

LOCTITE[®]

e ELLSWORTH
ADHESIVES

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Benzoxazine Resin Technology

For Cost-Effective Composite Solutions



Henkel Excellence is our Passion

Always a Reliable Member of Your Development Crew

As the aerospace industry constantly changes and seeks effective solutions for tomorrow, Henkel is dedicated to providing a competitive advantage for its customers. Based on innovation and continuous dialog with design, production and maintenance specialists, Henkel's experts are always tuned into the latest industry trends.

Henkel's technical expertise is based on over 40 years of experience in aerospace applications, as a trusted supply chain partner to provide the optimum solution to meet the most rigorous industry requirements. Working with Henkel means more to customers than just high performance products. Based on sustainability and efficient assembly system solutions, Henkel is the development partner of choice for the latest generation of adhesive technology. In addition, Henkel now offers superior composite materials for aircraft structure, as well as advanced technical solutions for engines and systems. Your Henkel Experts will support the development of customized solutions to reach maximum product performance, while achieving production and supply chain efficiency throughout your process.

Henkel offers composites and adhesives for three core segments of airplane construction, maintenance and repair:



Composites

products for manufacturing fiber reinforced structural components



Assembly

materials for bonding, surface preparation and protection



MRO

repair solutions for composite and metal structures to support your commitment to the aircraft lifecycle

Boarding Time for Composite Materials

More than 40 years ago, the first composite was used to construct lighter, more durable and comfortable aircraft. The proportion of composite to metal has increased steadily ever since as the industry has gained confidence in the use of the technology.

Composites provide superior stiffness and strength to weight compared to metals, enable flexible design, and meet customers' expectation of comfort, operating cost and sustainability. Today's airplanes are designed with carbon fiber composite structures, in some cases accounting for more than half of the weight of the plane.

Meeting industry trends at cruising speed

Global population growth and mobility along with the increased cost of oil have led to demand for fuel-efficient airplanes. Composite materials provide a solution, which



› Enable **lighter airplane** design to **reduce fuel consumption**



› Enable **design flexibility** (for better aerodynamics, efficiency and comfort)



› Promote sustainability through **reduced emissions** and noise



› Enable **large scale production** and automation to satisfy growing demand

Now Henkel is introducing an alternative portfolio to existing composite chemistries.

LOCTITE® Benzoxazine composite solutions provide **cost-effective** construction, improved **technical performance**, and **sustainability** throughout the entire value chain.

LOCTITE® Benzoxazine Resins –

Full T(h)rust for Composite Technology

Developed specifically for the aerospace industry, Benzoxazine resin technology offers a comprehensive solution over commonly used epoxies, phenolics, and BMIs. Benefits are seen in product performance, storage, processing, and health and safety.

Cross functional characteristics of Benzoxazine Resin-based products:

- > Stability at ambient temperature eliminates the need for refrigerated shipping and storage
- > Excellent flammability performance (flame, smoke and toxicity) leads to improved safety
- > Minimal shrinkage means lower residual stress
- > Low cure exotherm contributes to better thermal stability and improved safety
- > Weight savings potential at least 30 % compared to conventional metal structures

Advantages to comparable technologies

LOCTITE® Benzoxazine vs.

Epoxy	Phenolic	BMI
<ul style="list-style-type: none">• Lower cure shrinkage and cure exotherm• Improved hot/wet performance• Inherent Flame, Smoke and Toxicity characteristics	<ul style="list-style-type: none">• No microcracking• Improved durability• No water generated during cure	<ul style="list-style-type: none">• Lower cure temperature and shorter cure cycle• Lower cost• Higher toughness





Following the route to sustainability

Like any new product from Henkel, Benzoxazine Resins contribute to a more sustainable future. By using this new generation of resins, you will see improvements throughout your production life-cycle.

Main improvements:

-
- › Storage and shipping at room temperature

 - › Lower material consumption through improved performance

 - › Reduced waste due to less spoilage

 - › Reduced hazards from waste

 - › Improved health and safety

 - › Lighter weight allows lower fuel consumption of planes

Benzoxazine technology was developed with two processing aspects in mind:

The ability to be processed in existing and future product technologies, and enabling a new generation of process savings.

LOCTITE® Benzoxazines are suitable for most common production methods and processes:

Prepregs:

- Hand lay-up, AFP, ATL
- Autoclave curing

Infusion resins:

- RTM
- VARTM
- RFI

Film adhesive for composite bonding:

- Autoclave curing
 - Suitable for secondary bonding and co-curing
 - Can be used for honeycomb sandwich co-curing
-

Reducing Cost along the Entire Value Chain

Composites made with LOCTITE® Benzoxazine resins provide improvements in every stage of the value chain. Discover how much you can optimize your production with high-quality products and reduced process costs.



