Cytec
ENGINEERED MATERIALS

CYCOM® X5320

## Innovative Approach to Out-of-Autoclave Processing

September 9, 2008

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Agenda

- Introduction
- Problem Statement
- Cycom X5320
- Potential Value Proposition
- Solicit input on the interest for Out-of Autoclave
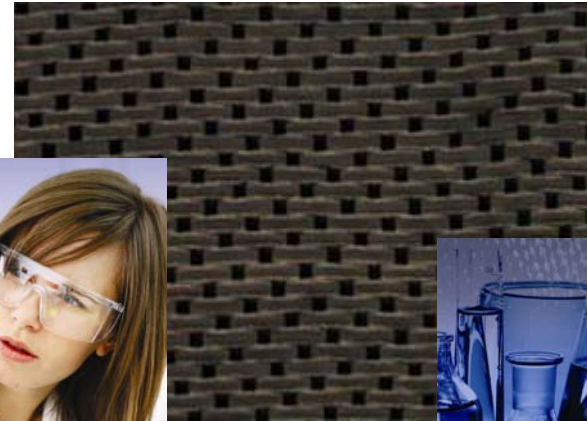
Introduction-Cycom X5320 prepreg

CEM is experienced and capable with OOA

– Material Science – through chemistry and understanding
  - Balanced cure cycles to customer requirements
  - Reduce porosity; control viscosity
  - Tack life and total out-time
  - Maximize mechanical properties that drive key design elements

– Technical Service Support – Global tech support of material selection, lay-up, tooling, and assembly

– Application Engineering – PRIM, Automation (AFP, ATL) - BMI & toughened epoxy
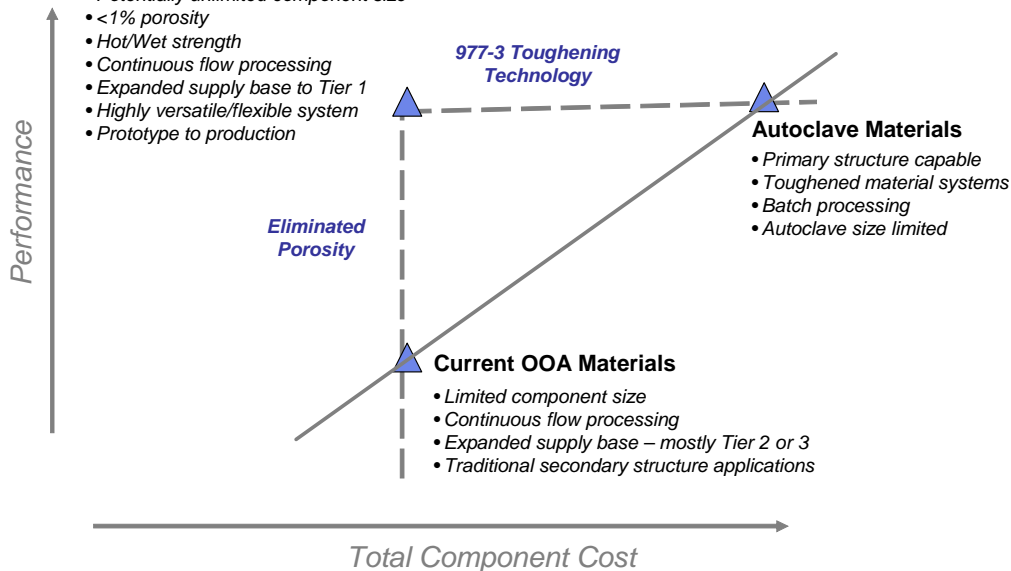
Problem Statement

– Progress technology/capability from secondary to primary structure
– Provide material system capable of prototype or production needs

Gaps Today	Specific Limitation	Target
Mechanical performance	secondary structure	primary
Porosity	<4%	<1%
Tack/Handling	<10 days	30 days
Component size	geometry and dimension limited	unlimited
Versatility	lengthy low temp cure varying properties w/cure poor green strength	<12hr initial consistent excellent

Attacking problem through material science

X5320 - *primary structure performance with OOA benefits*

- *Potentially unlimited component size*
- *<1% porosity*
- *Hot/Wet strength*
- *Continuous flow processing*
- *Expanded supply base to Tier 1*
- *Highly versatile/flexible system*
- *Prototype to production*

977-3 Toughening Technology

Eliminated Porosity

Autoclave Materials
- *Primary structure capable*
- *Toughened material systems*
- *Batch processing*
- *Autoclave size limited*

Current OOA Materials
- *Limited component size*
- *Continuous flow processing*
- *Expanded supply base – mostly Tier 2 or 3*
- *Traditional secondary structure applications*

Performance

Total Component Cost

– Fundamental material science approach

– 977-3 technology

– Critical in-depth understanding of key OOA characteristics of flow, gel, impregnation, resin advancement

– Versatile, robust manufacturing cure cycle options – providing necessary green strength
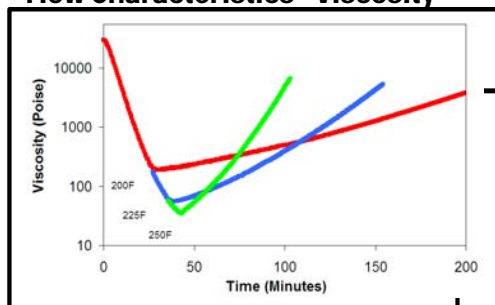
– Supported by in-application engineering

