Out-of-Autoclave (OOA) Technology
Toolfusion® 1 & 3
Infusion Resin
Out of Autoclave Composite Tooling

### Toolfusion® 1
Room temperature curing epoxy infusion resin

<table>
<thead>
<tr>
<th>Service temperature</th>
<th>Initial cure temperature</th>
<th>Resin type</th>
<th>Pot Life at 72°F (22°C)</th>
<th>Viscosity at 72°F (22°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>375°F (191°C)</td>
<td>72°F (22°C)</td>
<td>Epoxy</td>
<td>75 minutes</td>
<td>600 cps</td>
</tr>
</tbody>
</table>

#### BENEFITS
- **Room Temperature Curing Out of Autoclave**
  - Avoids thermal expansion of master models which can lead to dimensional deviations.
- **High Quality Tooling**
  - Resin infusion process for high quality laminates at low cost, no freezer storage, and no autoclave cure.
- **Save Money**
  - Low cost and low temperature materials can be used significantly reducing total tooling costs.

### Toolfusion® 3
Low viscosity high temperature epoxy infusion resin

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<tr>
<th>Service temperature</th>
<th>Initial cure temperature</th>
<th>Resin type</th>
<th>Pot Life at 72°F (22°C)</th>
<th>Viscosity at 72°F (22°C)</th>
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</thead>
<tbody>
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<td>400°F (204°C)</td>
<td>120°F (49°C)</td>
<td>Epoxy</td>
<td>300 minutes</td>
<td>450 cps</td>
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#### BENEFITS
- **High Glass Transition**
  - Longer, higher temperature tool life, reducing cost and remanufacturing.
- **Nano-Technology to Enhance Toughness**
  - Manufacture tougher tools, reducing the cost of repair.
- **Low Viscosity and Long Pot Life**
  - Ability to produce more complex tools with low cost resin infusion process.

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Process Selection and Optimization for Out-of-Autoclave Prepreg Structures

Out-of-Autoclave Fiber Placement Developments

Rapid Out-of-Autoclave Composite Manufacturing for Aerospace-Grade Prepregs

About the Cover
Out-of-Autoclave (OOA) fiber placement prepreg “head” contains numerous OOA prepreg CF materials in Ingersoll’s ‘Mongoose Head’ (left). Going clockwise, the first largest space payload fairing demonstrated by Boeing at SAMPE (upper right), followed by an Ingersoll fiber placement of OOA CF materials (center right), and second generation OOA materials flying on Spaceship 2 and White Knight 2 (bottom right).
Process Selection and Optimization for Out-of-Autoclave Prepreg Structures

C. Ridgard
Cytec Aerospace Materials, Tulsa, OK

Abstract
Out-of-autoclave (OOA) or vacuum bag only (VBO) prepregs depend on the physical extraction of entrapped air and volatiles to achieve low levels of porosity, a time dependent process. Strategies for minimizing the total cure duration are discussed in several scenarios including cures completed exclusively in-tool, cures in which part of the process involves a freestanding postcure after demolding and sandwich parts in which the characteristics of both the prepreg and the film adhesive need to be considered. The use of short ‘super-ambient’ temperature dwells to replace previously used long dwells at room temperature is a focus of current work. Kinetic models provide a powerful tool in the development of optimum process conditions and examples involving CYCOM® 5320-1 prepreg and FM® 309-1 adhesive are discussed.

Figure 7. Microcracks in a stratified MTM45-1/HM63 discriminator panel after a standard cure/postcure to 177°C and thermal cycling.

Out-of-Autoclave Fiber Placement Developments
R. W. Koon and S. C. Parsons
Lockheed Martin Aeronautics Company, Marietta, GE
K. A. Povlitz and S. R. Jirik
Lockheed Martin Aeronautics Company, Palmdale, CA

Abstract
Fiber placement of Out-of-Autoclave (OoA) epoxies presents unique challenges to high rate automated fabrication of composite structures. Development efforts by Lockheed Martin Skunk Works® on MTM45®-1, in particular, have shown that, as compared to autoclave materials, fabrication of high quality OoA structures by fiber placement requires significant modifications to the hand lay-up prepreg form, higher temperature placement conditions, and close attention to material tack and outtime levels. Recent efforts using Skunk Works® Ingersoll Mongoose AFP machine have fabricated a variety of MTM45®-1 articles from test panels, to elements, to complex wing skin structures, all of which have led to the formation of improved placement parameters. The lessons learned from these efforts have highlighted which changes in machine design and process parameters will have the greatest impact on improving the quality and cost of future OoA fiber placed structures.

Figure 1. Ingersoll Mongoose Machine located in Palmdale, CA.
Rapid Out-of-Autoclave Composite Manufacturing for Aerospace-Grade Prepregs

A. Haro, B. Lehman, K. Yoshioka, F. N. Nguyen
Toray Composites (America), Inc., Tacoma, WA

B. Luedtke, D. Brosius
Quickstep Composites LLC, Dayton, OH

Abstract

Current state-of-the-art composite manufacturing technologies developed for dual-aisle aircraft are limited to a low volume by an exclusive use of an autoclave molding method. This method is both time-intensive and costly. Future composite aerospace applications for primary and secondary aircraft structures could demand a rapid part production rate with void-free quality in addition to exceptional performance. Notably, single-aisle aircraft would need innovative composite manufacturing technologies that are rapid and cost competitive enough to compete with current metal alloy processes. Researchers at Toray Composites (America), Inc. have investigated a rapid out-of-autoclave (OOA) molding method known as the Quickstep process. This process allows rapid heating/cooling with moderate compaction pressures to fabricate composites from prepregs. Two commercially available aerospace prepregs were utilized in the present study for a comparison among Quickstep, vacuum bag only (VBO) and autoclave. A non-interlayer toughened system demonstrated more than 50% total cycle time reduction compared to VBO and autoclave. In addition, a low void content of less than 1% was achieved with comparable mechanical properties to those from autoclave cure. On the other hand, an interlayer toughened system showed a marginal reduction in total cycle time but achieved void content of less than 2% and comparable mechanical properties to those from autoclave cure as well.

Figure 1. (a) Quickstep Process Schematic, (b) Quickstep QSE250 Machine and curing chamber.

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