Snap Cure Materials for High Volume Manufacture of Automotive Parts

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JEC Paris: 12 March 2014

Agenda

- Hexcel overview
- Background to applications and solutions
- M77: snap cure matrix
- M77 HexMC: high performance moulding
- M77 PrimeTex: excellent surface finish
- Conclusions

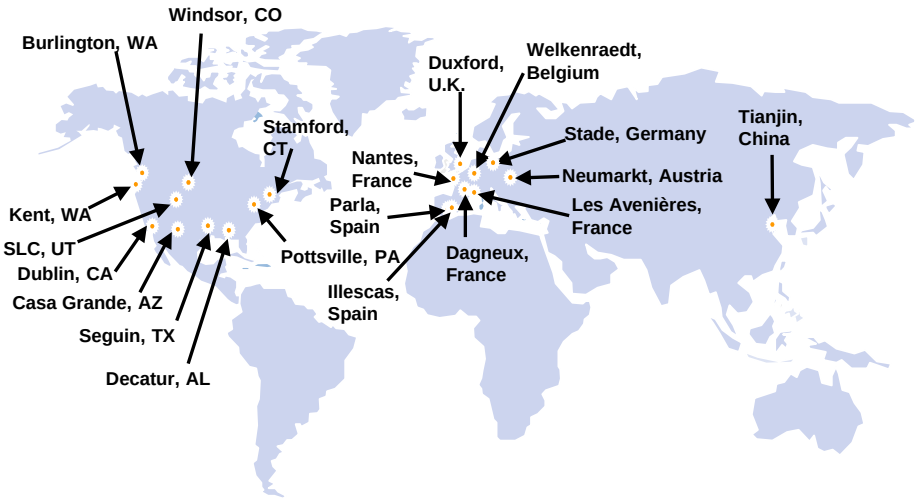
Company Profile

- Technology leader in advanced composites
- Serving commercial aerospace, space & defense and industrial
- Net Sales 2013: $1.68 billion
- 5,500 employees worldwide
- 19 manufacturing sites (including JV in Malaysia)
- Headquarters in Stamford, CT, USA
- Listed on New York and Paris Stock Exchanges





Overview



- *Leading advanced composites company with 65 years of experience*
- *Excellent customer relationships*
- *Technology leader with a broad range of products and qualifications*
- *Leading positions in all of our markets*
- *Demonstrated operational excellence*

Hexcel 2013 Total Sales of $1.68 Billion

Markets

- 13% Industrial
- 22% Space & Defense
- 65% Commercial Aerospace

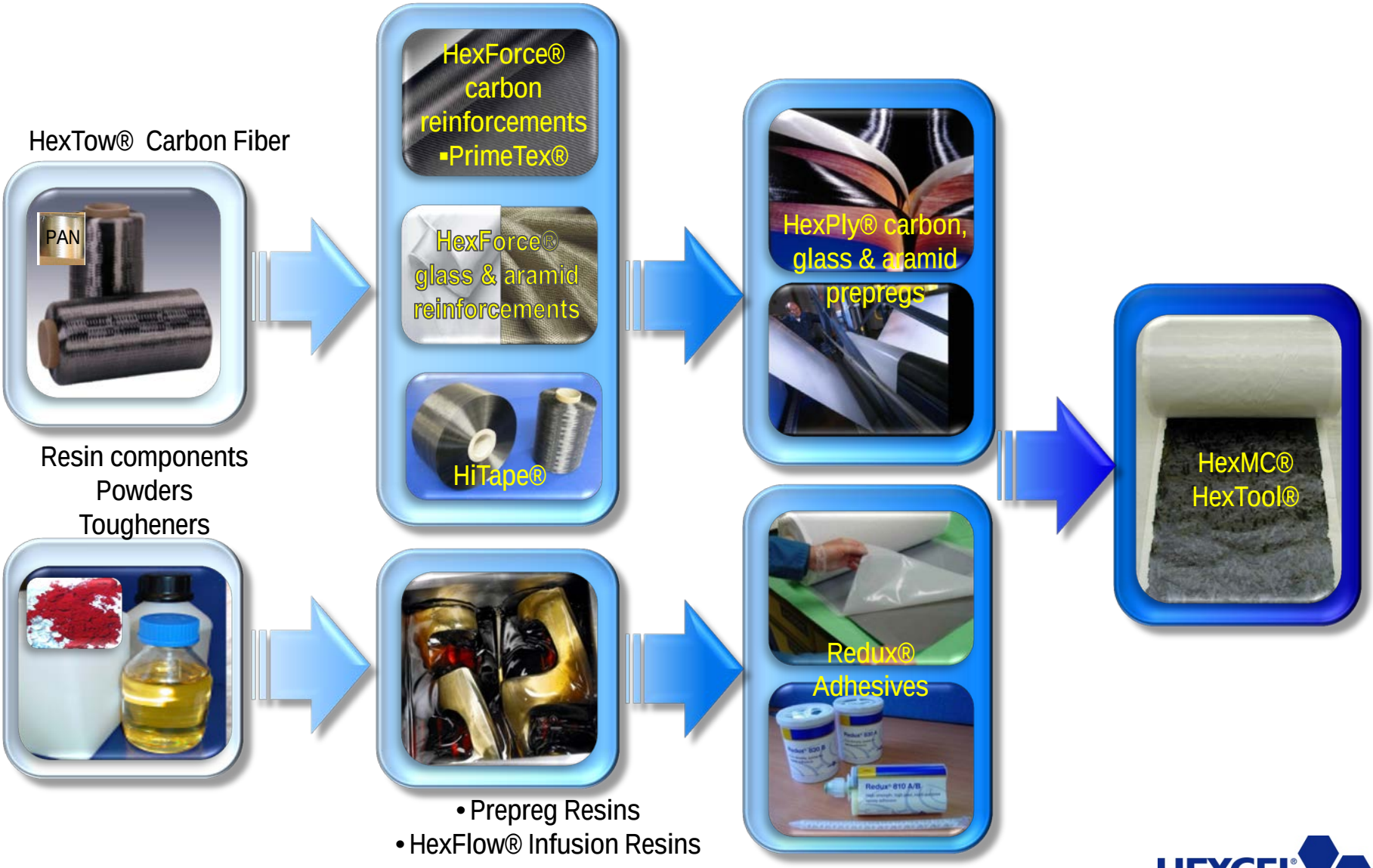
Products

- 22% Engineered Products
- 78% Composite Materials
  - Carbon Fiber
  - Reinforcements
  - Prepregs
  - Honeycomb

