Agenda

The New Subsea7
Description of BuBi\textsuperscript{R} Mechanical Lined Pipe
Overview of Reel Lay Installation method
Development programme
Installation methodology
Current Status
Our new beginning

A combination of Acergy and Subsea 7, two very strong subsea companies, that have come together to create a global leader in seabed-to-surface engineering, construction and services.
Subsea 7 Methods of Pipelay

S-lay

Reeling

J-lay

CDTM
Subsea 7 – Asia & Middle East Pipelay Capability

S-lay & J-lay of pipelines in Asia & Middle East is through our Joint Venture Company, SapuraAcergy and the Sapura 3000:

- 240 Tonnes S-lay
- 400 Tonnes J-lay
- First deep water project in Malaysia (S-lay) – Murphy Kikeh
- Work ongoing on second deep water project (S-lay and J-lay), Shell Gumusut Kakap
BuBi® Mechanical Lined Pipe is a cost effective solution where CRA materials are required.

Proven track record for S-lay, J-lay and CDTM

Extending the applicability to Reeling will have a positive impact on the economic viability of some offshore development projects.
Material price comparison based on 20 miles length.
Description of BuBi\textsuperscript{R} Mechanical Lined Pipe

- Carbon Steel outer pipe with a Corrosion Resistant Alloy liner
- Assembled by Hydraulic process
Description of BuBi® Mechanical Lined Pipe

Material options

<table>
<thead>
<tr>
<th>Carbon Steel</th>
<th>Rp 0.2 [MPa]</th>
<th>Rm [MPa]</th>
</tr>
</thead>
<tbody>
<tr>
<td>API X52</td>
<td>360</td>
<td>460</td>
</tr>
<tr>
<td>API X60</td>
<td>415</td>
<td>520</td>
</tr>
<tr>
<td>API X65</td>
<td>450</td>
<td>535</td>
</tr>
<tr>
<td>API X70</td>
<td>485</td>
<td>570</td>
</tr>
</tbody>
</table>

Example of material options

<table>
<thead>
<tr>
<th>Cladding</th>
<th>Rp 0.2 [MPa]</th>
<th>Rm [MPa]</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.4858 / 825</td>
<td>240</td>
<td>500 - 700</td>
</tr>
<tr>
<td>2.4856 / 625</td>
<td>276</td>
<td>690 - 890</td>
</tr>
<tr>
<td>1.4539 / 904L</td>
<td>220</td>
<td>520 - 720</td>
</tr>
<tr>
<td>1.4404 / 316L</td>
<td>220</td>
<td>520 - 670</td>
</tr>
</tbody>
</table>
Description of Mechanical Lined Pipe

- Pipe Sizes and wall thickness options.

![Graph showing producible size range in grades X52 up to X80. Detailed information on request.](image)
Construction Process for BuBi® Pipe

1. Outer Pipes
   - Seamless or welded
   - Cutting of pipes to required length
   - Goods inward inspection
   - Shot blasting
   - Drying
   - Assembly
   - Hydrostatic pressure test
   - End preparation for seal welding or weld overlay
   - Final beveling and sizing of pipe ends
   - Final cleaning
   - Marking and packing

2. Inner Pipes
   - Longitudinally welded
   - Pipe from coil
   - Heat treatment
   - Cutting of pipes to required length
   - Hydraulic expansion
   - Square cutting of ends
   - Welding or weld overlay of pipe ends
   - Non-destructive testing
   - Dimensional check
   - Despatch

- Pipforming and longitudinal welding
- 100% Eddy current testing
- Mechanical and corrosion testing
Assembly Process

Hydraulic expansion press (Schäferpresse)
Reel Lay Installation

Port Isobel Spool Base – Gulf of Mexico
Development Programme

**Objective:**
Demonstrate that installation by Reel Lay will not wrinkle the pipe or have an unacceptable impact on the mechanical or corrosion resistance properties required for its intended service.

