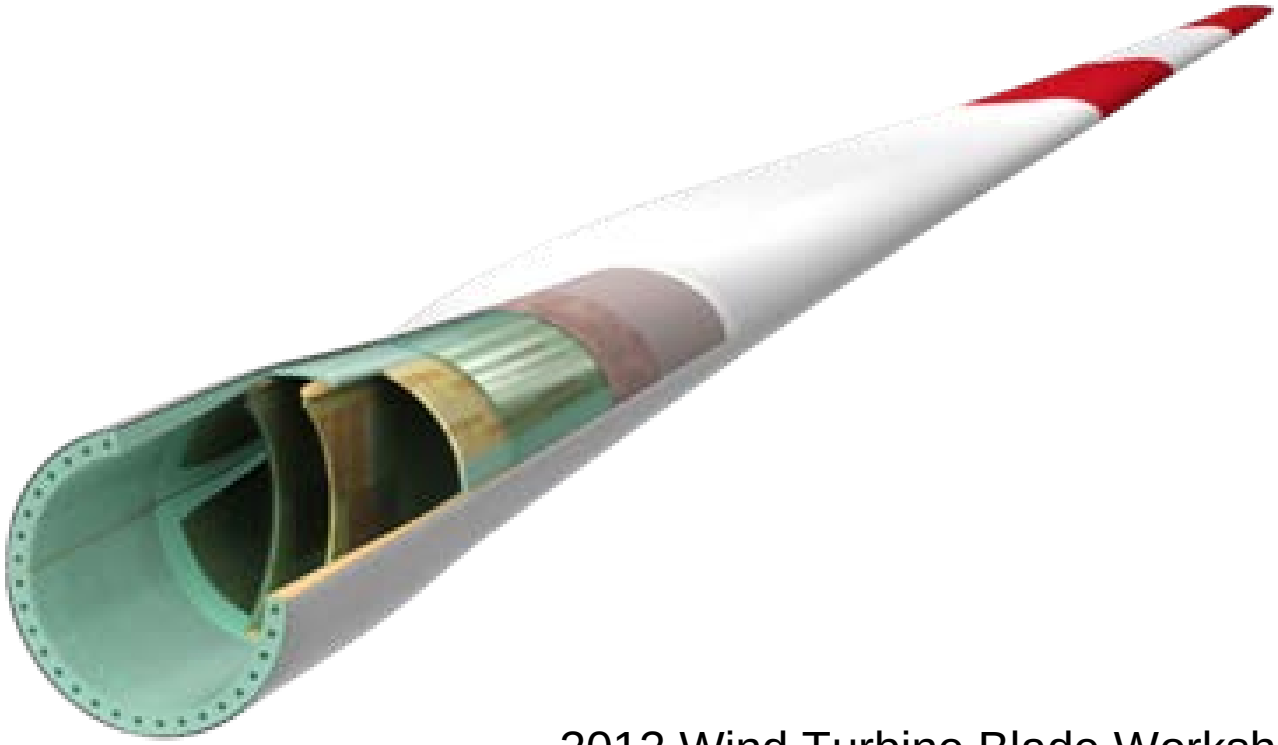
Advanced Materials Solutions for Infusing Carbon Fibers & Thick Composite Parts



BASF
The Chemical Company

2012 Wind Turbine Blade Workshop
May 31, 2012
jay.bhatia@basf.com

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- Data and pictures used in this presentation are either from public domain or from the sources as mentioned
- Product specific data and benchmarks are average values and will vary with specific production conditions
- Reflections on present and future market trends are presenter‘s personal opinions

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Outline

BASF
The Chemical Company

- **BASF - Introduction**
- Latent Cure Technology
- Proven Benefits in Blade Production
- Summary

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BASF – The Chemical Company

We create chemistry for a sustainable future

BASF
The Chemical Company

- Our chemicals are used in almost all industries
- We combine economic success, social responsibility and environmental protection.
- Sales 2011: €73,497 million (~$100 B)
- EBIT 2011: €8,586 million (~$11.6 B)
- Employees (as of Dec 31, 2011): 111,141
- 6 Verbund (integrated) sites and around 370 production sites worldwide
- World-class, innovative, sustainable systems & solutions
- R&D Expenditure (2011) : €1.6 B (~$2 B)
  #1 in chemical industry by Patent Asset Index™
- *World's Most Admired Chemical Company* : *Fortune* 2011, 2010 & 2009

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BASF in North America

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Sales 2011	~$20 Billion
Employees	16,000 +
Production Sites	100 +
R&D Sites	20

BASF in Wind Energy

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Polyurethanes	Performance Polymers	Construction Chemicals	Intermediates	Coatings	Wind Turbine
Foams	Foams		Epoxy Systems	Blade Coatings	
Adhesive			Adhesive	Tower Coatings	
		Grouts & Admixtures			

in development

Commercial

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BASF Epoxy Systems
Portfolio for Wind Turbine Blades