Regions

- 15% Middle East, Asia, Africa
- 39% Europe
- 46% Americas

Supply Chain Value: Fiber/Resin → Composite Materials



Background

Automotive applications; thermosets and thermoplastics; prepregs

Automobile Sections and Parts

BODY IN WHITE	CHASSIS	STEERING and SUSPENSION	CLOSURES	INTERIOR
				
% of car weight	35%	20%	17%	10%	18%

Potential Carbon Part Areas

- Pillars (A,B,C)	- Chassis structures	- Suspensions	- Side doors	- Seats body
- Firewalls	- Cross beams	- Wheels	- Hood	- Seat frames
- Roof	- Bottom chassis	- Prop/Drive shafts	- Tailgate	
	- Floor		- Fenders	

← **Thermosets** → ← **Thermoplastics** →

B.I.W and Chassis = 80% of metal substitution opportunities

HEXCEL®

Thermoplastics and Thermosets: Pros and Cons

Very difficult to generalise because of the wide range of materials

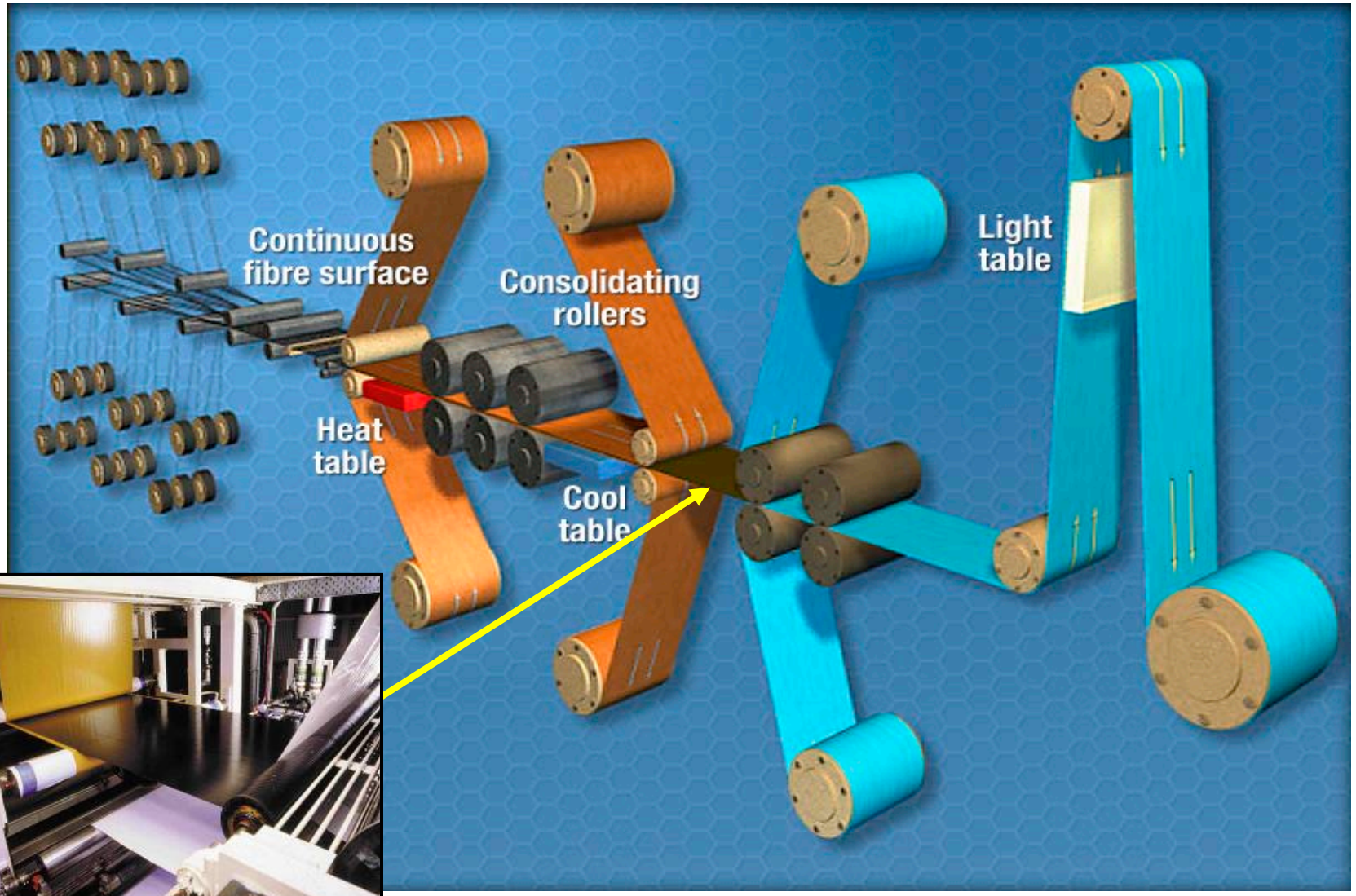
Thermoplastics: tough; shorter cycle times; can be reworked and recycled; difficult to bond; lower Tg; lower creep resistance

Thermosets: good mechanical properties; easier to bond; longer cycle times; difficult to rework and recycle

- **RTM:** lower cost but with lower Tg and toughness; outlife reflects two part system
- **Prepregs:** higher mechanical properties at higher cost; fully formulated (affects outlife); fully impregnated (consistent quality)

How can thermoset (prepreg) cycle times be minimised while retaining their advantages?

