Lightweighting & Fire Protection
For Composite Rail Applications
Solvay leads the way in the provision of structural and interior prepregs to the rail industry, supplying epoxy and phenolic resin systems formulated to comply with stringent fire requirements. Our portfolio includes a comprehensive range of processing consumables and tooling solutions, all of which are fully compatible with our prepregs.
Reduced weight lowers initial inertia, allowing higher speeds to be achieved quickly and efficiently. This also has the potential to reduce track load, decrease wear and lower trackside maintenance costs.

Our design, engineering and application support departments offer a unique service to assist customers in converting existing structures from current material configurations into weight-saving, cost effective prepreg formats.

A typical composite panel weighs
- 50% less than aluminum
- 80% less than steel

A Forward Thinking Approach
With our in depth understanding of the rail rolling stock market, Solvay is ideally placed to offer the correct materials from our range to meet any of the myriad of international fire regulations.

- Tooling materials for the manufacture of the tooling hardware necessary to form our prepregs
- Vacuum bagging consumables
- Adhesive films

Composite Materials
- Suitable for low cost vacuum bag processing, and press and autoclave molding
- Ease of use with a broad processing window
- Ideal for monolithic and sandwich structures
- Ideal for simple and complex shapes
- Provide an excellent surface finish
- Offer good mechanical performance
- Supplied across a wide range of fabrics and fibers
Composite Materials Product Selector Guide

Our MTM® prepreg technology allows for the manufacture of lightweight advanced composite panels for carriage interiors, and interior and exterior structural applications.

<table>
<thead>
<tr>
<th>Prepreg</th>
<th>Resin Type</th>
<th>Carriage Interiors</th>
<th>Exterior Panels</th>
<th>Structural Parts</th>
</tr>
</thead>
<tbody>
<tr>
<td>MTM® 82S-C</td>
<td>Phenolic</td>
<td>Yes</td>
<td>Yes</td>
<td>Limited</td>
</tr>
<tr>
<td>MTM® 29SFR</td>
<td>Epoxy</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>MTM® 348FR</td>
<td>Epoxy</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Applications

Carriage Interiors:
- Wall panels and partitions
- Window frames
- Connecting archways
- Floors, ceilings and decking
- Bulkheads and standbacks
- Luggage racks and compartments
- Seating and furnishings
- Hatches and doors
- Drivers’ cab instrument panels

Exterior panels and structural parts:
- Front end fairings
- Energy absorbers
- Doors and inspection covers
- Bogie debris inspection plates
- Stone guards
- Sundry interior and exterior structural parts
- Composite rooves and carriages
- Bogie leaf springs
- Bogie frames and fittings
- Tunnel reinforcement props and panels
- Fishplates

Fire Performance

MTM® 82S-C phenolic resin prepregs comply with:
- BS476 Parts 6 and 7
- BS 6853 Cat 1a
- NF P 92-501 Rating M1
- NF F 16-101 Rating F1
- DIN5510 Rating S4, SR2, ST2
- EN45545-2:2013, Categories HL1, HL2, HL3

MTM® 29SFR epoxy resin prepregs comply with:
- BS 6853 Cat 1b (exteriors)
- BS 6853 Cat 2 (interiors)
- DIN5510 Rating S4, SR2, ST2

MTM® 348FR epoxy resin system meets the requirements of:
- EN45545-2:2013, Category HL2
- ASTM E662-09
- ASTM E162-08
- ASTM E1354-08
- BSS 7239
Process Materials

We offer composite processing materials and consumables optimized for this market and which are completely compatible with our structural prepreg range.

Prepreg Processing

A select range of consumables for high temperature curing (over 212°F/100°C) includes:

- VACFILMTM 450V 338°F (170°C) vacuum bagging film
- High airflow breathers
- High temperature sealant tapes
- Quick release/high temperature peel ply
- Release films
- Flash tapes

Resin Infusion Processing

Unique consumables including INFUPLY, VMS3 and CW3 are designed to cater market requirements:

- Reduce labor costs
- Minimize the scrap rate
- Improve part repeatability

Value-Added Consumables & Engineering Solutions

We reduce the cost of resin infusion processing, by offering:

- Welded/tailored vacuum bags
- Combination assemblies of consumables to reduce lay-down time
- Reduce labor costs
- Reusable vacuum bags and kitted consumables

Process Materials Product Selector Guide

<table>
<thead>
<tr>
<th>Prepreg product</th>
<th>Bagging Film</th>
<th>Release Film</th>
<th>Sealant Tape</th>
<th>Peel Ply</th>
<th>Breather</th>
<th>Flash Tape</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>250°F (120°C)</strong></td>
<td><strong>Epoxy OOA</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>250°F (120°C)</td>
<td>VACFILMTM 450V</td>
<td>HS8171</td>
<td>A6000</td>
<td>LTS90B</td>
<td>A100</td>
<td>AB100</td>
</tr>
<tr>
<td>250°F (120°C)</td>
<td>STRETCH-VAC™ 3000</td>
<td>A2000</td>
<td>UCS180</td>
<td>B100</td>
<td>AB10</td>
<td>FT2</td>
</tr>
<tr>
<td><strong>350°F (180°C)</strong></td>
<td><strong>Epoxy OOA</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>350°F (180°C)</td>
<td>VACFILMTM 450V</td>
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<td>STRETCH-VAC™ 3000</td>
<td>A2000</td>
<td>UCS180</td>
<td>B100</td>
<td>AB10</td>
<td>FT2</td>
</tr>
<tr>
<td>Phenolic</td>
<td>VACFILMTM 450V</td>
<td>HS8171</td>
<td>A6000</td>
<td>SM5142</td>
<td>A100</td>
<td>AB40N</td>
</tr>
<tr>
<td>Polyester Infusion</td>
<td>VACFILMTM 200G</td>
<td>A2000</td>
<td>SM5142</td>
<td>60001</td>
<td>AB100</td>
<td>FT2</td>
</tr>
<tr>
<td>Polyester Infusion</td>
<td>VACFILMTM 300R</td>
<td>A2000</td>
<td>SM5127</td>
<td>G500</td>
<td>AB10</td>
<td>FT3</td>
</tr>
<tr>
<td>Polyester Infusion</td>
<td>VACFILMTM 400Y</td>
<td>A2000</td>
<td>SM5130</td>
<td>RS200</td>
<td>AB40N</td>
<td>FT4</td>
</tr>
<tr>
<td>Polyester Infusion</td>
<td>VACFILMTM 450V</td>
<td>A6200</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Polyester Infusion</td>
<td>VACFILMTM 800G</td>
<td>A2200</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Infuply (resin carrier) GFMT (bonding tape)
**Tooling**

Our tooling prepregs offer outstanding surface finish and longevity for the manufacture of complex mold tools. Our design service can support tool design optimization to ensure a fit-for-purpose solution. In addition we offer soft tooling technology including reusable vacuum bags, integral heater blankets, intensifiers and caulk sheets.