Design / Performance

Improved performance

- Multifunctional resin
- Reduced complexity
- Design freedom
- Flammability resistance

Warehouse

Room Temperature Storage

- No refrigeration required
- No temperature records
- Less sampling
- No insulated boxes to dispose

Handling / Processing / Lay-up

Room Temperature Stability

- No thawing
- Less handling effort
- Lower risk of moisture contamination
- Less waste due to expired or miss-handled product

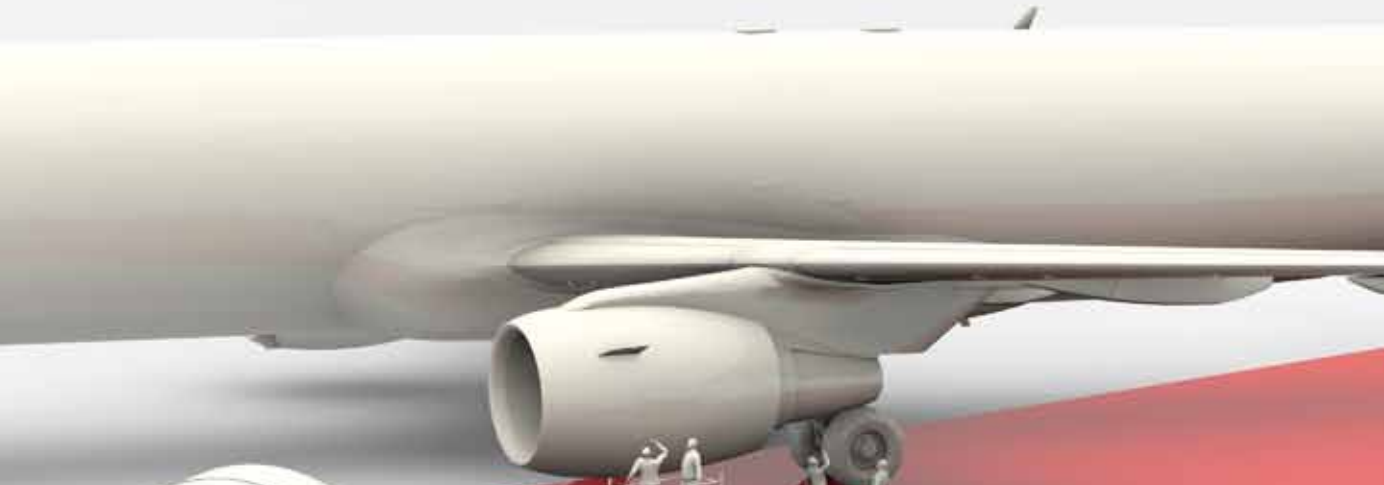
Model Calculation of cost savings*

Warehouse:
\$ 0.23/ft² (\$ 2.47/m²)

Handling:
\$ 0.14/ft² (\$ 1.46/m²)

Processing:
\$ 0.25/ft² (\$ 2.69/m²)

*Savings dependent on volume per year and application (Customer validated +- 15 %).



Operating /
In-service
Performance

Repair

Finish

Autoclave

PROCESS

Lower Exotherm

- Less labor
- Shorter processing time
- Easier autoclave scheduling
- Less N₂/CO₂ required for autoclave
- Improved safety

Lower Cure Shrinkage

- Less fitting and shimming
- Reduced surface preparation
- Lower internal stress

Lower Exotherm & Less Cure Shrinkage

- Less microcracking
- Reduced repair rate
- Improved durability

Lower Cure Shrinkage

- Higher durability
- Fewer repairs

Lower Density

- Better strength-weight ratio
- Reduced fuel consumption

Autoclave:
\$ 0.19/ft² (\$ 2.09/m²)

Finishing and Repair:
\$ 0.27/ft² (\$ 2.91/m²)

Total savings:
\$ 1.09/ft² (\$ 11.62/m²)