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Infusion

- Baxxodur® 5300 System (Latent)
- Baxxodur® 5400 System

Laminating

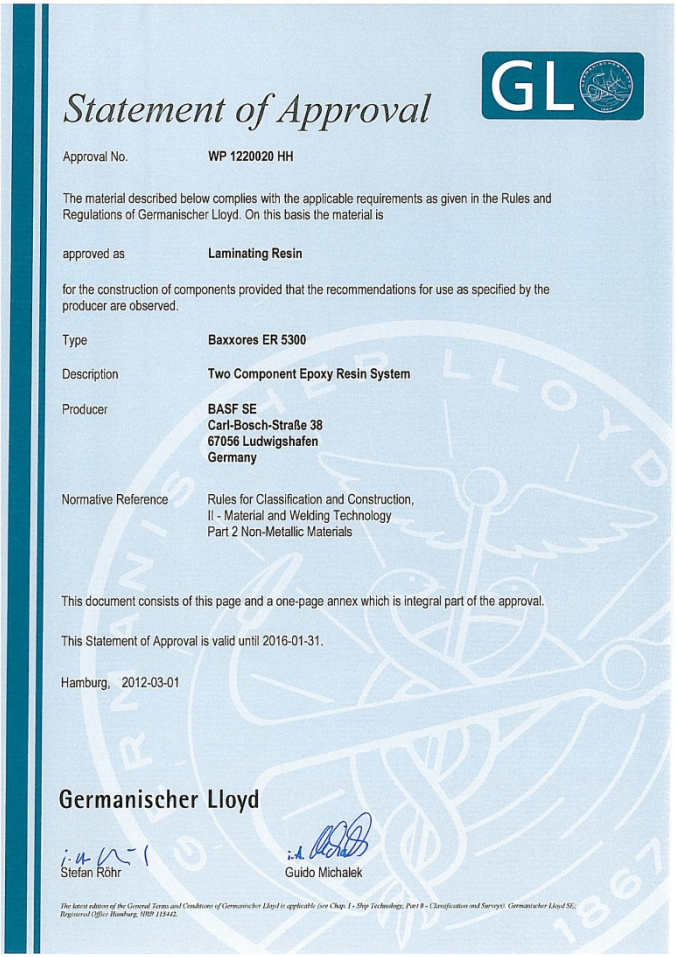
- Baxxodur® 5500 System
- Baxxodur® 5503 System

Adhesive

- Baxxodur® 4100 System
- Baxxodur® 4200 System (Latent)

Tooling

- Baxxodur® 3100 System (Infusion)
- Baxxodur® 3601 System (Gelcoat)



Statement of Approval

GL

Approval No. **WP 1220020 HH**

The material described below complies with the applicable requirements as given in the Rules and Regulations of Germanischer Lloyd. On this basis the material is

approved as **Laminating Resin**

for the construction of components provided that the recommendations for use as specified by the producer are observed.

Type **Baxxores ER 5300**

Description **Two Component Epoxy Resin System**

Producer **BASF SE**
Carl-Bosch-Straße 38
67056 Ludwigshafen
Germany

Normative Reference Rules for Classification and Construction,
II - Material and Welding Technology
Part 2 Non-Metallic Materials

This document consists of this page and a one-page annex which is integral part of the approval.

This Statement of Approval is valid until 2016-01-31.

Hamburg, 2012-03-01

Germanischer Lloyd

Stefan Röhr Guido Michalek

The latest edition of the General Terms and Conditions of Germanischer Lloyd is applicable (see Chap. 1 - Ship Technology, Part 0 - Classification and Surveys). Germanischer Lloyd SE; Registered Office Hamburg, HRB 115442.

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Chemistry in
Rotor Blade Production

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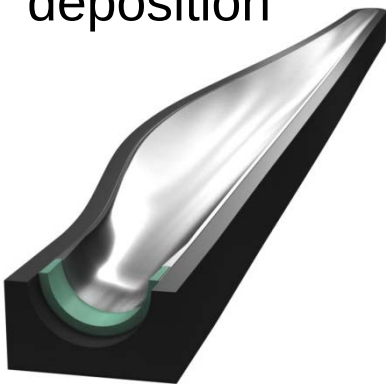
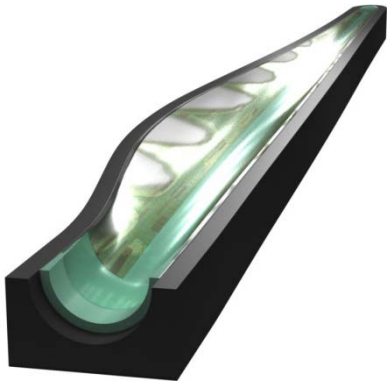
Fabric deposition