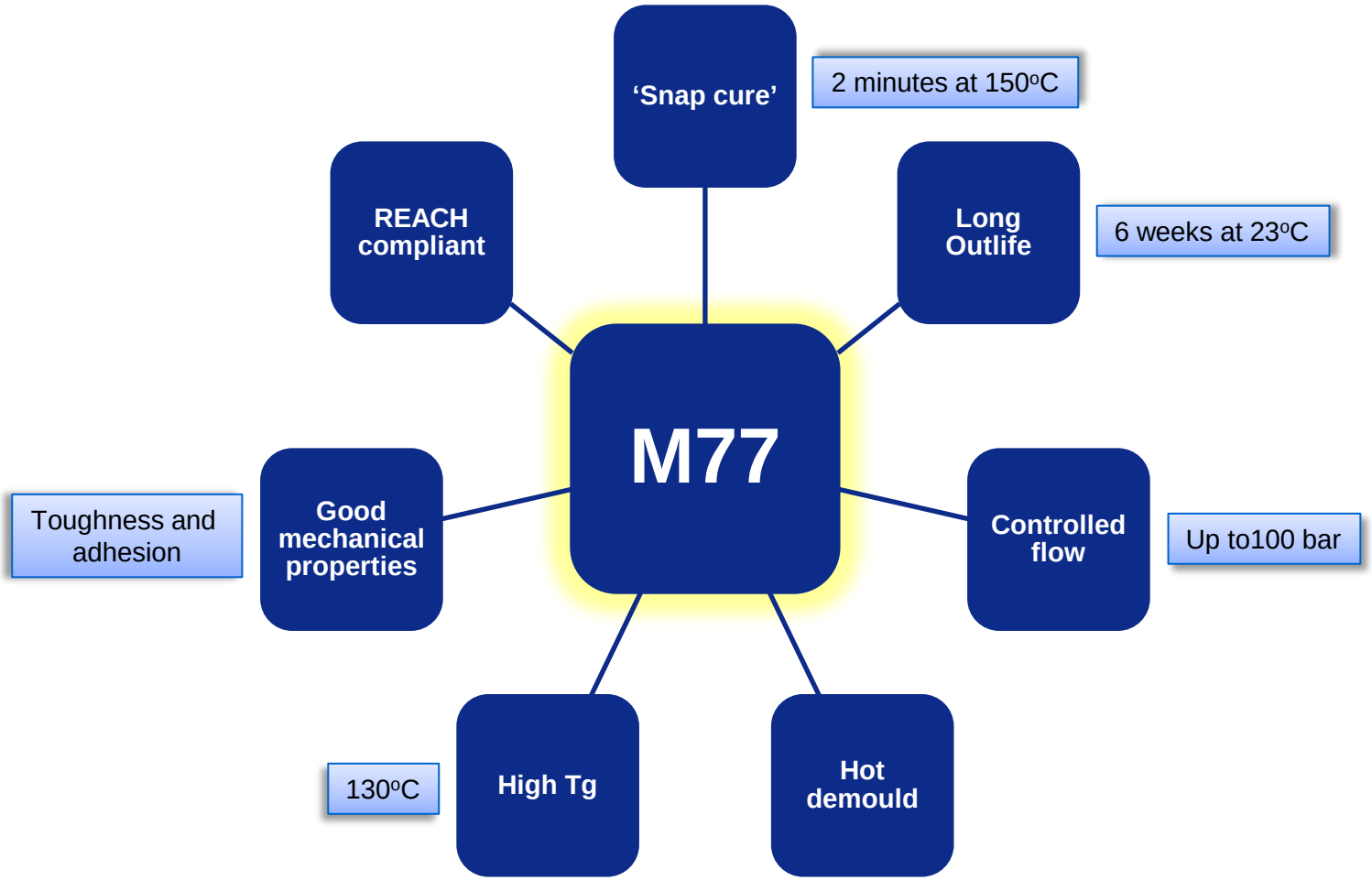
Prepreg: Film Impregnation



M77

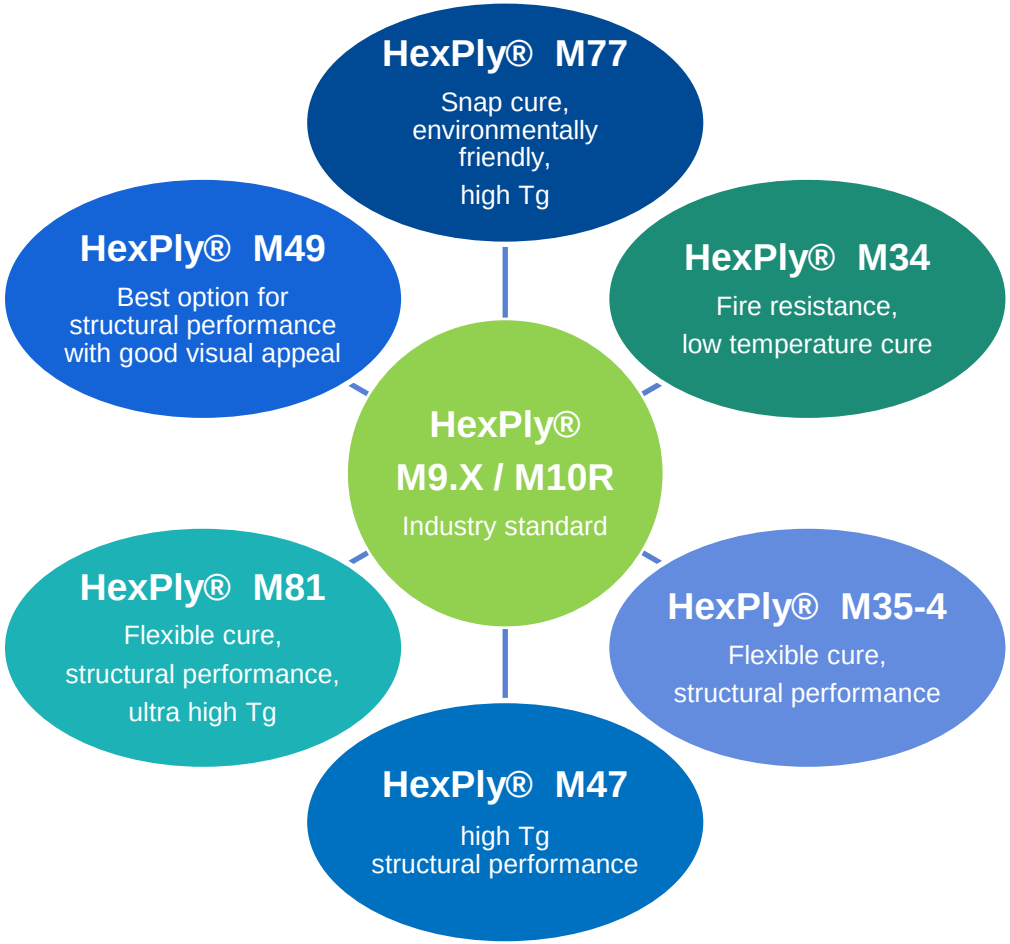
‘Snap cure’ matrix system

M77 Profile



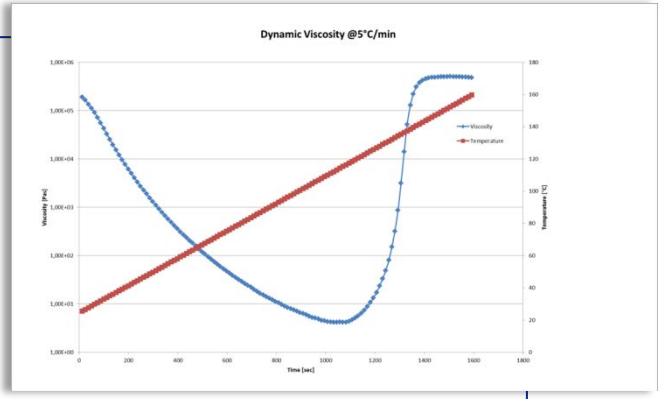
