Development of Innovative Polymer-Alloys
- Thermal Insulation Systems for Deepwater Pipelines

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LOGSTOR Oil & Gas and Rosehill Offshore have decided to join forces to provide the market with new cost-effective Thermal Insulation Systems for Deepwater Pipelines.

This presentation will explain what are polymer alloys - manufactured by Rosehill Offshore and how they will be applied to the pipes – application by LOGSTOR Oil & Gas.

Main topics covered are:
• Who is LOGSTOR
• Who is Rosehill
• The Polymer Alloys, why, design, benefits and properties
• The range available for the market
• The application process
• The advantage of the system
LOGSTOR

- Headquarters in Denmark
- 1,500 employees – EUR 250M
- 8 plants in Europe, 1 in Asia, 2 mobile production units
- Over 5,000 km of insulated pipes every year
- More than 190,000 km of insulated pipes supplied to date
Rosehill Offshore

- Part of Rosehill Polymers Group
- Focus on one business: polymers
- At the forefront of polymer innovation
- Systems deployed across a range of industries
- Supply a range of products and materials for line assurance applications within the Oil and Gas industry
- Exciting new high temperature resistant systems up to 120°C Hot Wet
Polymer alloys – Why?

• Polyurethanes (PU) –
  Popular due to:
  ✓ Fast cycle times
  ✓ Easy application
  ✓ Properties (eg toughness)
  But...
  x Poor hot-wet performance

• Epoxies –
  Used for their:
  ✓ Good thermal performance (eg FBE as anti-corrosion on 3-layer PP pipes)
  ✓ Adhesion
  However..
  x Flexibility is limited
  x Application time is longer/more complex
Polymer alloys – **Design**

New Rosehill Offshore polymer alloys:

- Polyurethane-epoxy
- **Processing advantages and toughness** of polyurethanes
- **Temperature resistance and adhesion** of epoxies

The best of both worlds
Polymer alloys – Benefits

New Rosehill Offshore polymer alloys:

• Increased thermal resistance compared to PU (RS-3060 to 95°C & RS-3173 to 120°C)
• PU processing parameters - equipment, temperatures, cycle times
• Latent epoxy cure resulting in retention of toughness
• Excellent adhesion to a wide range of materials
# Polymer alloys – Properties

<table>
<thead>
<tr>
<th>Property</th>
<th>Test Specification</th>
<th>RS-3060</th>
<th>RS-3173</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Ambient Test Temp 23°C ± 2°C</td>
<td>Maximum rated Test Temp 95°C</td>
</tr>
<tr>
<td>Thermal Conductivity</td>
<td>ISO 8301 (FOX 50)</td>
<td>0.186 W/mK</td>
<td>0.186 W/mK</td>
</tr>
<tr>
<td>Specific Heat Capacity</td>
<td>ISO 12736</td>
<td>1.755 J/K</td>
<td>2.116 J/K</td>
</tr>
<tr>
<td>Water Absorption</td>
<td>ISO 12736</td>
<td>2.4% @ 12months</td>
<td>7.1% @ 12months</td>
</tr>
<tr>
<td>Density</td>
<td>ISO 1183</td>
<td>1150 kg/m³</td>
<td>1156 kg/m³</td>
</tr>
<tr>
<td>Tensile Properties</td>
<td>ISO 527</td>
<td>12.6 MPa</td>
<td>2.8 MPa</td>
</tr>
<tr>
<td>Hardness</td>
<td>BS ISO 7619-1:2004</td>
<td>95 Shore A</td>
<td>73 Shore D</td>
</tr>
</tbody>
</table>
Polymer alloys – Properties

1. Initial application
Mostly standard PU formation and crosslinking reaction to facilitate easy application and efficient cycle times

2. Storage & Deployment
Most epoxy groups remain dormant, however some epoxy curing takes place, ensuring retention of flexibility and toughness

Change In Properties of RS-3173 With Time At Different Storage Temperatures
Polymer alloys – Properties

3. In-service conditions
When exposed to temperature from hot oil, the latent epoxy mechanism is activated, providing enhanced thermal resistance.
Polymer alloys – Properties

4. Failure Mode
Hydrolysis of PU leads to decomposition products, some decomposition components help catalyse the latent epoxy cure and repair mechanism.

![Graph showing hydrolysis resistance over time](image-url)
The C-PiPe 120 DW – System for Deep Water

The C-PiPe 120 DW – Polymer Alloys System

- Anti-Corrosion coating layer – If required...
  - ✓ Typical single FBE layer as base case

- 1st Insulation layer / Thermal Barrier
  - ✓ Acts as Insulation and thermal barrier
  - ✓ Polymer Alloy Rosehill RS 3173
  - ✓ Thickness built to target interface temperature below 95°C
  - ✓ Typical thickness minimum 15mm

- 2nd Insulation layer (Thicker)
  - ✓ Polymer Alloy Rosehill RS 3060
  - ✓ Thickness build to achieve the project U-Value
  - ✓ Typical thickness 20mm - 60mm
Application Process

The pipe with or without anti-corrosion is placed in the customized mould #1.

The mould is closed and the pipe is ready for injection with the 1st layer – RS 3173.

The insulation material is injected in the mould filling the cavity between the mould and steel pipe.

The pipe is inspected and transferred to customized mould #2.

The pipe with 1st layer is placed in customized mould #2.

The mould is closed and the pipe is ready for injection with the 2nd layer – RS 3060. The insulation material is injected in the mould filling the cavity between the mould and the 1st layer.

The pipe is removed from the mould and inspected for defects; if necessary, defects are repaired. Pipe insulation is completed. Cutbacks are tailored to client requirements.
Test Plan & Current Schedule

Tests performed on applied raw materials.

• March 2016 – Proof of concept:
  ✓ Setup and commissioning mock-up plant in Denmark
  ✓ First injections
  ✓ Validate Proof of concept

• April 2016 – Basic testing phase:
  ✓ Basic tests completed as per the ISO 12736:2015.

• May / June 2016 – Full Scale testing:
  ✓ Launch full scale testing

• Summer 2016 : Product qualification subject to long term results (6 months later...)
Benefits (Commercial)

- **Material - The best of both worlds:**
  - Polyurethane-epoxy
  - Processing advantages and toughness of polyurethanes
  - Temperature resistance and excellent adhesion of epoxies

- **Cost effective insulation system:**
  - Fast application process (plant tailored from 2 to 4 pipes per hour depending on project schedule)
  - Marginal thickness increase compared to Syntactic 5LPP, but moulding allow tighter tolerances
  - Mobile plant in-country or at the spoolbase
  - Double-joints possible

- **Low risks process / No interface issue:**
  - Simple process
  - Customized cutback to tolerances and design
  - Same material on the field joints, bends, fittings...
  - Field joint 1 layer RS3173 or 2 layers system.
  - Solid material, no compression and no glass beads

Polymer Alloys as Anti-Corrosion Coating

- Due to the epoxy content of the Polymer Alloy the RS 3173 has excellent anti-corrosion properties.
- This allows to remove the FBE layer and reduce the costs for the pipeline coating.
- No FBE at Field Joint and permit faster cycle times.
- Plan is to test the material in line with the ISO 21809-1 and in cooperation with interested EPC’s and/or NOC/IOC’s.
Questions?

Thank You for attention

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