Prefab integration

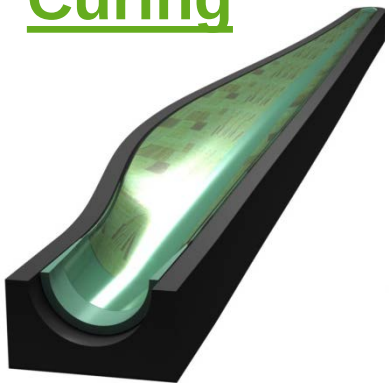
Fabric deposition



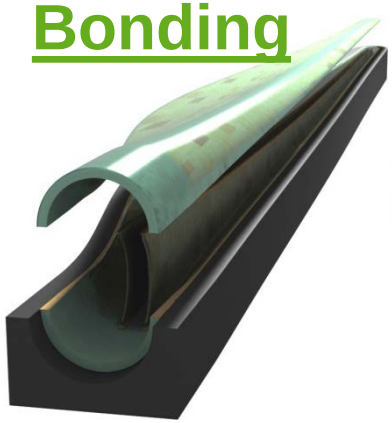
Infusion



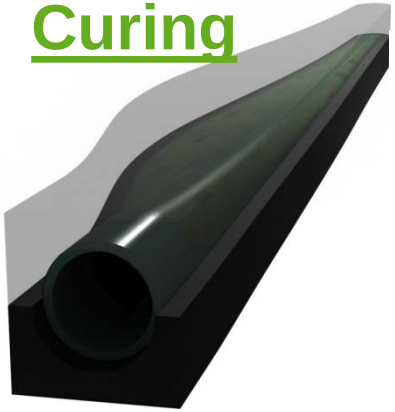
Curing



Bonding



Curing



Precoating

Coating

~40% of blade production cycle time is driven by chemistry...

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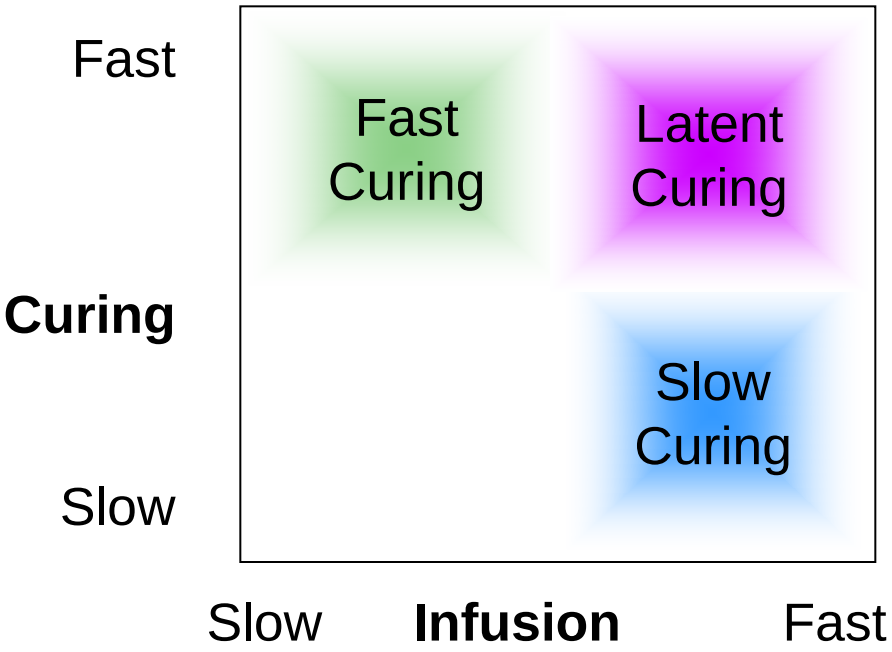
“Reaction Dilemma“ of VARTM
(Epoxy Infusion)

Customers look for a combination of…

- fast infusion with good fibre wetting through low reactivity
- fast polymerization / vitrification through high reactivity



Latent curing systems solves the „reaction dilema“.

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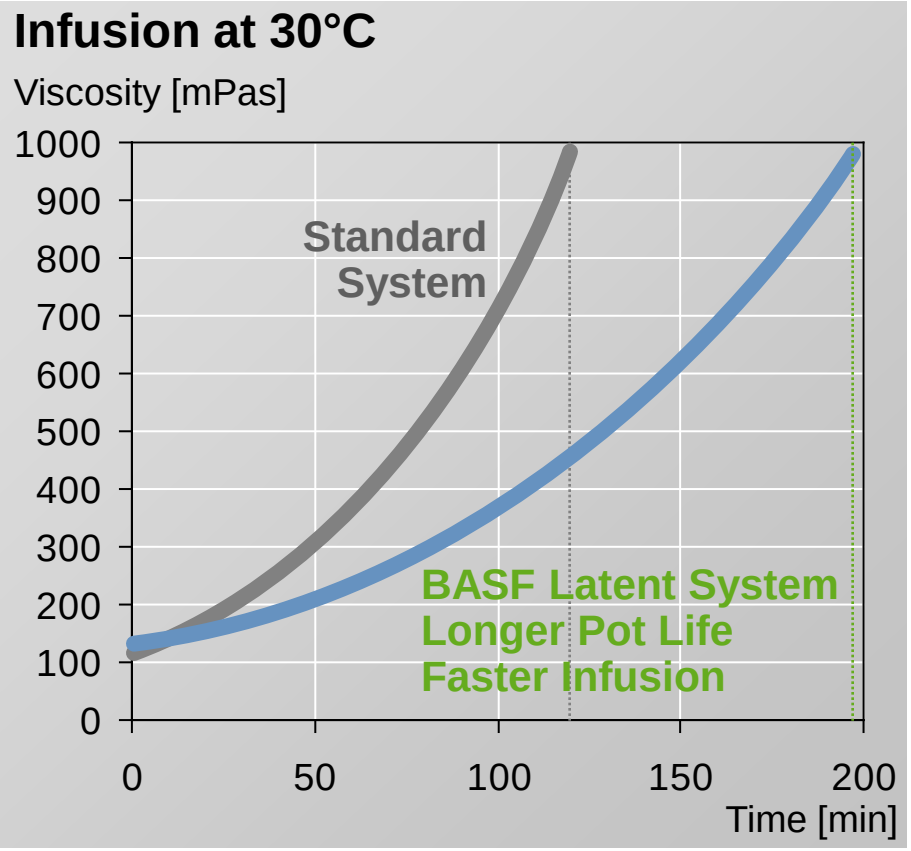
Advantage
Longer pot life, Faster infusion → Better process control