M77 extends the limits for thermoset prepregs with a unique combination of properties

M77 in the Industrial Product Range

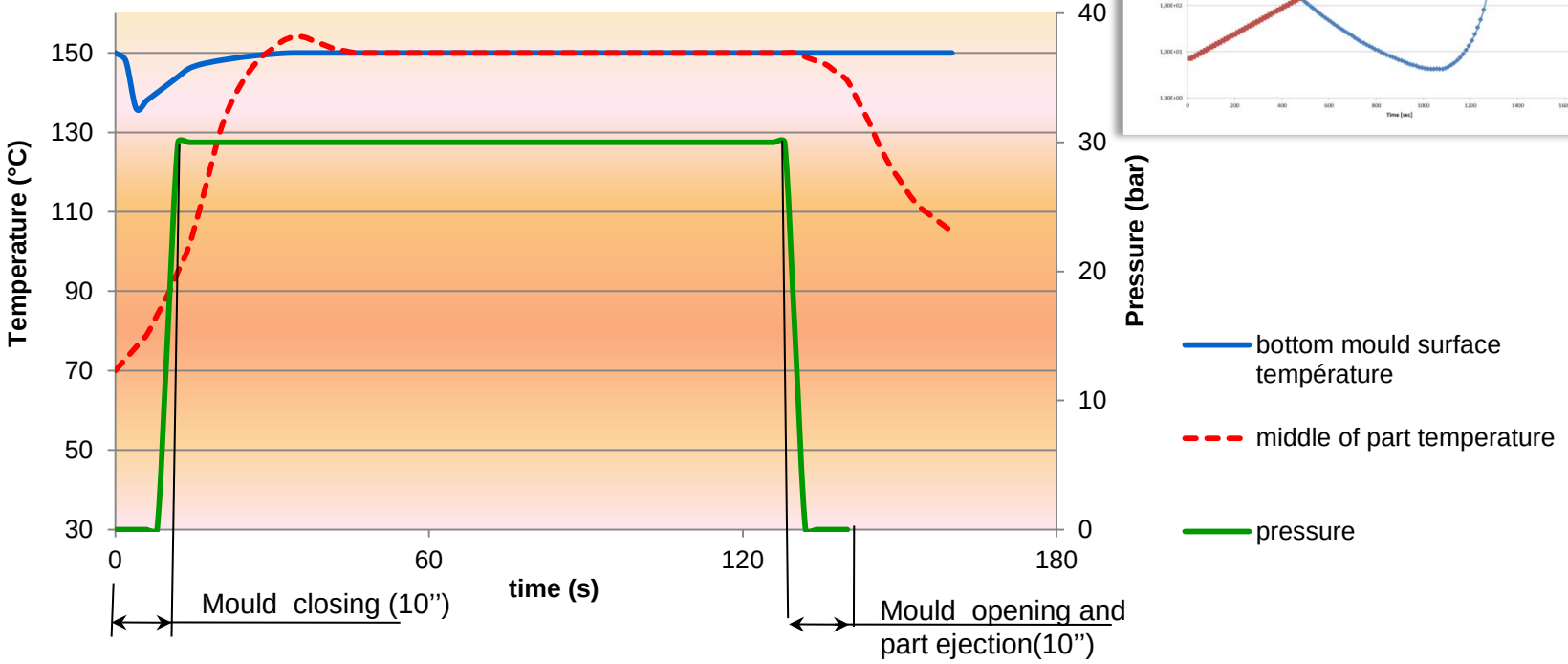


M77: unique 'snap cure'

