TECHNICAL PAPER

Threat Based Approach for Inspection and Repair Solutions to Extend the Life of Flexible Risers

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Threat Based Approach for Inspection and Repair Solutions to Extend the Life of Flexible Risers

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Agenda

- Introduction to Un-Bonded Flexible Pipe
- Failure Modes and Incidents Statistics

- Flexible Riser Threats (Failure Modes)
  - Detection
  - Monitoring
  - Repair

- Life Extension
  - Event Based Re-Assessment
  - Re-Assessment of Initial Design Assumptions

- Wrap-Up
Annulus – Space between two extruded polymer fluid barriers

Protects the armour wires which are not corrosion resistant (Carbon Steel)
Riser Failures and Damage Incidents Statistics
UK and Norway

Source: UKOOA

Learn more at www.2hoffshore.com
Flexible Riser Threats

- Each Layer has Failure Modes -> Threats

- Failure Modes highlighted at Design Stage (Develop Inspection Plan)

![Diagram of inspection/monitoring process]

Inspection/Monitoring Plan

Engineering Review
Actions Proposed?

Inspection/Monitoring

Confirm Integrity and Ongoing Management Strategy

Learn more at www.2hoffshore.com
Flexible Riser Threats In Operation

- Temperature
  - Affects Pressure Sheath Layer (Polymer)
  - Too High Might Lead to Loss of Structural Capacity
  - Too Low Might Lead to Reduced Elasticity

- Rapid De-Pressurisation
  - Might Lead to Collapse of Carcass (Multi-Layer Pressure Sheath)
  - Might Lead to Blistering of Pressure Sheath

- Follow Design Operation Instructions
Threats
Detection – Inspection – Monitoring – Repair

- Outer Sheath
- Tensile Armour Wires
- Pressure Wires
- Pressure Sheath
- Carcass
Outer Sheath – Detection – Inspection – Monitoring – Repair

- **Characteristics**
  - Most External – Environmental Barrier
  - Robust Polymer, approx. 8-14mm thick

- **Threats**
  - Breach causing Flooded Annulus
  - Flooded Annulus Causing Wires Corrosion
  - Venting Ports Blockage Causing Burst

Learn more at www.2hoffshore.com
Annulus Testing

- Test the Integrity of Layer
- Post Installation – Define a Starting Point
- Regularly Scheduled (Yearly)
- Fluid Volume in the Annulus
- Confirm Correct Venting Operation (blockage)
- Positive (Low) Pressure or Vacuum
Outer Sheath – Detection – Inspection – Monitoring – Repair

- Can be Directly Inspected

- General Visual Inspection (air or subsea)

- Focus on Damage
  - Can be Confirmed with Annulus Testing

- Ancillary items can be included in inspection
Outer Sheath – Detection – Inspection – Monitoring – Repair

- Automated Annulus Testing (Live Results)
  - Installed on Topside Venting Ports
  - Free Volume Estimation
  - Checking of Venting Ports Blockage
  - Identify Outer Sheath Breach

- Allows Early Repair

Learn more at www.2hoffshore.com
Outer Sheath – Detection – Inspection – Monitoring – Repair

- Clamp Installation on Outer Sheath Breach Location
  - Stop Fresh Seawater Ingress
  - Stop Oxygen Come In to the Annulus
  - Arrest Corrosion of Carbon Steel Wires

- Direct Repair (Dry Riser)
  - Polymer Welding/Refilling
Characteristics
- Provides Tensile Capacity
- 1 or 2 Pairs of Helically Crosswound Layers
- Carbon Steel Wires
- Material Selected based on Sour/Sweet Op. Fluid

Threats
- Corrosive/Aqueous Annulus
- Corrosion resulting Fatigue

Learn more at www.2hoffshore.com
Tensile Armour Wires – Detection – Inspection – Monitoring – Repair

- Direct Inspection not Possible

- Ultrasonic
  - Armour Wires Thickness Measurements
  - Requires Annulus to be Flooded (Couplant)
  - Confirm annulus is Flooded/Unflooded

- Radiography & Eddy Current
  - Detect Disarrangement of Wires
  - Detect Irregularities, Defects (Cracks)
  - Not Possible to Detect Flooded Annulus