- During infusion at temperatures below 55°C the Baxxodur 5300 system reacts slowly allowing long open time (pot life)
- The lower viscosity at e.g. 40°C with the slow reactivity enables fast infusion and improved fiber wetting

Novel infusion system reduces infusion time around 40%

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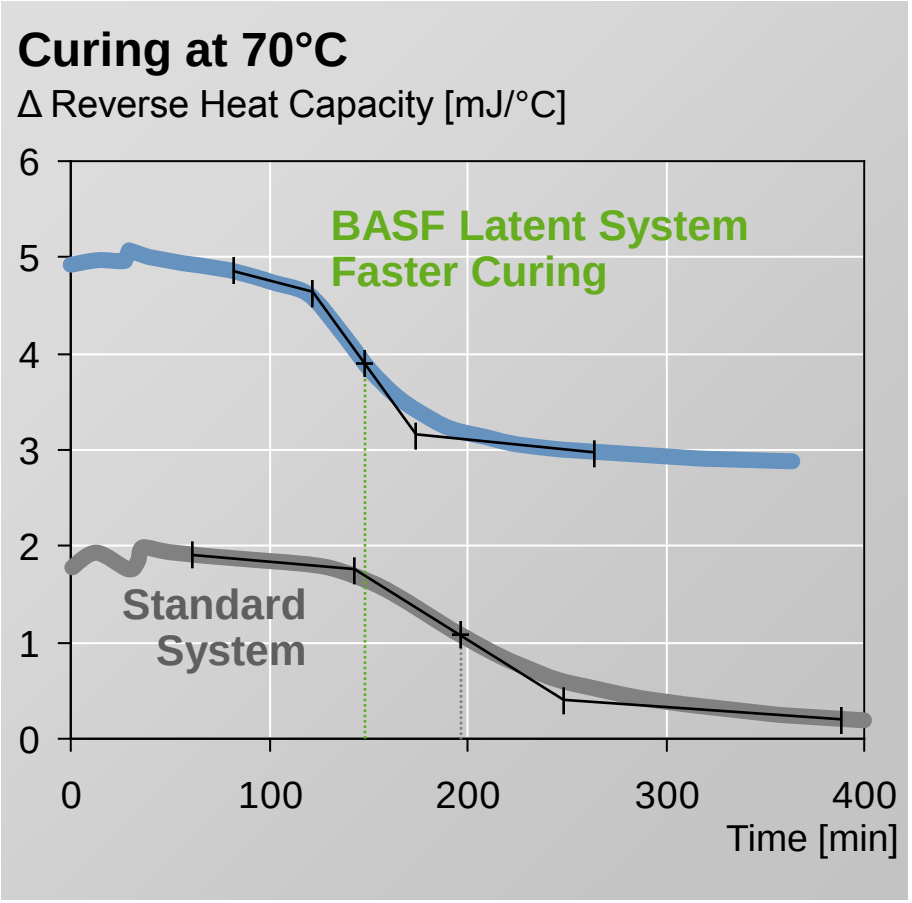
Advantage
Faster Curing → Cycle Time Reduction



- Once the temperature inside the laminate rises to 70°C, the latent curing mechanism “kicks in”
- At this temperature System cures much faster than the standard system

Latent infusion system reduces curing time by 30-40 %

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Crosslinking / Tg Development at 70°C