M77: Designed for Press Processing



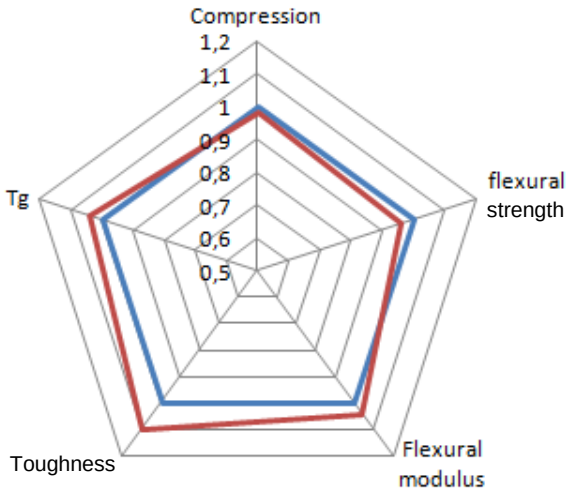
M77 cure cycle for 3mm thick part

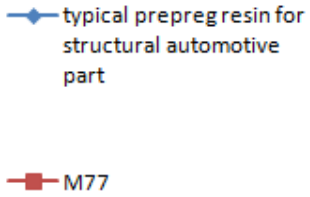


Designed for high production rates

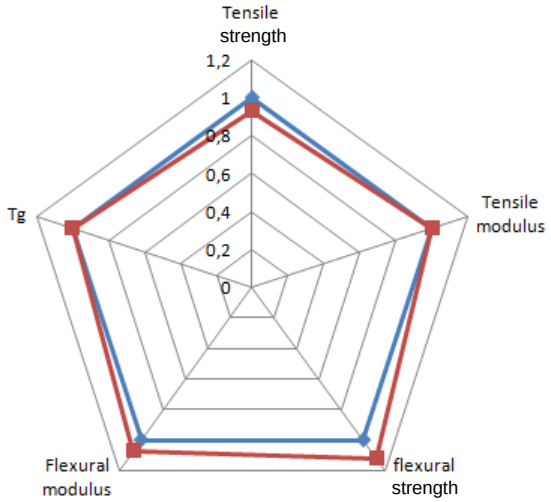
M77 Prepreg: Mechanical Performance

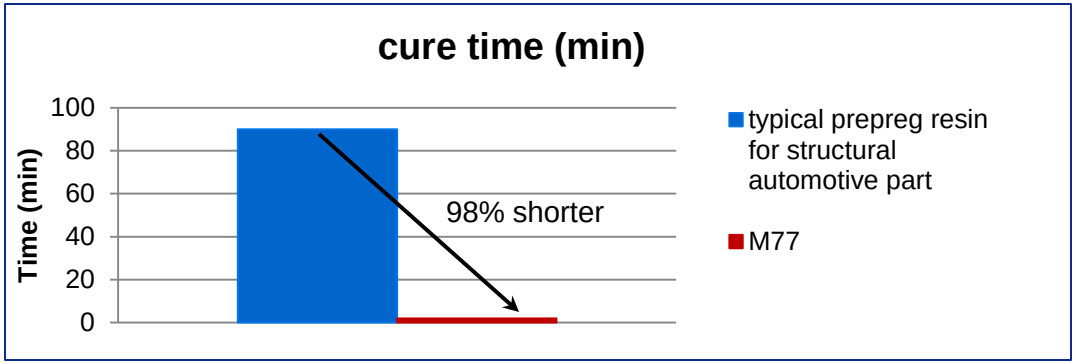
200gsm twill 2X2 3k carbon fabric





150 gsm unidirectional carbon tape





High mechanical performance with much shorter cure cycle

M77 Prepreg: Adhesion to Honeycomb

Nomex honeycomb A1-48-3 12.5 mm

Product	Cure cycle	average	min	Max
M77/56%/200T2/CHS-3k	20 minutes at 120°C; 3 bar autoclave	**57.8**	52	65
	3 minutes at 150°C 3; bar under press	**49.1**	42.1	55
Ref: 1458/50%/220T2/3K	180 minutes at 160°C; 3 bar autoclave	**50**	36	75

Aluminium honeycomb 5052-3/16-12.5mm

Product	Cure cycle	average	min	Max
M77/56%/200T2/CHS-3k	20 minutes at 120°C; 3 bar autoclave	**37.1**	34.4	42
	3 minutes at 150°C; 3 bar under press	**32.3**	28.7	36.5
Ref: 1454/54%/193P/3K	90 minutes at 125°C; 3 bar autoclave	**33**	28	38

Good adhesion even with fast cure cycle

M77 HexPly® Current Product Range

Product type	Fabric	Item description	Product width [mm]
Prepreg Glass	UD	M77/32%/1200/G	1200
	Satin weave	M77/55%/48P/G	1100
	Satin weave	M77/52%/106P/G	1260
	Multiaxial	M77/45%/160P/G	1100
	Satin weave	M77/45%/296H8/G	1250
	Plain weave	M77/38%/395P/G	1250
	Multiaxial	M77/40%/LT570/G+F	1240
Prepreg Carbon	UD	M77/42%/UD90/CHS	616
	UD	M77/38%/UD150/CHS	460
	UD	M77/42%/UD300/CHS	1200
	UD	M77/39%/UD600/CHS	1300
	Twill	M77/42%/200T2/C	1250
	Twill	M77/42%/600T2/C	1250

