TenCoat™ Marine 5-Layer Syntactic Polypropylene (5LPP Syntactic)

TenCoat™ Marine 5-Layer Polypropylene is a high performance external coating developed to provide thermal insulation to tubular systems in deep water maritime environments.

The product can be supplied with the desired thickness and coating configuration in order to fulfill the requested thermal performance (during steady and transient states) and installation requirements of each project.

Typical field conditions where TenCoat™ Marine 5-Layer Polypropylene is used are temperatures ranging up to 140°C and water depths up to 3000 meters. Besides thermal properties, TenCoat™ Marine 5-Layer Polypropylene is able to supply excellent anticorrosive properties and mechanical resistance.

### Insulation properties

<table>
<thead>
<tr>
<th>PROPERTY</th>
<th>STANDARD</th>
<th>LAYER</th>
<th>UNIT</th>
<th>VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermal Conductivity</td>
<td>ISO 8301</td>
<td>Solid PP PP Syntactic</td>
<td>W/(m.K)</td>
<td>0.20 – 0.22 0.150 – 0.165</td>
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<tr>
<td>Specific Heat Capacity</td>
<td>ISO 11357 - 4</td>
<td>Solid PP PP Syntactic</td>
<td>J/(g.K)</td>
<td>1.8 – 2.4 (20°C – 80°C) 1.6 – 2.0 (20°C – 80°C)</td>
</tr>
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</table>

### Mechanical properties

<table>
<thead>
<tr>
<th>PROPERTY</th>
<th>STANDARD</th>
<th>LAYER</th>
<th>UNIT</th>
<th>VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peel Strength</td>
<td>ISO 21809 - 1</td>
<td>5LPP</td>
<td>N/mm</td>
<td>≥ 25 at 23°C ≥ 10 at 90°C</td>
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<tr>
<td>Compression Strength @ 10% strain</td>
<td>ISO 844</td>
<td>Solid PP PP Syntactic</td>
<td>MPa</td>
<td>≥ 25 ≥ 14</td>
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<tr>
<td>Compression Module</td>
<td>ISO 844</td>
<td>Solid PP PP Syntactic</td>
<td>MPa</td>
<td>≥ 900 ≥ 750</td>
</tr>
<tr>
<td>Tensile Strength at Break</td>
<td>ISO 527</td>
<td>Solid PP PP Syntactic</td>
<td>MPa</td>
<td>≥ 18 ≥ 6</td>
</tr>
<tr>
<td>Elongation at Break</td>
<td>ISO 527</td>
<td>Solid PP PP Syntactic</td>
<td>%</td>
<td>≥ 400 ≥ 100</td>
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<tr>
<td>Young Module</td>
<td>ISO 527</td>
<td>Solid PP PP Syntactic</td>
<td>MPa</td>
<td>≥ 900 ≥ 850</td>
</tr>
<tr>
<td>Adhesion Between Layers</td>
<td>Internal Procedure</td>
<td>Solid PP PP Syntactic – PP Syntactic</td>
<td>MPa</td>
<td>≥ 5 ≥ 5</td>
</tr>
<tr>
<td>Abrasion (ICS 17 Wheel / 1000 Cycles / 1 Kg)</td>
<td>ASTM D 4060</td>
<td>Solid PP</td>
<td>mg</td>
<td>≤ 30</td>
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<tr>
<td>Indentation</td>
<td>ISO 21809 - 1</td>
<td>Solid PP</td>
<td>mm</td>
<td>≤ 0.1 at 23°C ≤ 0.4 at 110°C</td>
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<tr>
<td>Hardness at 1 second</td>
<td>ISO 868</td>
<td>Solid PP PP Syntactic</td>
<td>Shore D</td>
<td>≥ 65 ≥ 55</td>
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<tr>
<td>Fatigue 0.2% Strain</td>
<td>ISO 12736 – Annex C</td>
<td>5LPP Syntactic</td>
<td>Cycles (No failures)</td>
<td>&gt;1,000,000</td>
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<tr>
<td>Reeling Test (Simulated Bend Test) Bend radius 7.0 m, Straightening radius: 31.1 m</td>
<td>ISO 12736 – Annex B</td>
<td>5LPP Syntactic</td>
<td>–</td>
<td>No defects</td>
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<tr>
<td>Impact Resistance</td>
<td>ISO 12736 – Annex E</td>
<td>5LPP Syntactic</td>
<td>kJ</td>
<td>≥ 12</td>
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<tr>
<td>Interlayer Ring Shear Test</td>
<td>ISO 12736 – Annex I</td>
<td>5LPP Syntactic</td>
<td>MPa</td>
<td>≥ 5</td>
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<tr>
<td>UV Resistance 5 GJ/m²</td>
<td>ISO 21809 - 1</td>
<td>Solid PP (Top coat)</td>
<td>% MFI</td>
<td>≤ 35 from original value</td>
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<tr>
<td>Heat Ageing</td>
<td>ISO 21809 - 1</td>
<td>Solid PP (Top coat)</td>
<td>% MFI</td>
<td>≤ 35 from original value</td>
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</table>

**Notes**

* Any additional property not listed, can be provided upon request.
* The nominal values informed herein should not to be considered as specification limits.
Physical properties

<table>
<thead>
<tr>
<th>PROPERTY</th>
<th>STANDARD</th>
<th>LAYER</th>
<th>UNIT</th>
<th>VALUE</th>
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<tbody>
<tr>
<td>Density</td>
<td>ISO 1183</td>
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<td>g/cm³</td>
<td>0.89 – 0.91</td>
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<td>PP Adhesive</td>
<td>Solid PP</td>
<td>0.89 – 0.91</td>
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<td>PP Adhesive</td>
<td>Solid PP</td>
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<td>Melting Point</td>
<td>ISO 11357-3</td>
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<td>°C</td>
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<td>PP Adhesive</td>
<td>Solid PP</td>
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<td>PP Adhesive</td>
<td>Solid PP</td>
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<td>Catholic Disbondment @ 48 hrs/90°C -3°C/-1.5V/NaCl(3%)</td>
<td>ISO 21809-1</td>
<td>3LPP</td>
<td>mm</td>
<td>≤ 3</td>
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<tr>
<td>Catholic Disbondment @ 28 days/20°C/-1.5V/NaCl(3%)</td>
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<td>Water Absorption (250 bar, 120°C, 125 days)</td>
<td>ASTM D 570</td>
<td>Solid PP</td>
<td>%</td>
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<td>PP Syntactic</td>
<td>%</td>
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<td>Tri-axial Creep (250 bar, 120°C, 125 days)</td>
<td>ISO 12736 – Annex A</td>
<td>Solid PP</td>
<td>%</td>
<td>≤ 0.5</td>
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<tr>
<td></td>
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<td>PP Syntactic</td>
<td>%</td>
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Track record

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<tr>
<th>Year</th>
<th>Project</th>
<th>Contractor</th>
<th>End Customer</th>
<th>OD [mm]</th>
<th>WT [mm]</th>
<th>Length [m]</th>
<th>Thickness [mm]</th>
<th>Max. Temp. [°C]</th>
<th>Installation method</th>
<th>U-value [W/m²°K]</th>
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<td>2012</td>
<td>Guara Lula</td>
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<td>Petrobras</td>
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</tbody>
</table>

*TenCoat™ Marine is the new branded name for Tenaris’s thermal insulation offshore solutions.
**This track record includes all oil and gas projects that Tenaris have supplied 5LPP Syntactic, either performing the coating at Tenaris’s facilities or at a subcontracted third party coating company.