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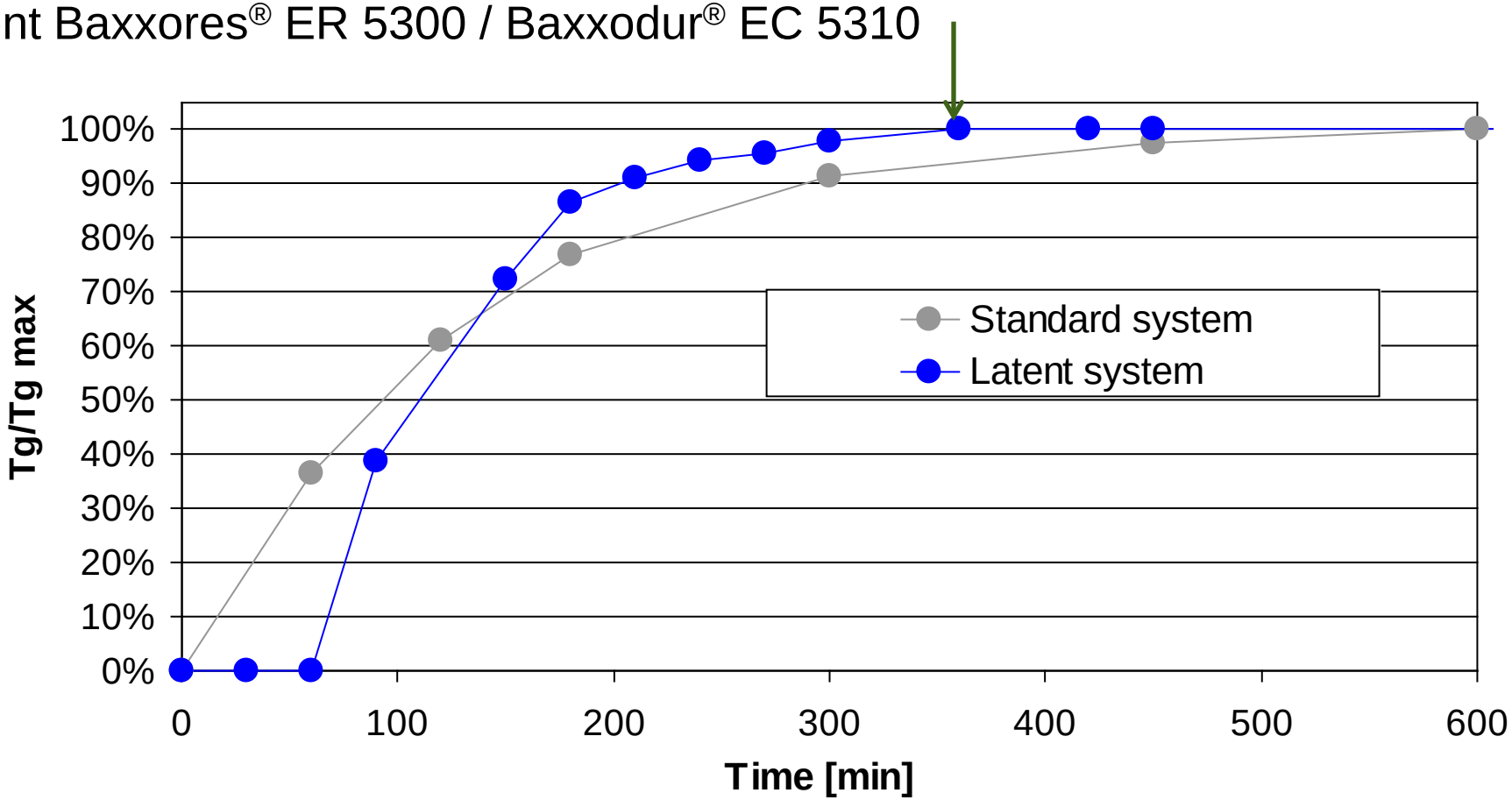
Latent Baxxores® ER 5300 / Baxxodur® EC 5310



Latent Baxxodur® system allows faster curing and higher Tg_{max} (~85 C)

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Outline

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Proven Benefits in Production
Cycle Time Reductions

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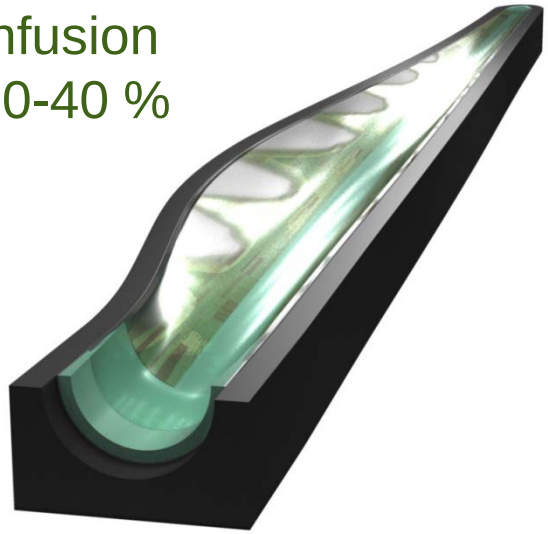
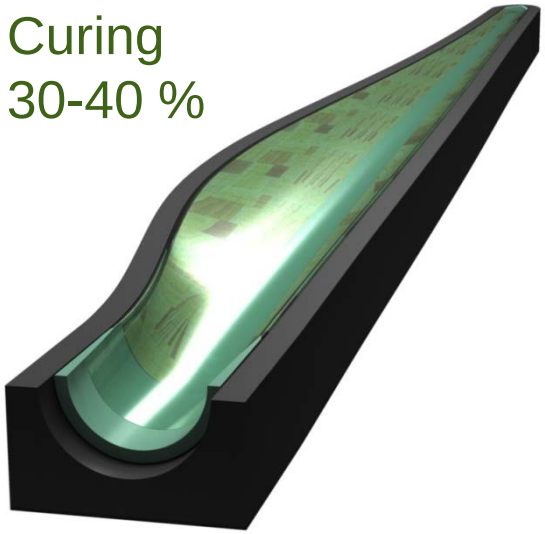
Cycle time reduction in rotor blade production

Infusion
30-40 %



Curing
30-40 %



Baxxodur epoxy systems with latent but fast curing agents enable

- fast infusion at low viscosity with inactive reactants at low temperatures
- fast curing above temperature threshold with activated reactants