M77 Prepreg: Process Adapted for Automotive Parts

Short cure cycle
(2 min at 150°C or
1.5 min at 160°C)

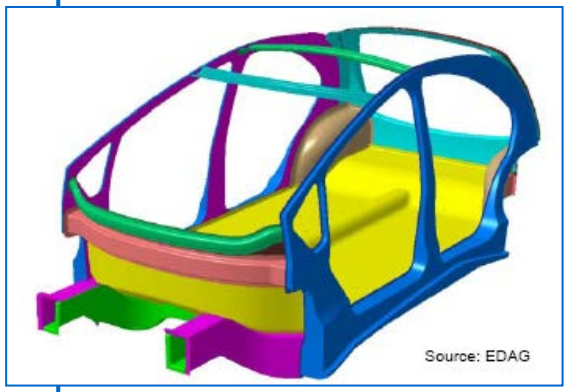
Demould
in hot conditions
(high Tg)

Controlled flow

No fridge

Long shelf life
(6 weeks at
23°C)

REACH compliant



M77: 'snap cure' for high production rate

HexMC® and M77

High performance moulding with ‘snap cure’

What is HexMC®?

UD prepreg precursor

Slitting + chopping

Random distribution

Consolidation

HexMC® Mat

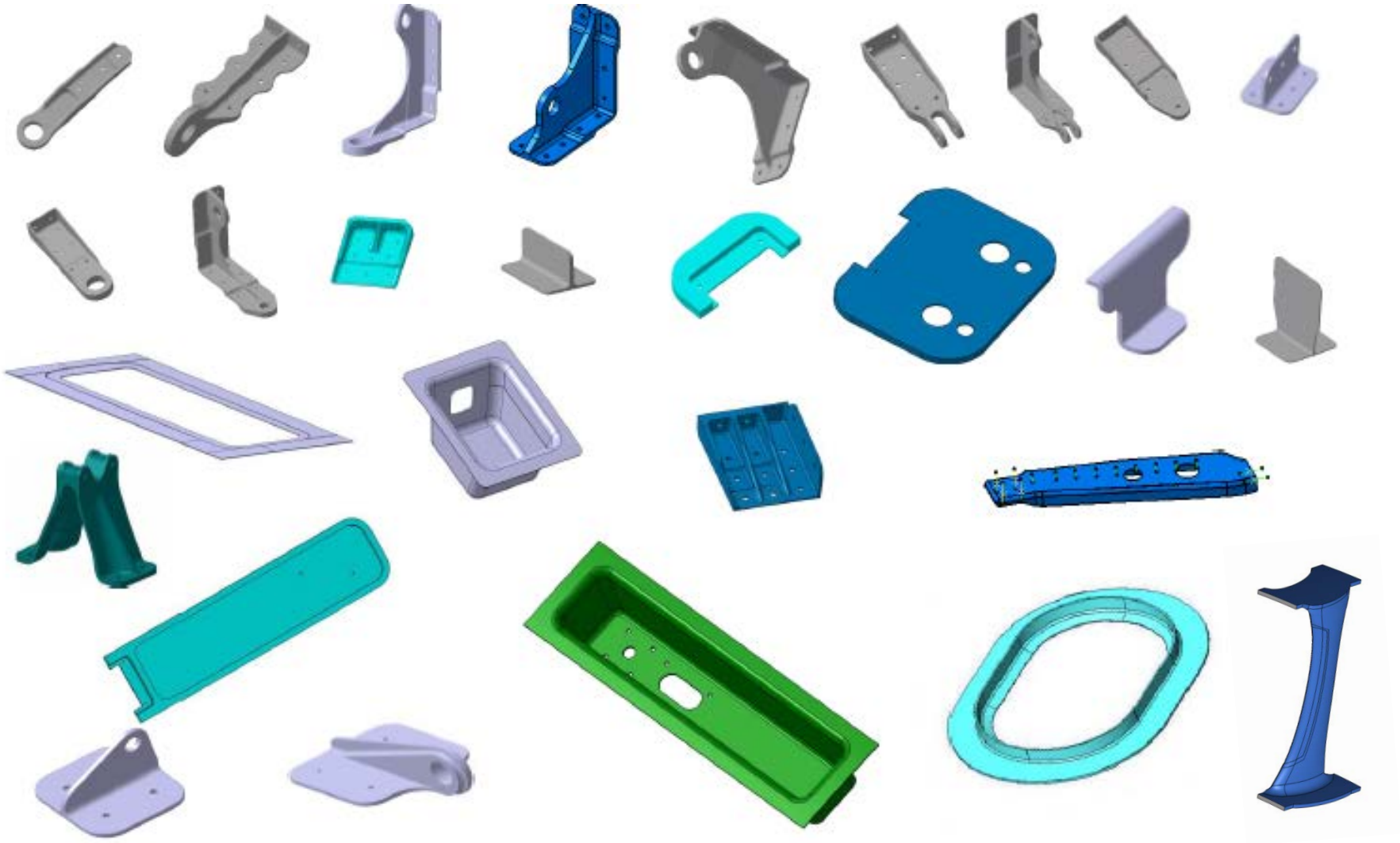
- 450mm wide roll
- 2000 gsm
- ≈2 mm thick