Radiography of Riser Cross Section
Source: REL JIP

Learn more at www.2hoffshore.com
Tensile Armour Wires – Detection – Inspection – Monitoring – Repair

- Sensors
  - Acoustic Can Detect Breakage Signals of Armour Wires
  - Motion Can Detect Small Torsion Changes
  - Measure Steel Strain

- Connection via Optical Fibres

Strain Gauging
Source: Pulse Structural Monitoring
Pressure Wires – Detection – Inspection – Monitoring – Repair

- **Characteristics**
  - Provides Hoop Strength
  - 2 Helically Wound Overlapping Wires
  - Carbon Steel Wires

- **Threats**
  - Corrosive/Aqueous Annulus
  - Corrosion Leads to Wire Fatigue
  - Unlocking Might Cause Loss of Hoop Strength
Pressure Wires – Detection – Inspection – Monitoring – Repair

- Direct Inspection not Possible

- Radiography & Eddy Current
  - Detect Disarrangement of Wires
  - Detect Irregularities, Defects (Cracks)
  - Not Possible to Detect Flooded Annulus

Radiography of Riser Cross Section

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Pressure Wires – Detection – Inspection – Monitoring – Repair

- Sensors
  - Measure Steel Strain

- Connection via Optical Fibres

Strain Gauging
Source: Pulse Structural Monitoring
Pressure Sheath – Detection – Inspection – Monitoring – Repair

- Characteristics
  - Sealing Layer
  - Continuous Extruded Polymer Tube Over the Carcass
  - Polyamide / Polyvinylidene Fluoride (PVDF)
  - Polyethylene (PE) / Cross Linked Polyethylene (XLPE)

- Threats
  - Polymer Degradation Might Lead to Loss of Containment
Pressure Sheath – Detection – Inspection – Monitoring – Repair

- Direct Inspection not Possible

- Coupon Sampling Placed on Fluid Stream
  - Removed for Testing

- Destructive Testing
  - Mechanical Properties
  - Identify Premature Degradation

- Must be Considered at Design Stage

*Pressure Sheath Section on End Fitting*

Source: REL JIP

Learn more at www.2hoffshore.com
Carcass - Detection - Inspection - Monitoring - Repair

- Characteristics
  - Provides Collapse Resistance
  - Single Helically Wound Shaped Wire
  - Stainless Steel
  - Compatible with bore fluid

- Threats
  - Collapse
  - Internal Bore Erosion/Corrosion

Source: API 17B

Learn more at www.2hoffshore.com
Carcass – Detection – Inspection – Monitoring – Repair

- Direct Inspection by Running a pig in the Bore
  - Internal Visual Inspection
  - Production Halted

Learn more at www.2hoffshore.com
Flexible Riser – Alternative Inspection Method

- Computerised Tomography (CT)

- High Resolution Image
  - Real Time Results

- Wall Thickness Map

- Including Bore Contents
  - Deposits or Hydrates

- Limited Track Record (New Tech.)

Source: Tracerco
Life Extension – Event Based Re-Assessment

- Identified Through Integrity Assessment
- An Event may Result in Limited Life
  - Ex.: Outer Sheath Breach, Blocked Venting Ports, Loss of Buoyancy Modules
- Repair or Re-Instatement May Extend Life
- Update Global and Local Models and Assess Remaining Life

Source: NORSOK

Learn more at www.2hoffshore.com
Life Extension – Re-Assessment of Original Design Assumptions

- Identified Through Inspection and Monitoring
- Reduced Conservatism from Design Phase Based on Recorded Conditions
  - Environment
  - Operating
  - Vessel Motions
  - Annulus

- Update Global and Local Models
- Assess and Extend Life?
Wrap-Up

- Understand Threats at Design Stage
- Clear Plan for Inspection/Testing/Monitoring
- Refine Strategy as Time Goes – It is a Continuous Process

- Mitigation, Intervention or Repair Can Extend Life
- Recorded Data Beneficial to Performing a Life Extension
- Analysis Based on Gathered Data to Reduce Conservatism

- Life Extension Possible – Use Information Gathered
Questions?

Thank you for your attention!

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