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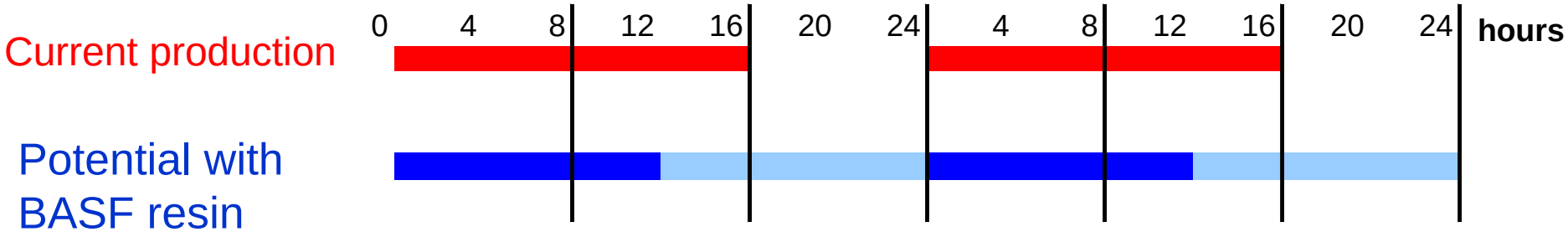
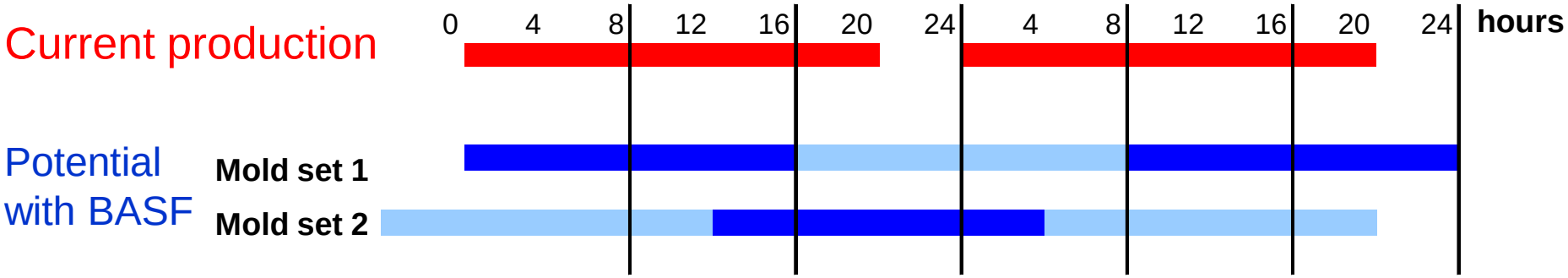
Taking advantage of cycle time reductions

Reduced tooling costs

Produce 2 Root Rings per mold set instead of 1



Produce 1.5 sets of Spar Caps per mold set instead of 1 set



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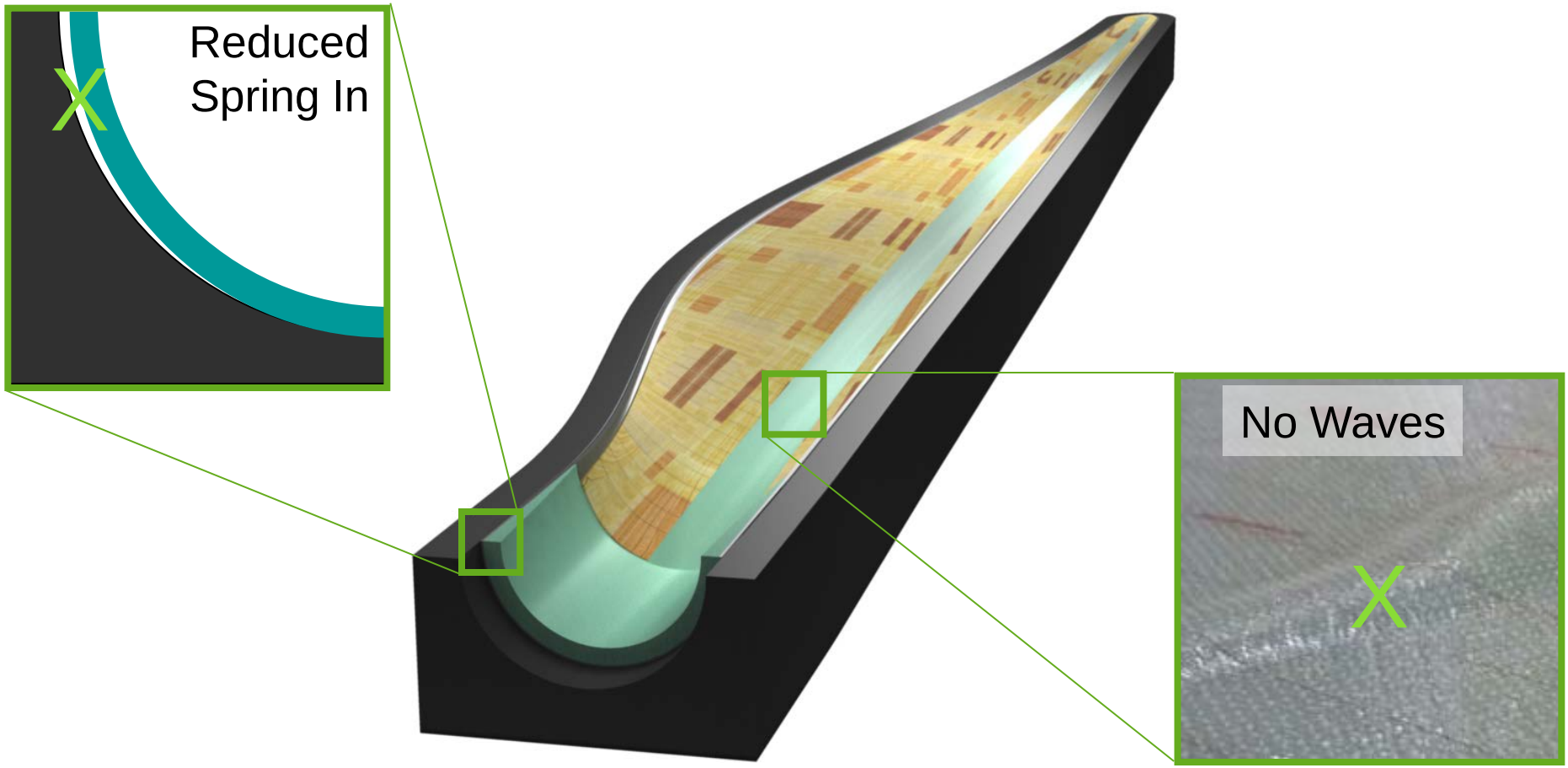
Proven benefits in blade production
High Quality Structural Parts