### Tooling Product Selector Guide

<table>
<thead>
<tr>
<th>Product Form</th>
<th>Out Life (days)</th>
<th>Service Temp. °F (°C)</th>
<th>Cure Flexibility/Recommended Cure °F (°C)</th>
<th>Cure Method</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CYFORM® 1-5-1</strong></td>
<td>3 to 4</td>
<td>356 (180)</td>
<td>40 hours at 95 (35) or 8 hours at 140 (60) Post-cure 15 minutes at 392 (200) plus 8 hours at 374 (190)</td>
<td>Autoclave</td>
</tr>
<tr>
<td><strong>CYFORM® 22</strong></td>
<td>3 to 4</td>
<td>350 (177)</td>
<td>168 hours at 68 (20) or 5 hours at 131 (55) Post-cure 5 hours at 390 (200)</td>
<td>Autoclave</td>
</tr>
<tr>
<td><strong>CYFORM® 777</strong></td>
<td>12 to 15</td>
<td>350 (177)</td>
<td>48 hours at 122 (50) or 3 hours at 194 (90) Post-cure 5 hours at 390 (200)</td>
<td>Autoclave</td>
</tr>
<tr>
<td><strong>DForm® Fabric</strong></td>
<td>3</td>
<td>356 (180)</td>
<td>8 hours at 140 (60) Post-cure 15 minutes at 392 (200) plus 8 hours at 374 (190)</td>
<td>Autoclave</td>
</tr>
<tr>
<td><strong>LTM® 12</strong></td>
<td>3</td>
<td>356 (180)</td>
<td>70 hours at 86 (30) or 5 hours at 158 (70) Post-cure 15 minutes at 392 (200) plus 8 hours at 374 (190)</td>
<td>Autoclave</td>
</tr>
<tr>
<td><strong>LTM® 16</strong></td>
<td>6</td>
<td>356 (180)</td>
<td>70 hours at 104 (40) or 4 hours at 176 (80) Post-cure 15 minutes at 392 (200) plus 8 hours at 374 (190)</td>
<td>Autoclave</td>
</tr>
<tr>
<td><strong>LTM® 212</strong></td>
<td>2</td>
<td>356 (180)</td>
<td>40 hours at 95 (35) or 8 hours at 140 (60) Post-cure 15 minutes at 392 (200) plus 8 hours at 374 (190)</td>
<td>Autoclave</td>
</tr>
<tr>
<td><strong>LTM® 217</strong></td>
<td>8</td>
<td>356 (180)</td>
<td>20 hours at 131 (55) or 5 hours at 176 (80) Post-cure 15 minutes at 392 (200) plus 8 hours at 374 (190)</td>
<td>Autoclave</td>
</tr>
<tr>
<td><strong>LTM® 317-1B</strong></td>
<td>30</td>
<td>302 (150)</td>
<td>16 hours at 150 (65) or 5 hours at 176 (80) Post-cure 2 hours at 302 (150)</td>
<td>Vacuum/Autoclave</td>
</tr>
</tbody>
</table>
Case Study: Penso Lightweight Composite Rail Door

The Challenge
To manufacture a composite door leaf assembly that builds on existing performance by improving reliability, maintenance and delivery of substantial mass savings.

The Materials
Solvay provided MTM® 82C, a state of the art, market leading phenolic based prepreg system, as well as support from our engineers and material scientists. Our prepreg technology allows thinner structures, FST, weight savings and high mechanical performance to meet all necessary requirements.

The Penso Approach
1. Penso developed a 3D CAD model in Catia V5 based on GOM scan data obtained from carriages in the depot. This involved the integration of existing tube line paper drawings with a complete teardown of a door leaf assembly.
2. Then manufactured composite solution test coupons, which successfully passed fire, smoke and toxicity testing to meet stringent BS6853 Category 1A requirements.
3. Finally performed detailed CAE analysis of the current aluminum door to establish baseline targets for the composite door design.

The Results
Penso’s engineers reached a ground breaking solution that utilizes Solvay’s phenolic composite material in its construction. This maintains and improves on the performance from existing materials used in the manufacture of the doors, as well as a mass savings greater than 10kg (well above the agreed target of 5kg). Lighter rolling stock also means there will be less wear on the track, which is important when managing on-going maintenance and expected increases with the number of journeys being made.
Case Study: Kuala Lumpur Monorail

DK Composites used Solvay’s MTM® 29SFR epoxy prepreg to manufacture the skin of sandwich constructions for the cab masks and apron doors of the new, lower weight, trains for the Kuala Lumpur monorail system.

**MTM® 29SFR:**
- Meets the fire requirements of DIN 5510 for rolling stock
- Can be molded to complex shapes
- Offers good surface finish
- Has the added advantage of being able to bond directly to both foam core and aluminum honeycomb by vacuum bag processing alone and without the need for any additional adhesive film, thus significantly reducing manufacturing costs and part weight

Significant weight savings were achieved with the new apron doors and the cab masks in comparison with the older trains. See table below:

<table>
<thead>
<tr>
<th>Construction</th>
<th>Old</th>
<th>New</th>
<th>Weight Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Apron door</strong></td>
<td>Aluminum composite panel with tubular steel frame</td>
<td>Epoxy/glass prepreg with aluminum honeycomb</td>
<td>745 Kg/Train, 49%</td>
</tr>
<tr>
<td><strong>Cab mask</strong></td>
<td>Hand-laminated polyester/glass/PVC foam</td>
<td>Epoxy/glass prepreg with PET foam</td>
<td>268 Kg/Train, 30%</td>
</tr>
</tbody>
</table>
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