



Snap Cure Materials for High Volume Manufacture of Automotive Parts

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Agenda

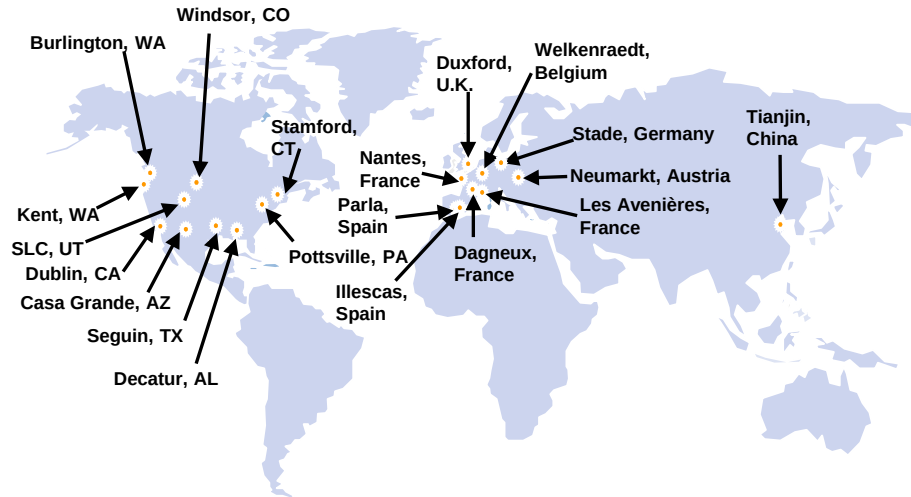
- **Hexcel overview**
- **Background to applications and solutions**
- **M77: snap cure matrix**
- **M77 HexMC: high performance moulding**
- **M77 PrimeTex: excellent surface finish**
- **Conclusions**