Benzoxazine-Resin-Based Product Portfolio

	Aerospace Structural Prepreg			Infusion Structural Resin
Product	LOCTITE® BZ 9703	LOCTITE® BZ 9704	LOCTITE® BZ 9705	LOCTITE® BZ 9110
Cure Conditions ⁽¹⁾	177 °C (350 °F) / 2 hrs	185 °C (365 °F) / 3 hrs	210 °C (410 °F) / 2 hrs	180 °C (356 °F) / 2 hrs
Maximum service temperature ⁽²⁾	120 °C (248 °F)	140 °C (284 °F)	180 °C (356 °F)	135 °C (275 °F)
Toughness ⁽³⁾	Medium	High	Medium	Medium
Product Benefits	<ul style="list-style-type: none"> › Available in variety of product forms › High retention of hot/wet properties › Damage tolerance equivalent to toughened epoxy › Extended room temperature storage › Outstanding flammability resistance › Low shrinkage and residual stress › Other cure cycles available › Light weight 			<ul style="list-style-type: none"> › Balanced performance › Easy processing › Enhanced mechanical performance and durability with: <ul style="list-style-type: none"> • High temperature performance (hot/wet) • Lower cure shrinkage and heat release › VARTM processable
Process	<ul style="list-style-type: none"> › Hand lay-up › Automatic tape laying › Automated fiber placement › Autoclave cure 			<ul style="list-style-type: none"> › Resin transfer › Vacuum infusion
Energy & Climate	<ul style="list-style-type: none"> › RT storage & shipping › Suitable for automated processing › Lower weight structure 		<ul style="list-style-type: none"> › RT storage & shipping › Shorter processing cycle vs BMI › Suitable for automated processing 	<ul style="list-style-type: none"> › RT storage & shipping › Can be shipped in bulk › Approved for air shipment
Materials & Waste	<ul style="list-style-type: none"> › Less materials use due to higher performance › Reduced waste due to lower spoilage › Reduced hazards of waste 			<ul style="list-style-type: none"> › Reduced weight › Reduced waste
Safety & Health	<ul style="list-style-type: none"> › Improved health & hygiene vs epoxy › Lower weight of finished part 		<ul style="list-style-type: none"> › Improved health & hygiene vs BMI 	<ul style="list-style-type: none"> › Very low risk of exotherm › Improved health & hygiene vs epoxy
Performance	<ul style="list-style-type: none"> › Improved mechanical & flammability performance and durability vs epoxy 		<ul style="list-style-type: none"> › Improved toughness and durability vs BMI 	<ul style="list-style-type: none"> › Reduced flammability vs epoxy
Social Progress	<ul style="list-style-type: none"> › Improved aircraft fuel efficiency and lower emissions due to lower weight of finished part 			<ul style="list-style-type: none"> › Improved aircraft fuel efficiency



1) Typical cure time and temperature

2) Service temperature is defined as 28 °C below the wet Tg

Resin		Film Adhesive for Composite Bonding	Tooling Prepreg
LOCTITE® BZ 9120	LOCTITE® BZ 9130	LOCTITE® BZ 9691	BETA PREPREG manufactured by AIRTECH <small>ADVANCED MATERIALS GROUP</small>
180 °C (356 °F) / 2 hrs	180 °C (356 °F) / 2 hrs + 232 °C (450 °F) / 1 hr post-cure	180 °C (365 °F) / 3 hrs	177 °C (350 °F) / 2 hrs + 232 °C (450 °F) / 1 hr post-cure
120 °C (248 °F)	168 °C (334 °F)	160 °C (320 °F)	180 °C (356 °F)
High	High	Medium	High
<ul style="list-style-type: none"> › High toughness <ul style="list-style-type: none"> • Microcrack resistant › Outstanding toughness and elongation › Excellent hot-wet performance › Broad process window › Very low exotherm compared to epoxy resins › VARTM processable 	<ul style="list-style-type: none"> › High temperature performance › High toughness › VARTM processable 	<ul style="list-style-type: none"> › Compatible with Henkel BZ composite matrix resins › Capable of high temperature performance 	<ul style="list-style-type: none"> › Outstanding toughness and stability at high temperature › Developed for repeated cures to 177 °C (351 °F) › Exceptionally low shrinkage improves tool surface quality › Excellent post machining quality › High vacuum integrity even after machining › Exceptionally long out-life >6-months at room temperature
<p>Transfer molding (RTM) only infusion and cure (VARTM)</p>		<ul style="list-style-type: none"> › Autoclave cure › Suitable for secondary bonding and co-cure › Can be used for honeycomb sandwich co-cure 	<ul style="list-style-type: none"> › Autoclave cure
<ul style="list-style-type: none"> › RT storage & shipping › Can be shipped in bulk › Approved for air shipment 	<ul style="list-style-type: none"> › RT storage & shipping › Can be shipped in bulk › Approved for air shipment › Shorter processing cycle vs BMI 	<ul style="list-style-type: none"> › RT storage & shipping 	<ul style="list-style-type: none"> › Room temperature shipping and storage of prepreg › Lower energy for cure of tools vs BMI due to shorter cure cycles › Lower energy for cure of components vs metal
<p>waste due to stability during infusion hazards of waste (reactivity, HSE)</p>		<ul style="list-style-type: none"> › Reduced hazards of waste (reactivity, HSE) 	<ul style="list-style-type: none"> › Reduced machining of tools › Less rejected tools and parts › Reduced tooling rework
<ul style="list-style-type: none"> › Very low risk of exotherm › Improved health & hygiene vs epoxy 	<ul style="list-style-type: none"> › Very low risk of exotherm › Improved health & hygiene vs BMI 	<ul style="list-style-type: none"> › Improved health & hygiene 	<ul style="list-style-type: none"> › Low cure exotherm › Improved health & hygiene › Lower tool weight
<ul style="list-style-type: none"> › Improved mechanical & flammability performance and durability vs epoxy 	<ul style="list-style-type: none"> › Higher toughness vs BMI 	<ul style="list-style-type: none"> › High temperature performance 	<ul style="list-style-type: none"> › Reduced microcracking vs BMI › Longer tool life
<p>Efficiency and lower emissions</p>			<ul style="list-style-type: none"> › Enables economic air travel › No dry ice required

LOCTITE®
BONDERITE®
TECHNOMELT®
TEROSON®
AQUENCE®

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