New Technology on Aasta Hansteen
Deepwater Pipeline and Catenary Risers

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Presentation Overview

Subsea 7 on Aasta Hansteen
Bubi mechanically lined pipes
SCR welding technology
Deepwater structure installation
Subsea 7 technology on Aasta Hansteen

Reeled installation of Bubi mechanically lined flowlines
Flowline and SCR fabrication and welding technology
Deepwater installation in harsh environment
Bubi mechanically lined pipe

Tecknology Background
Bubi technology
Feasability Test – Analysis and Full scale reeling tests
Technology Background

Reel-Lay

- Cost efficient
- Fast lay method
- Suitable for deep water lay
- Onshore fabrication (QA/QC)
- Extensive track record

BuBi® Pipe

- Cost efficient
- Availability
- Choice of CRA liner material
- Good pipe end tolerances
- Extensive subsea track record (S-lay, Bundles)
Reelable Mechanically Lined Pipe

- Combination of advantages from Reel-Lay and BuBi technologies
- Cost efficient solution for transport of corrosive fluids in most deep water conditions
- Short lead time (compared to clad) and good availability
- Option for deep water Steel Catenary Risers
- Driven by growing market demand and cost focus
BuBi Manufacture – by Butting

Hydro-forming process

Schäferpresse
Post manufacturing Bubi pipe

- Inner liner has hoop compression and outer backing steel has progressive variation from hoop compression to tension.

- Small thinning of wall thickness is expected due to hydraulic expansion process.
Feasibility Test

Prediction of wrinkling by preliminary FEA

Liner wall relative deviation

Longitudinal strain
Full Scale Reeling Simulation

- With and without applied internal pressure
- 15m diameter
- 3 x bending/straightening cycles
- Applied strain: up to 2.2%
- Test show good correlation with FE analysis
Inspection and Testing

- X-ray testing of the liner weld and girth weld in the reeled condition
- Survey of the liner-pipe
- Dye-penetrant testing at internal surface, liner weld and girth weld
- Tensile tests acc. API
- Charpy impact tests (V-notch at –30°C) acc. to DIN EN 10045-1
- Hardness tests acc. to DIN EN ISO 6507-1 (Vickers)
- Corrosion tests of liner and girth weld acc. to ASTM G48, G28, ASTM A262
- Metallographic examination

All results are acceptable
Fatigue Test Results

8 ins. Dia. X65, 625 Liner

Test results

Nominal Outer Wall Stress Range, MPa vs. Endurance, cycles

Class C Target
Class C/2 Target
Class D Target
Class E Target
Class C Design
Class C/2 Design
Class D Design
Class E Design
RF1
RF2
RF3

RF1
RF2
RF3

1,000
100
10
10,000
1,000,000
10,000,000
10,000,000,000

1,000,000
10,000,000
100,000,000
1,000,000,000

10,000,000
100,000,000
1,000,000,000
10,000,000,000

10,000,000
100,000,000
1,000,000,000
10,000,000,000
Conclusion

• FEA model has been developed and validated through comparison with actual test results
• Installation procedure including the use of internal pressure has been fully developed and independently qualified
• Without on-set of wrinkling, the possibility of cyclic fatigue damage is negligible and the post reeled lined pipe pass Resonance Fatigue Tests with DNV F1 classification.
• Inspection procedure developed and qualified by DNV
• Successfully completed DNV-RP-C203 ‘New Technology Qualification’ and was granted ‘Certificate of Fitness for Service’ by DNV.
• Qualified by Statoil’s technology qualification programme
Conclusion

2011 – Guara-Lula Award
2012 - Pipeline Industry Guild Award
2012 – ASME Award
2013 – Aasta Hansteen Award
SCR welding technology

Specifics of fabrication of SCRs for reel-lay installation
High integrity welding solution
Fatigue performance
Fabrication of SCRs for Reel-ay Installation

Pre-requisites for SCR fabrication include:

