectified)
    - Fatigue assessment only until CoP
  - Low (RBS + support wires)
    - Sufficient fatigue life for RBS
    - Regular replacement of wires
- Recommendations
  - Ongoing IMR
  - HD/HB fatigue assessment using new MetOcean data



Case Study – LE Risk Summary

Component	P1	WI	P2	P3	P4	Gas	P5	P6	P7	P8
Flexible pipe section c/w end-fittings										
Carcass	L	N/A	L	L	L	L	L	L	L	L
Internal sheath	L	M	L	L	L	L	L	L	L	L
Armour wires	M	L	M	L	L	L	M	M	M	L
Anti-wear tapes	L	L	L	L	L	L	L	L	L	L
Outer sheath	M	M	M	L	M	L	M	M	M	M
End-fittings	L	L	L	L	L	L	L	L	L	L
Ancillary equipment										
RBS + RBS wires	L	L	L	L	L	L	L	L	L	L
Hold back system	M	M	M	L	M	L	M	M	M	M
Hold down system	M	M	M	L	M	L	M	M	M	M

NB:

1. Good quality IMR data
2. No gaps in operational data
3. Full history of repair & modifications
4. Lessons learnt from dissections

Relatively new risers with design life > new CoP

Discussion

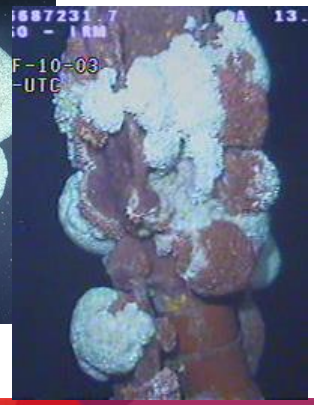
- Key considerations
  - Data availability/quality/confidence (DFI, IMR)
    - Key input into LE process
    - Lack of data/confidence → conservative assumptions
    - Includes history of repair and modifications
  - Industry experience
    - Experience from similar equipment
      - SureFlex JIP / retired pipe dissections
  - Knowledge transfer
    - Standard assumption – transfer of knowledge from retiring personnel and during change of ownership

Discussion

- Key considerations (cont'd)
  - IMR
    - No reduction assumed in capability to monitor, assess, and maintain the risers (PoF impact)
    - Any major change in operating/environment conditions will require LE revisit (degradation model)
  - Riser ancillary equipment
    - RBS cannot be repaired in service
      - Consider fatigue life in conjunction with riser fatigue life
    - CS repair clamps may require CP retrofits / change-out
    - CP system
      - Option 1: anode assessment + CP retrofits
      - Option 2: GVI/CP + repair clamps

Discussion

- Other possible LE threats
  - External sheath embrittlement
    - Insulation from RBS / clamps
    - Ageing → cracking
    - Mitigation: improved design/material
  - Marine Growth
    - Reduced buoyancy (LP coral, 3 Te/m^3)
    - Altered catenary → sheath damage
    - Mitigation: GVI + MG removal
  - Outer sheath abrasion
    - Abrasion at J-tube exit / touch-down
    - Annulus flooding → reduced fatigue life
    - Mitigation: GVI / improved design



Summary & Conclusions

- Case study
  - LE assessment of 10 dynamic risers c/w ancillary eq.
  - Layer-by-layer approach + ancillary equipment
  - Risk assessment based on long-term prediction of credible degradation mechanisms
  - LE possible (min 9 years, corrosion fatigue)
- General
  - Flexible riser LE requires specialist knowledge
  - LE mainly based on design / IMR data
  - Industry experience / dissection is a key input
  - Ongoing IMR required during further operation period to ensure acceptable integrity level

Acknowledgements

- Mark Murray
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