HexMC®: a quasi-isotropic molding compound for structural applications

Material highlights

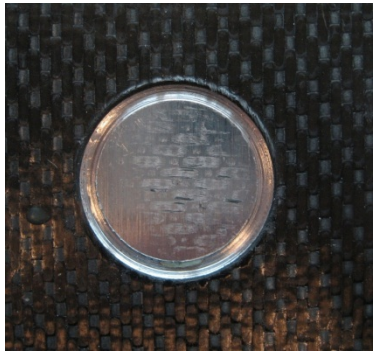
- Stiffness comparable to a QI UD lay-up
- CTE compatible with carbon fiber structures
- Excellent fatigue and thermo-cycling resistance
- Notch insensitive (OHC, OHT)
- Very tolerant to damage and defects
- Unidirectional prepreg or fabric can be co-cured to improve stiffness / strength if needed

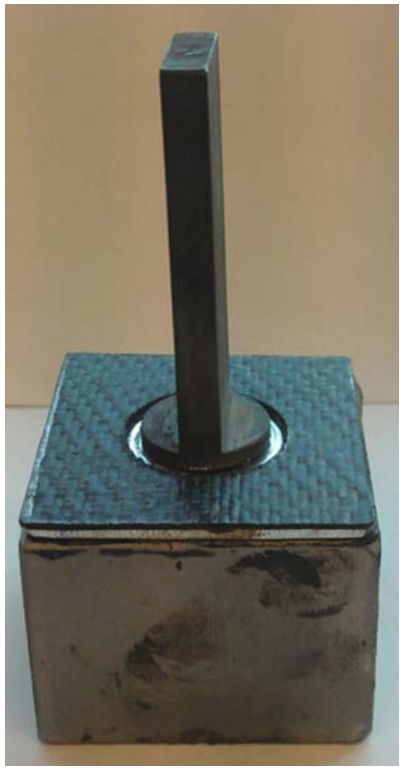
Examples of HexMC® Parts



M77 and HexMC®

- **Conventional HexMC® is formulated to cure at 120ºC in 15 minutes and can be de-moulded immediately**
- **M77 HexMC® can be cured at 150ºC in 2 minutes**
  - Tg is sufficient for hot de-moulding
- **Mould release properties can be measured using a modified flatwise tensile test**





HexMC with 'snap cure' enables high volume moulding of smaller, more complex parts

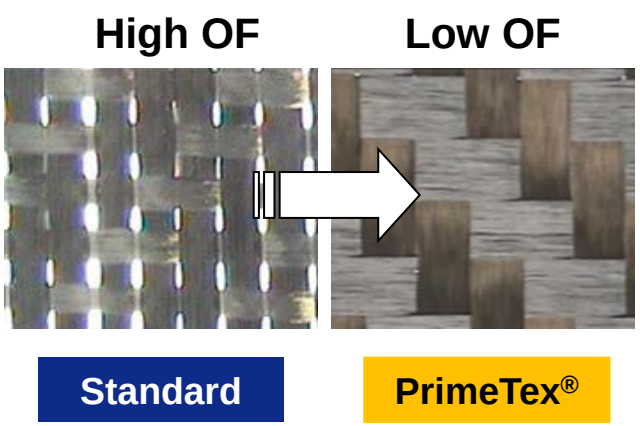
PrimeTex and M77

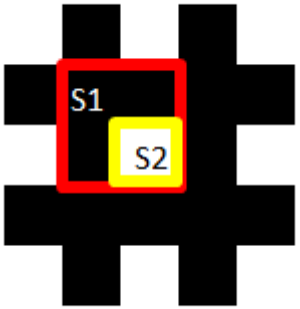
Excellent surface finish with ‘snap cure’

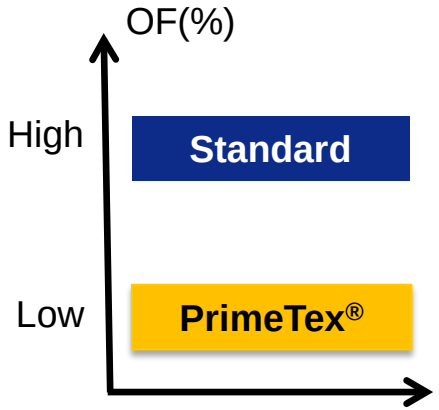
PrimeTex®

PrimeTex®: Innovative range of carbon fabrics which have been processed for a closed weave and uniform appearance

- Carbon fibre tows are woven flat and spread in both warp and weft directions
- PrimeTex® quality is measured through Open Factor (OF)