**Phase 1**

**Test a** – Simulated reeling trials of pipes without internal pressure.

**Test b** – Simulated reeling trials of pipes with internal pressure

10ins.Dia, X65 outer pipe15.09 + 3mm Alloy 825 liner
Test a – No internal pressure

FE Analysis - wrinkle prediction performed on pipe with no internal pressure.
Simulated reeling test rig.
Bend Radius 7.5 mtrs.
Herriot Watt University Scotland.
Test a – No Internal Pressure

Wrinkles recorded in line with FE Analysis.
Test b – With internal pressure

FE Analysis - wrinkle prediction performed on pipe with internal pressure

No wrinkles measured
Further Development – Phase 2

- Testing of different pipe sizes & liner materials
- Demonstration for low fatigue applications
- Enhanced FEA
Testing of different pipe sizes & liner materials

Phase 2

2010 Scope (completed)
Simulated Reeling trials with internal pressure
  8 ins dia. X65, Alloy 625 & 316L (no girth weld)
Depressurisation Test
Fatigue Testing – Strip & Full scale
DNV Qualification – DNV RP – A203
Testing of different pipe sizes & liner materials

Depressurisation Test
Enhanced FEA

BUBI PIPE STAGES SHOWING MECHANICAL GRIP FROM 30 BAR PRESSURE DURING REELING

- **Start**: Shot blasted carbon steel
- **Telescopied**: Liner inserted 6mm gap
- **Hydroformed**: Liner expansion at 1200 bar
- **Coated**: Coating at 240°C ~ 40µm gap
- **Installation**: 30 bar for Reeling
Pipeline Inspection – 2000 readings every 20mm along the pipe

Pipe Wall Deviation Along Pipe 262 (12 o'clock)

Bore measurements taken to record any change during o/a process and provide inputs to FE model.

On Manufacture at Butting
Prior to simulated reeling
Following Simulated reeling
Post fatigue testing
Fatigue Testing – Strip Test

40M cycles and no failure at 60MPa on 2 post reeled sample.
Fatigue Testing – Full Scale Resonance Test

Fatigue test was taken to a stress/no. of cycles as per the DNV 30.2 F1 Curve

<table>
<thead>
<tr>
<th>Stress range, MPa</th>
<th>Design life (F1), cycles</th>
<th>Target life (F1), cycles</th>
</tr>
</thead>
<tbody>
<tr>
<td>180</td>
<td>85,740</td>
<td>293,424</td>
</tr>
<tr>
<td>120</td>
<td>289,372</td>
<td>990,307</td>
</tr>
<tr>
<td>60</td>
<td>2,314,975</td>
<td>7,922,458</td>
</tr>
</tbody>
</table>

All samples showed no defects which could be attributed to the fatigue testing

NDE (AUT, X-ray and Dye Penetrant testing) and Sectioning was performed to confirm integrity of the clad weld to liner interface
Testing

Dye- penetrant testing to check for defects on liner longitudinal, overlay and Girth welds.
X-ray of longitudinal, seam and girth welds.
Tensile test of both materials.
Charpy V notched impact tests at -30oC on the carbon steel
Hardness testing on X65 and the Alloy 625
Metallographic examination of the seal weld area
G48 Corrosion tests carried out at 50oC, on Alloy 625 liner
G28 Intergranular corrosion (Method A)
Installation Methodology

Key objective:
Maintaining internal pressure during the stalk reeling onto the vessel and installation.
Installation Methodology

PIG
MANIFOLD
END CAP

TIE IN SHED

Pig
End Cap

PIG
MANIFOLD
END CAP
Installation Methodology

- PIG
- MANIFOLD
- END CAP

TIE IN SHED

subsea7
Installation Methodology

PIG
MANIFOLD
END CAP

TIE IN SHED
Key procedures:
- Straightening Trials
- Offshore tie – ins
- Offshore Emergency Abandonment
High Friction Pig Tests

The tests performed to date demonstrated that the high friction pig could be pumped into position and located accurately to the desired position in the pipeline.