Latent Baxxodur® systems produce high quality composites

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Proven benefits in blade production
Direct Infusion of Root Ring

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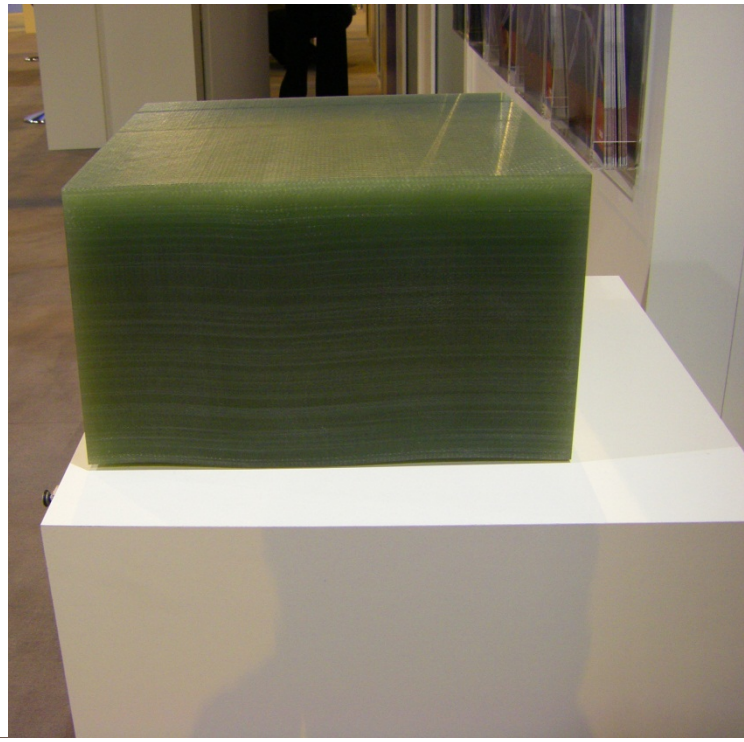
- Lower viscosity and longer stability of latent system allows direct infusion of root ring in shell molds
- Successfully adopted in production



Thickness: 22 cm (~9 inch)
No. of layers: 270
Fabric type: TRIAX 1200 g/m2

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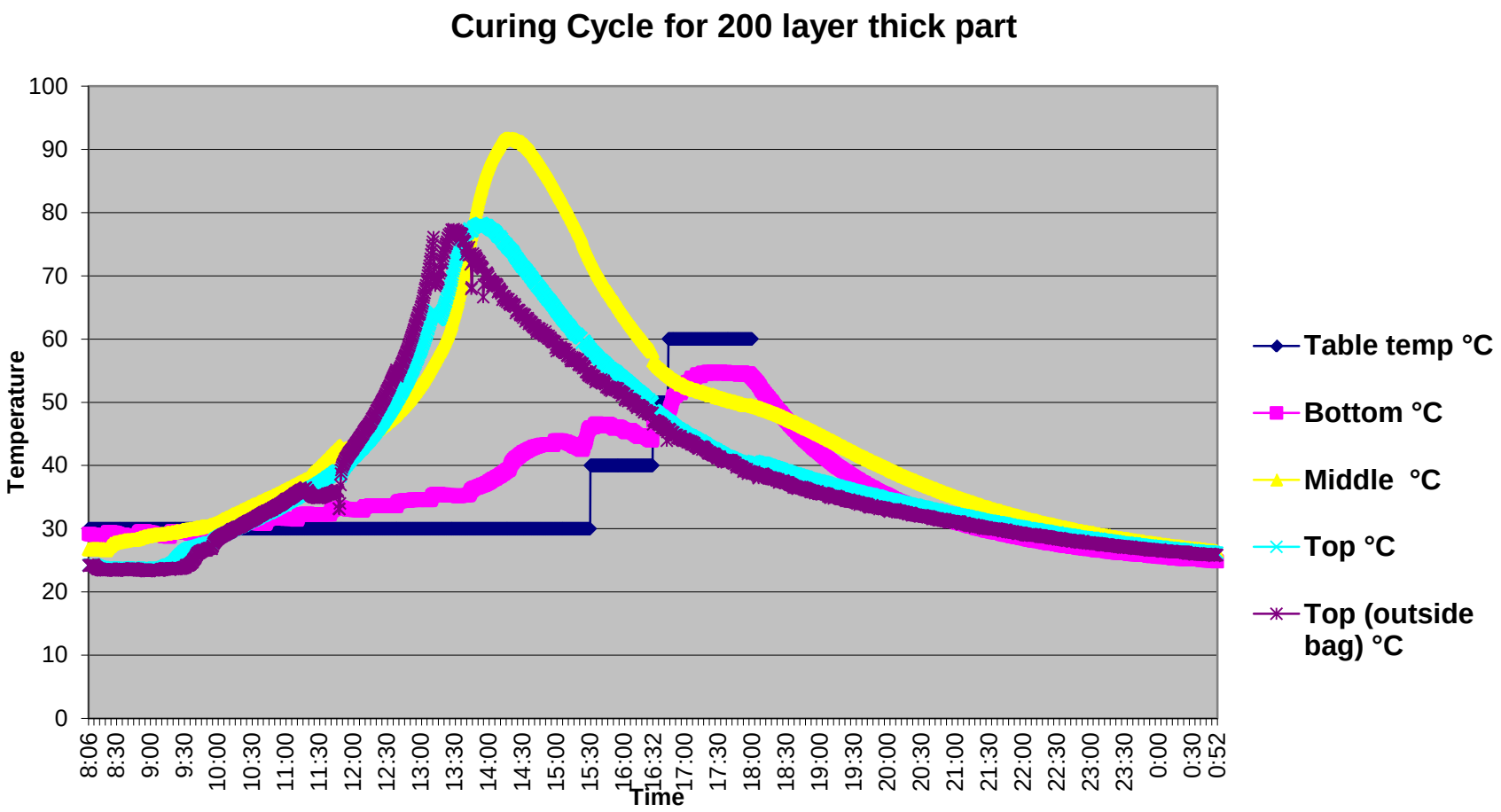
Baxxodur® Latent System