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

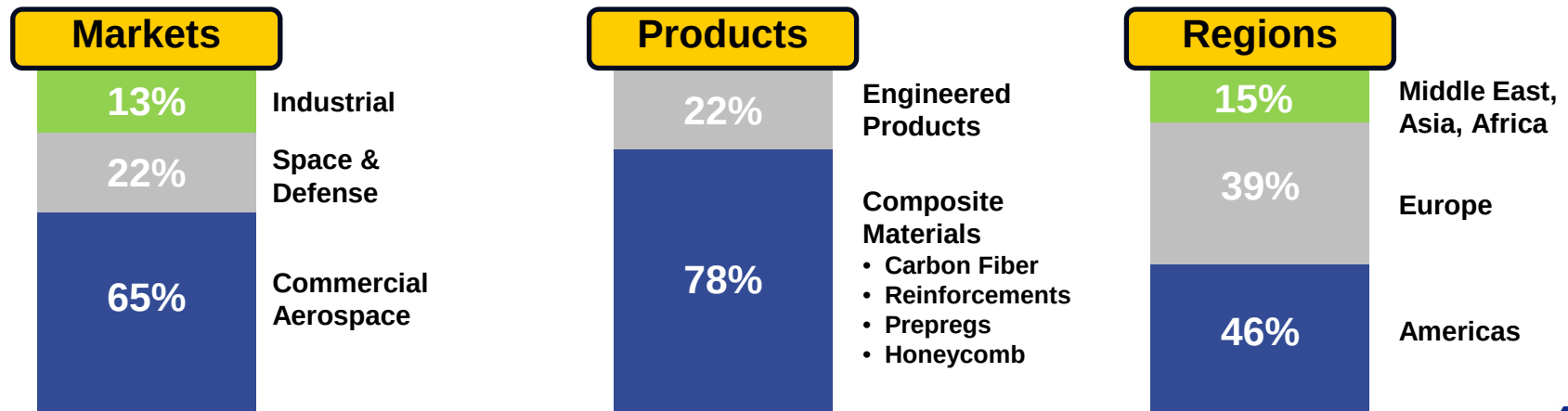


Overview

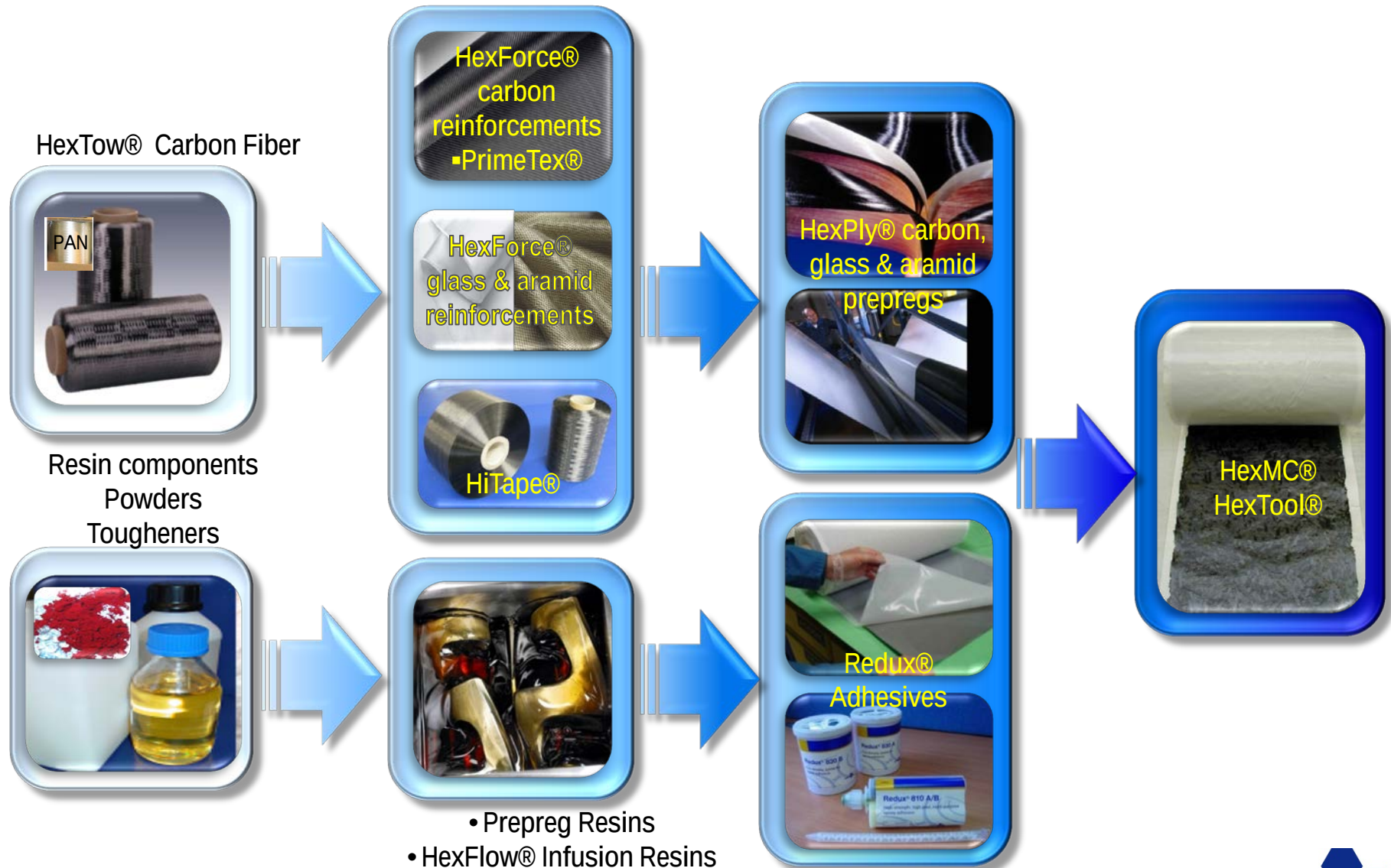


- *Leading advanced composites company with 65 years of experience*
- *Excellent customer relationships*
- *Technology leader with a broad range of products and qualifications*
- *Leading positions in all of our markets*
- *Demonstrated operational excellence*