Leak proof at 4 bar differential pressure – (tested over 12 hrs).

Consistent launch, running & reversal pressures recorded.
Safety

Risk assessment performed using the Shell software FRED (Fire, Release, Explosion and Dispersion).

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Mass Flow Rate (kg/s)</th>
<th>Maximum Force at Failure Location (N)</th>
<th>Force per Unit Area (N/m²)</th>
<th>Potential Distance of Horizontal Water Jet (m)</th>
<th>Minimum Duration of Release (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 mm leak</td>
<td>3.65</td>
<td>169.6</td>
<td>$2.2 \times 10^8$</td>
<td>65</td>
<td>32.1</td>
</tr>
<tr>
<td>50 mm leak</td>
<td>91.24</td>
<td>4,239.0</td>
<td>$2.2 \times 10^6$</td>
<td>65</td>
<td>1.3</td>
</tr>
<tr>
<td>Full bore Rupture</td>
<td>96.15</td>
<td>377.8</td>
<td>$1.5 \times 10^4$</td>
<td>5.5</td>
<td>1.2</td>
</tr>
</tbody>
</table>

All personnel within 10m of the reel, either deck level or at height, should wear normal suitable eye protection and safety clothing.
DnV Qualification

Qualification Work Process

1. Define Qualification Basis
2. Technology Classification
3. Failure Mode Identification and Risk Ranking
4. Concept Improvement
5. Selection of Qualification Methods
6. Probability of Success (PoS)
7. Analysis and Testing
8. Functionality Assessment

Milestones

- Phase I
- Phase II
- Phase III

DNV deliverables

1. Technology Assessment Report
2. Statement of Feasibility
3. Technology Qualification Plan
4. Statement of Endorsement
5. Technology Qualification Report
6. Statement of Fitness for Service

Certification: DET NORSKE VERITAS
CERTIFICATE OF FITNESS FOR SERVICE

Reliable Buried Lined Pipe System

This is our custom qualification of the Reliable Buried Lined Pipe System, which has been constructed in accordance with DNV OS-J102 Qualification Standards for New Technology. The system has been designed and tested according to the requirements of the DNV-OS-J102 standards. The system has been manufactured and tested by Subsea 7, ensuring compliance with all relevant regulations.

Technology Owner: Subsea 7 Ltd.
Name of Technology: Reliable Buried Lined Pipe System
Description: The system is designed to operate in severe subsea conditions, including high pressure and temperature, ensuring reliable performance under extreme conditions.

Application: Suitable for a wide range of subsea applications, including offshore oil and gas extraction, subsea infrastructure, and subsea pipeline systems.

Conditions and Limitations:
1. The system is designed to operate at temperatures ranging from -20°C to 120°C.
2. The system is designed to withstand pressures up to 100 MPa.
3. The system is designed to operate in water depths up to 3,000 meters.
4. The system is designed to operate in water temperatures up to 60°C.
5. The system is designed to operate in water salinity up to 500,000 ppm.

Design and fabrication requirements are met according to the applicable standards, including API 17J and DNV-OS-J102. The system has been tested in accordance with the relevant standards and has been approved for use in the offshore oil and gas industry.
Development Scope 2011

Reeling Trials on 12 ins. X65 with Alloy 625 liner.

Reeling Trials on 8ins. X65 with 316l liner

Full Scale fatigue testing on 8ins. X65 with Alloy 625 liner.

Reeling Trials on 12 ins. X80 with Alloy 625 liner.
Pre Salt - Guará and Lula

Submerged Buoy

70+ km of BuBi Mechanical Lined Pipe to be installed in approx. 2100 mtrs. Water depth
Conclusions

- Tests to date demonstrate no wrinkling occurs when reeling is performed with internal pressure.

- Installation of mechanical lined pipe by Reel Lay is achievable, safe and will offer significant economic advantages.

- DNV Qualified

- First project awarded