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Cycom X5320 Introduction

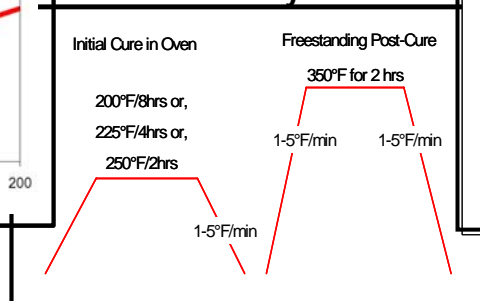## *Breakthrough OOA material – addresses primary structure needs*

- Legacy military fighter epoxy autoclave mechanical properties with OOA processing
- Large, primary structure component processing
  - Porosity
  - Hot/Wet
- Tailorable handling properties to meet hand-layup and automation part manufacturing
- Prototype parts to high-rate production capable
- Flexible cure cycles providing robust degree of cure with final resin cross-linking

	Current		X5320
	Autoclave	OOA	
Large scale components	☒	☑	☐
Primary structure	☑	☒	☐
Continuous flow process	☒	☑	☐
Hot/Wet strength	☑	☒	☐
Eliminates porosity	☑	☒	☐
Automation	☑	☒	☐

Flow Characteristics - Viscosity

Flexible Cure Cycles

Initial Cure in Oven

200°F/8hrs or,
225°F/4hrs or,
250°F/2hrs

1-5°F/min

Freestanding Post-Cure

350°F for 2 hrs

1-5°F/min   1-5°F/min

X5320 Degree of Cure

50%   60%   90%

200F/8 hr, 200F/16 hr, 225F/4 hr, 250F/2 hr, PC-350F/1 hr, PC-350F/2 hr

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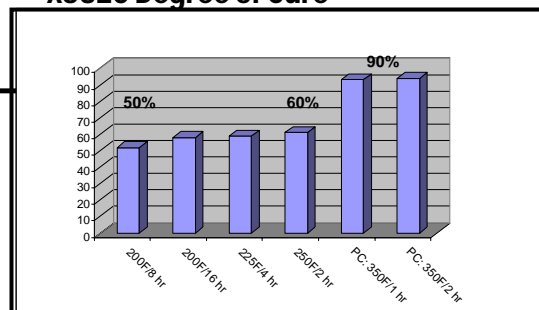
Properties of X5320 limited and preliminary data collection

Properties	977-3 IM fiber	X5320 IM fiber
OHC (220F/Wet) [0/90]3s; ASTM D6484; qty=8	39.3 ksi	42.3 ksi
Tg (Wet) DMA Storage Mod; [0]10	303°F	310°F
OHT (-65F/Dry) [+,0,-,90]3s; ASTM D5766; qty=8	65.4 ksi	75.1 ksi
CAI [+,0,-,90]4s; SRM02R94; qty=8	25.2 ksi	29.6 ksi
Solvent Resistant	Pass	Pass
Initial Cure Temp	355F (autoclave)	200F/16 hours (VBO)

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Product Portfolio

Unidirectional Tape

– X5320 T40-800B 145 gsm/33% resin content, 49" width
– X5320 T40-800B 290gsm/33% resin content, 49" width

Fabric

– X5320 WT650-35 3K-8HS 48" width, 36% resin content

Non-Carbon Forms

– X5320 4581Q-9837 38" DP 35% resin content
– X5320 108 50" width, 50% resin content
– X5320 60001 50" width Peel Ply

Ancillary products

Material	Recommended	Target Properties
Film Adhesive	FM300-2K or FM209M	FWT (220F/Wet) Equivalent to FM300 (-65F:800psi, RT:700psi, 250f:500psi)
Foaming Adhesive	FM490A	Similar to FM404A. Passes expansion requirement at 200F of 200%.
Peel Ply	X5320 Peel Ply	Compatible with resin and removes cleanly from part
Syntactic Core	FM381	Density:40 pcf, FWT similar to FM381
Surfacing Film	SM 905M	Clean surface; no surface porosity

Out-of-Autoclave Value Proposition

Performance

- Address **porosity** and **mechanical performance** which have historically limited Out-of-Autoclave materials to secondary structures
- **Geometrically limited** due to part quality of autoclave processing (resin rich, thin out, etc)
- **Unitized structure design**
- Ability to support rapid, small volume **aircraft demonstrations** & insertion into **production rates**

Cost

- **Alternative tooling** design concepts
- **Part count reduction** addressing legacy black aluminum designs
- **Supply-base capability** & **expansion**
- **Lower capital costs** for further composite application adoption
- **Qualification** serves demonstration articles **and** production

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Discussions/Feedback

- – Material characteristics
- – Material product forms
- – Industry Material Specifications – interest, approaches
- – Processing constraints, desires
- – Database considerations
- – Tooling approaches, concerns
- – Equipment requirements – ovens, vacuum sources, other heat sources
- – Challenging part features for producibility evaluation/scale
- – Applications and related constraints/issues
- – Variability, robustness
- – Further interest?

Please complete the questionnaire provided... your input is essential!