Goliat Bonded offloading hose; integrity management, inspection, experience transfer & learning

Olaf Døble, 4.12.2019
Agenda

- The Goliat offloading hose
- Integrity management
- Inspection
- Failure case
- Experience transfer and learning
Goliat offloading hose

- API 17K
- Hose diameter 500mm (20”)
- 28 (29) elements
- 12.2 meter section
- Length 354 meter
- Design loads:
  - Internal pressure
  - External pressure
  - Tension
  - Temperature
  - Reeling
  - Bending moment
  - Lifetime-integrity
  - Fatigue of a complex build-up
**Integrity management planning**

**Offloading Hose Specification**
- Inspection frequency shall be such that potential defects are identified before there is any risk of loss of integrity
- what can go wrong?

**Failure modes**
- External damage
- External wear
- Kinking and over-bending
- Tensile failure
- Corrosion

**Failure drivers**
- Handling
- Interference
  - FPSO bilge box interference
  - Mooring line interference
  - Drifting object interference
- FPSO bilge box interference
- Tanker bow interference
- Excessive loads during hose replacement
- Excessive tension interference
- External environment
- Corrosive media in the hose
- External environment
- Drifting objects on the sea

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<tr>
<th>External damage</th>
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<td>Fatigue in metallic liner</td>
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<td>Fatigue in end fitting including welding to piping</td>
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<td>Excessive Pressure</td>
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<td>Elastomer degradation</td>
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Possible failure modes; extensive testing

- Fatigue
- Kinking and overbending
- Crushing
- Tensile strength
- Tension and bending
- Burst pressure capacity
- Bonding failure
- Ovality

Fatigue test at Marintek

Tension and bending test at NLI
Inspection and monitoring

- External inspection with camera
- RFID identification (yellow ring)
- Internal inspection, camera/video
- Oil spill detection:
  - CCTV in tanker bow
  - CCTV in FPSO hang of area
- FPSO hang off loads
- Bow Loading System (BLS) tension
- Flow measurement on FPSO and shuttle tanker
- Visual inspection
Damage mechanism

- Stresses in outer steel cords at nipple end
- Radial stresses in rubber with beginning delamination outside nipple
Length measurement for segment 1-18
**Status today**

- Stable situation since August 2017
- spare hoses available
- DNVGL involved and agreed with the modifications
- Well known replacement method
- Known failure mechanism
- Partial replacement possible without production interference, but subject to weather and preparation activity.
- 100% visual inspection
- Length measurement of the first 18 segments
- Knocking test randomly
- Decided to change supplier
  - Qualification of prototype is ongoing
  - Different design
Experience transfer and learning

• Technical
  • Reeling is now part of API 17K certification
  • Rubber creep can damage hose at the end-fitting
  • Long time vertical hanging out of the hose can contribute to creep at the hose ends
  • Action to reduce the load have shown effect
    • removed one hose element
    • reel out, transfer, reel in and store the hose with oil, not with water
  • 10 years lifetime of existing hose could not be obtained
  • Expensive and time consuming inspection with existing hose

• Competence
  • DNVGL, Contractors and suppliers
  • Experience personnel from 4subsea
  • Close cooperation with the partner Equinor; involved in meeting, invited to failure investigation etc.
Thank you for your attention!