Typical Cure Profile for 200 layers fiberglass laminate



Source: Data generated in BASF lab

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Proven benefits in blade production
Infusion of Carbon Fiber Spar Cap

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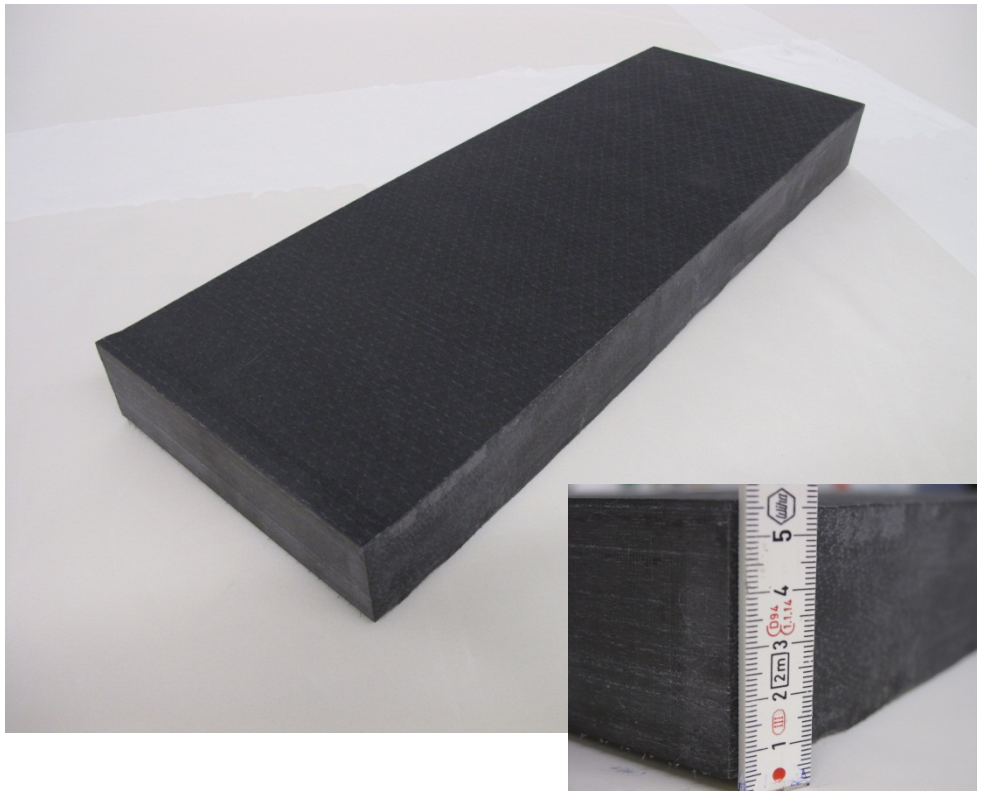
- Lower viscosity & better stability of latent system allows infusion of carbon fibers at higher temperature
- Only epoxy infusion system in commercial production of carbon spars



90 layers of UD carbon fabric in 1000 X 600 mm laminate; thickness 55 mm
Infusion time: 100 minutes @ 35C
Curing time 2 hours @ 50 C + 2 hours @ 75C

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Summary

- Significant scope for innovations in blade production through creative use of chemistry
- BASF's Latent Cure Technology enables cycle time reductions and quality improvements
- Several blade producers are successfully using latent system for direct infusion of root ring and for infusing carbon spars
- Latent system offers substantial opportunity for capital and operational cost reduction

* * *

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