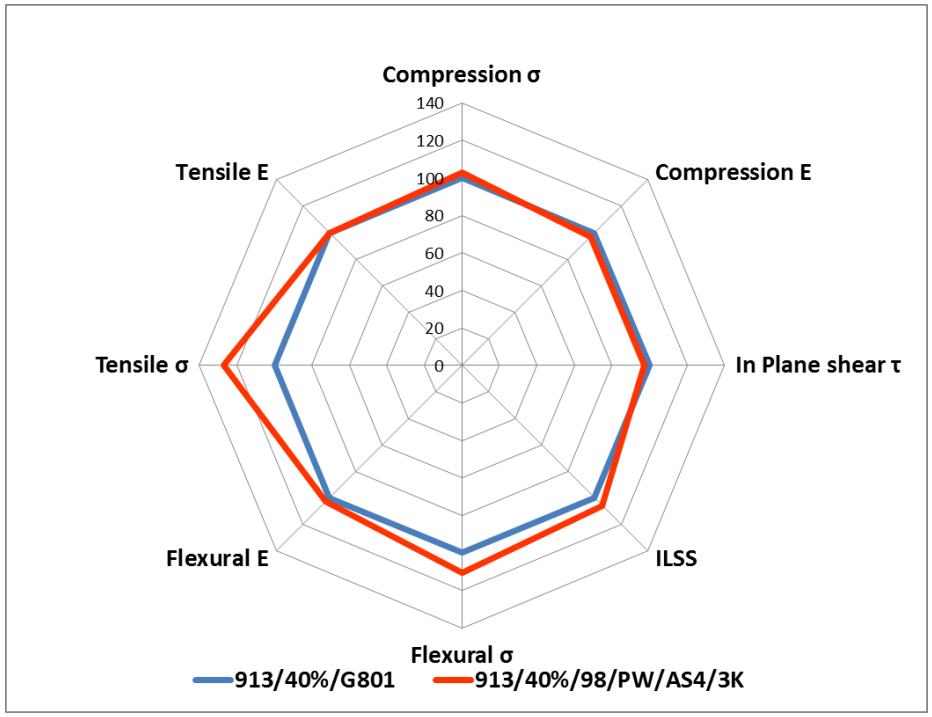


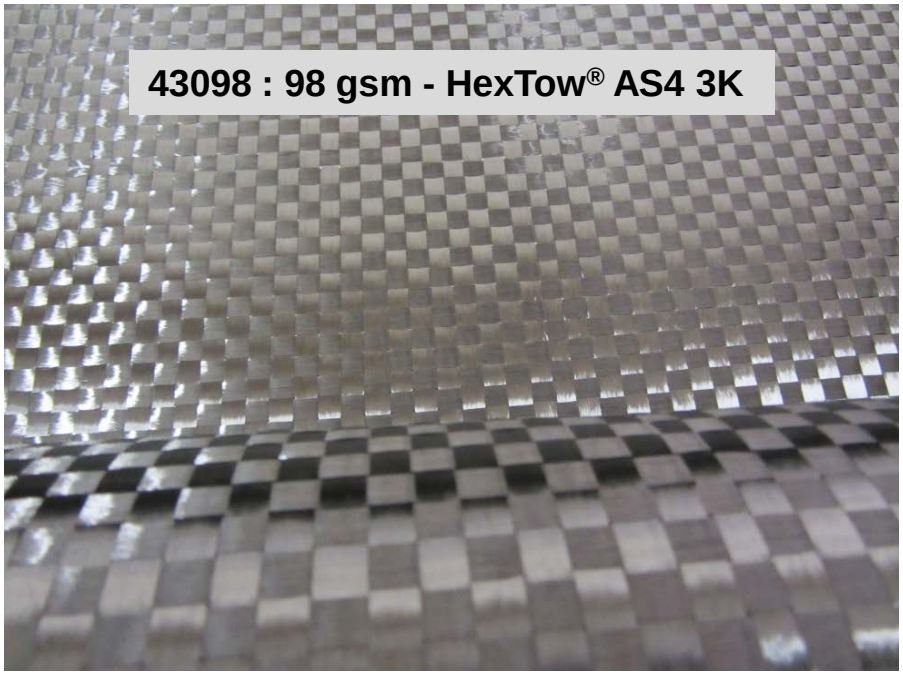




PrimeTex®, a new range of woven carbon fabrics

PrimeTex® 98 gsm – AS4 3K





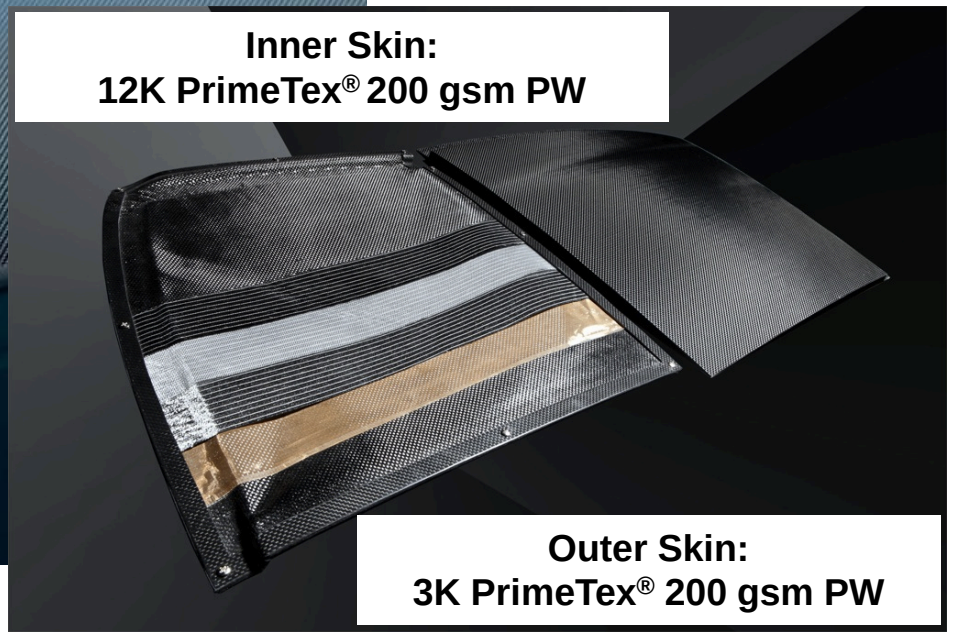
Open Factor >99%

Standard

PrimeTex®

M77 with PrimeTex fabrics- new combinations for excellent surface finish AND 'snap cure'

PrimeTex®



BMW M3/M6 series composite roof

Conclusions

- **M77 extends the boundaries of thermoset prepregs with a unique combination of properties**
  - 'Snap cure' in 2 minutes at 150^{o}C with long outlife
  - High Tg enables hot demoulding
  - Good adhesion and high toughness
- **Such fast cure is well adapted to the volume manufacture of automotive parts**
- **'Snap cure' can be combined with HexMC® for high volume moulding of smaller, more complex parts**
- **M77 on PrimeTex fabrics give new combinations for excellent surface finish and fast cure**

M77: the 'snap cure' prepreg uniquely suited to high volume manufacture of parts

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