Hexcel 2013 Total Sales of \$1.68 Billion



Supply Chain Value: Fiber/Resin → Composite Materials



Background

*Automotive applications; thermosets
and thermoplastics; prepregs*



Automobile Sections and Parts

BODY IN WHITE



% of
car
weight **35%**

CHASSIS



20%

STEERING and SUSPENSION



17%

CLOSURES



10%

INTERIOR



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

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

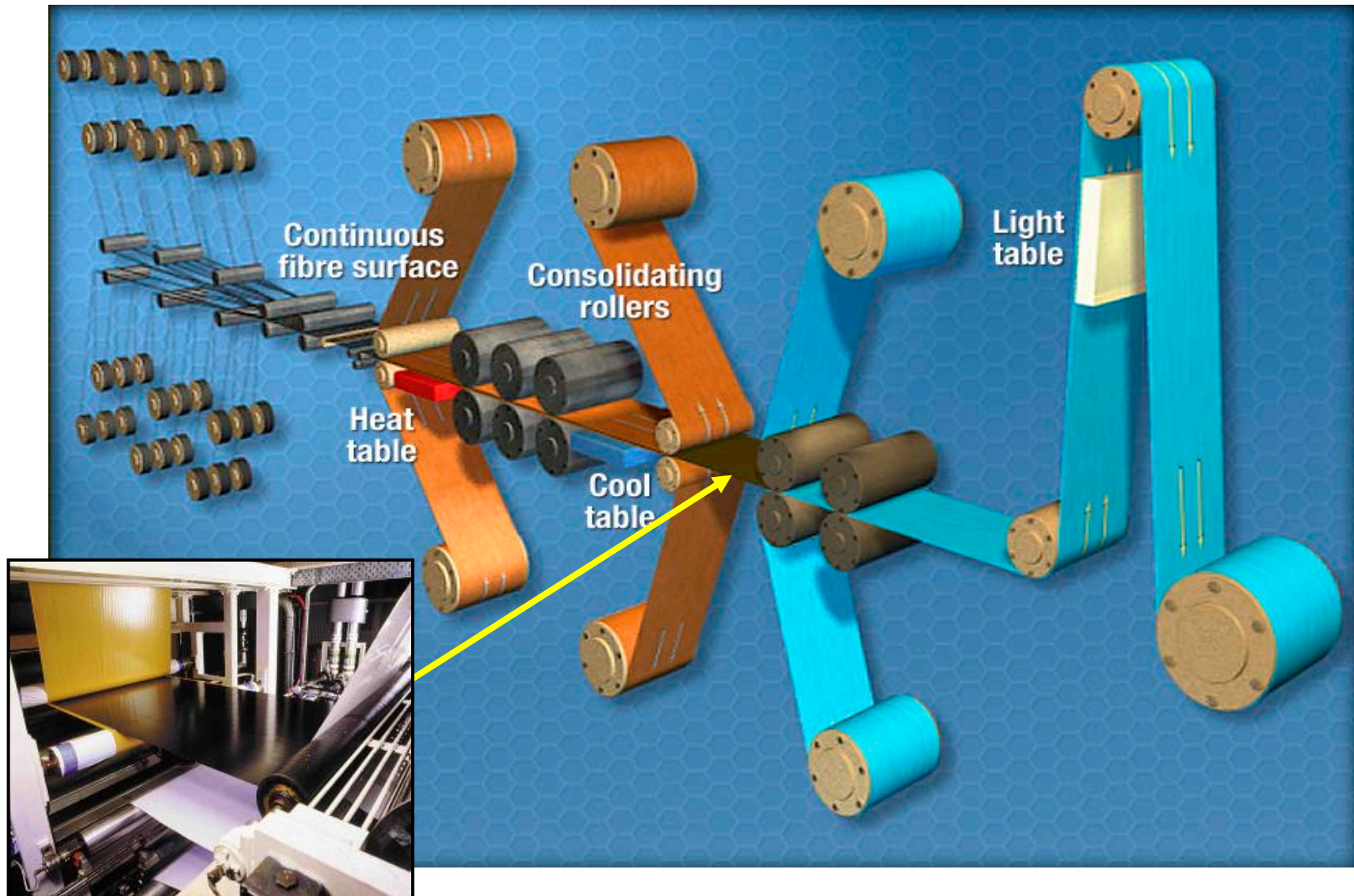
Thermosets: good mechanical properties; easier to bond; longer cycle times; difficult to rework and recycle