- Close control of pipe end tolerances and joint alignment
- High integrity welding procedures
- Flush grinding of weld caps
- Additionally for clad and lined pipe:
  - Provision of internal gas purge
  - Weld metal strength may give partial over match or fully under match conditions
  - Austenitic weld metal requires specific AUT procedures
  - Internal camera/laser inspection to confirm weld root quality
High Integrity Welding Solution

- Proven and established Hot wire PGTAW welding solution
- Process established for reelable carbon steel SCRs and clad flow lines
- High integrity welds possible with satisfactory mechanical properties
- Overmatching weld strength achieved in clad pipe as a result of plastic straining during reeling
- AUT inspection using multi-probe pulse echo technique
High Fatigue Performance

- PGTAW welds in clad pipe Grade 415 263.5mm ID x 21.5mm WT with 3.0mm thick Alloy 825 liner
- Welds tested with flush ground caps in the reeled condition
- Around Class B fatigue performance achieved – life limited by parent pipe

S-N curve showing all unfailed test welds plotted using average nominal outer wall stress range.
What is new from a marine installation perspective?
Deepwater combined with Harch environment
Challenges from a marine operations point of view

- Water depth (1300m)
  - Resonance during lowering of structures
  - Increased weight of lifting wire
- Harsh environment
  - Strong current and deep water column
  - Sea states with larger waves than southern fields
Harsh environment - challenges

- Combining the current velocities of the southern North Sea with the wave heights of the Norwegian Sea
- Strong current variations through water column – difficult to predict
- A traditional approach to the design criteria (1-year Hs and 10-year current profile) may cause increased waiting on weather compared to similar operations on other fields

<table>
<thead>
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<th>Field</th>
<th>1-year Hs (m)</th>
<th>10-year Hs (m)</th>
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<td>Ormen Lange</td>
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<tr>
<td>All year</td>
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<td>13.9</td>
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<tr>
<td>Spring</td>
<td>9.3</td>
<td>11.4</td>
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<tr>
<td>Summer</td>
<td>5.8</td>
<td>7.1</td>
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<tr>
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<tr>
<td>All year</td>
<td>14.3</td>
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<tr>
<td>Spring</td>
<td>11.2</td>
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<tr>
<td>Summer</td>
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<td>Snøhvit</td>
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<tr>
<td>All year</td>
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<tr>
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<tr>
<td>Summer</td>
<td>6.2</td>
<td>8.0</td>
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Harsh environment – meeting the challenges

- Robust solutions with respect to operational windows
- Active use of monitoring equipment, also current velocity through the water column
- Evaluate the right return period for design data
- Reduced conservatism in analysis combined with real-time monitoring of conditions
- Improved alpha factor

![Graph showing horizontal distance from touchdown vs. water depth]

<table>
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<th>Operational Period (h)</th>
<th>$H_s = 1$</th>
<th>$1 &lt; H_s &lt; 2$</th>
<th>$H_s = 2$</th>
<th>$2 &lt; H_s &lt; 4$</th>
<th>$H_s = 4$</th>
<th>$4 &lt; H_s &lt; 6$</th>
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<td>0.95</td>
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</tr>
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</table>

According to Table 4-1 or Table 4-2 as applicable
Universal Launch Assistant

- Tugger winches and deck handling are often the limiting factor during a structure installation
- Effective control and dampening of loads
- Increased control during over-boarding phase
- Increased seastate and reduced weather risk
Resonance in lifting wire

- Mass and added mass important parameters with respect to resonance
- Preliminary studies (simplified and SIMO) indicates that this may be an issue for the Aasta Hansteen manifold
- Possible resonance will be remediated by activating the AHC system
- Important to know when to expect resonance
  - CFD analyses to obtain a reliable estimate on the added mass of the manifold
Conclusions

- New challenges related to Deepwater developments in Norwegian conditions
- Highly technology driven project – importing technology and adjusting to Norwegian Conditions
- Cost and safety focus drives smart solutions
- There is a solution to every challenge