Flexible Pipe Integrity Assessment
An Alvheim Case Study
04.12.2019
Subsea Integrity Management – A Full Time Job

AkerBP Subsea Assets

- 582km Pipelines
- 60 XT’s
- 15 Manifolds
- Umbilicals
- Power cables
- Fibre optic cables

AkerBP Subsea Engineers with Industry Support
Greater Alvheim Area Field Developments
Alvheim Subsea Integrity Management

Greater Alvheim Area Field Developments

Neil Addison – Subsea Engineering Manager
Planned Subsea Integrity Management Activity – 4th June 2019

Alvheim Mid Water Arch

- Risk – loss of buoyancy due to flooded buoyancy tanks.
- Activity – Flooded member detection of each buoyancy tank to confirm no compromise of integrity.

Not what we expected…
Initial Response

Complex Integrity Issue

Make Safe and Prevent Escalation

- Flexible risers shut in (well isolation and riser base valves closed) and depressurised.
- Standing instruction on FPSO to restrict headings above East Mid Water Arch
- Flexible risers secured within the riser tray guides.
- Umbilical secured to installation guide and still operational.
- Upended East Mid Water Arch secured with secondary tether.
Project Reimagine

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re·imag·ine (verb): rē-i′-ma-jan
Definition: to imagine again or anew:
    to form a new conception of:
    RE-CREATE
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Subsea Execution

Replacing Failed Tether and Reinstate Design Configuration.
Path to Restart

Multiple Workstreams

Preparedness & Response Strategy

Governance

- Risk Assessment & Basis Dossier
  - Root Cause Analysis
  - Anomalies
    - FMECA studies
    - Fitness for Service
  - Verification
  - Integrity Management

- Operational Risk Assessment
  - Asset risk assessment
  - Synergi deviation
  - Barrier viewpoint
  - Temporary Instruction

- Rectification Handover Dossier
  - Completed procedures
  - Test records
  - Management of Change

Restart
FMECA and Fitness for Service

«AkerBP Smart Subsea tool»

- Risk assessment
- FMECA
- Knowledge
- Compliance

Alvheim Mid Water Arch and Flexibles «graph»

- Sheath
- Unlock
- Fatigue
**Potential for Unlocking of Pressure Layer**

**Finite Element Analysis**

- Risers bent beyond the allowable dynamic and storage minimum bending radius.
- Risers resting and bent around installation guide tubulars.
- Risers passed leak test.
- No inspection tooling available for inspecting condition of pressure armour layer.
- Finite Element Analysis to understand expected condition of armour layer.
  - No unlocking in analysis when bending against narrow support.
  - Ovalization “saves” the pressure armour extrados
  - Pressure armour ring collapse the governing failure mode
- Finite Element Analysis supported by full scale bend tests and high accuracy offshore bending and ovality data.
Potential for Unlocking of Pressure Layer

Full Scale Bend Tests

Final Destructive Test with Safety Factor 2.5
Potential Fatigue of Armour Wires

**Analysis**
- Original Equipment Manufacture Fatigue Analysis
- Supported by Finite Element Analysis approach

**Field Inspection**
Pressure Sheath and Outer Sheath

Monitoring Annulus During Leak Test

Monitoring Annulus During Down-ending Mid Water Arch

Accumulated vented volume (litres)
Pressure Sheath and Outer Sheath

Monitoring During Operation

- Monitoring flexible riser ‘health’ on a daily basis

Machine Learning

- Need to recognize deviation from «normal»
  - Input process parameters (valves, chokes, temperature, pressure)
  - Other relevant input (waves, vessel motions, air pressure….)
  - Model vent rate
  - Model vent composition

Improved Diagnostics
Ongoing Integrity Management

System Monitoring Hardware

Gaining Knowledge

- Acoustic depth sensors
- Sonar
- Motion Response Units on mid water arches.
- Fatigue counter
Key Learnings

- Industry collaboration – Flexshare
- Acknowledge today's “state of the art” (computational power)
- Product robustness and governing failure modes
- Updated Design Basis
- Improved hydrodynamic coefficients & models
- High value in measured responses / data
- Corporate knowledge

Thank you

Official opening at Alvheim in 2008 – Reimagined!!
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