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



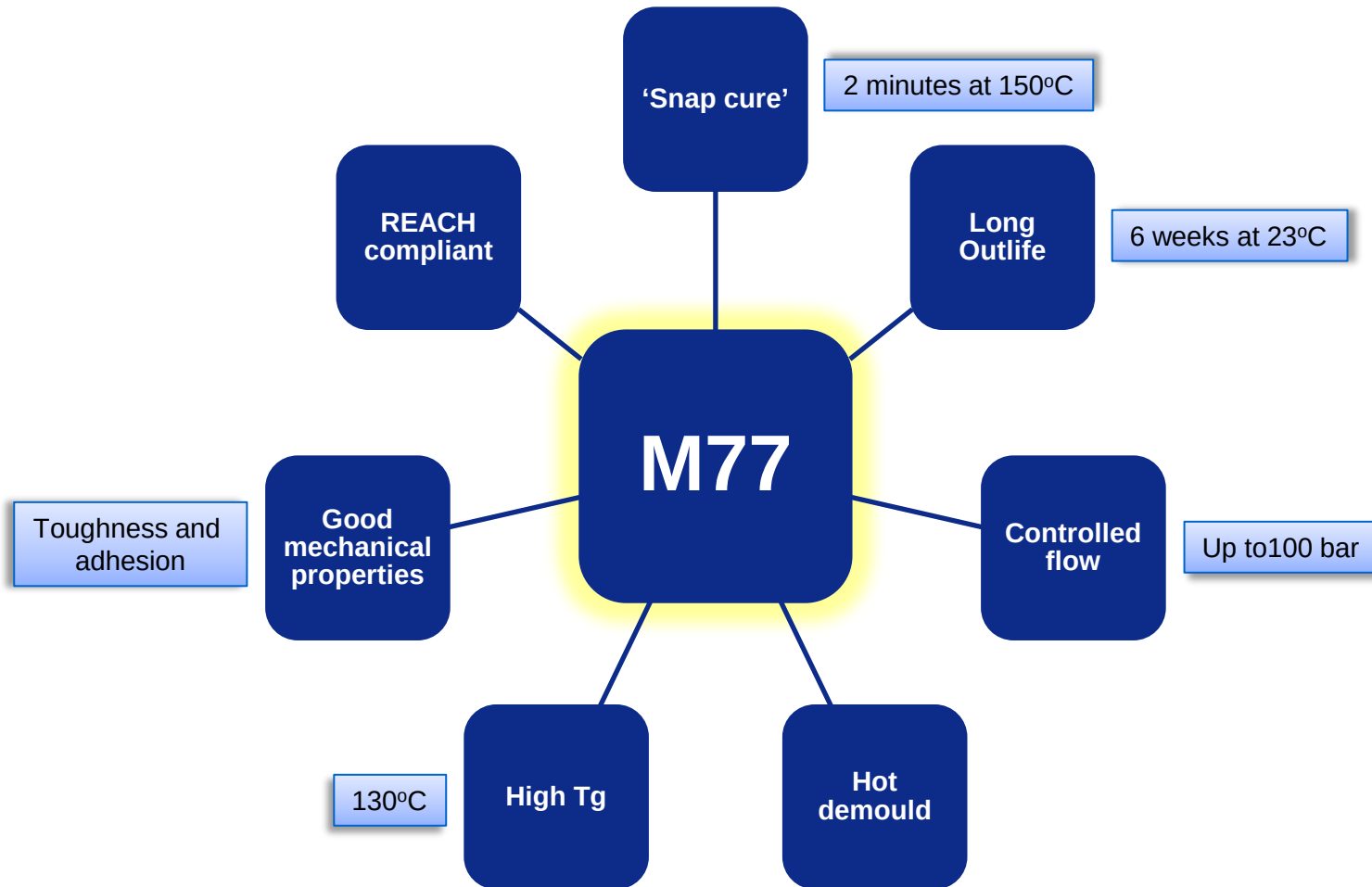


M77

'Snap cure' matrix system

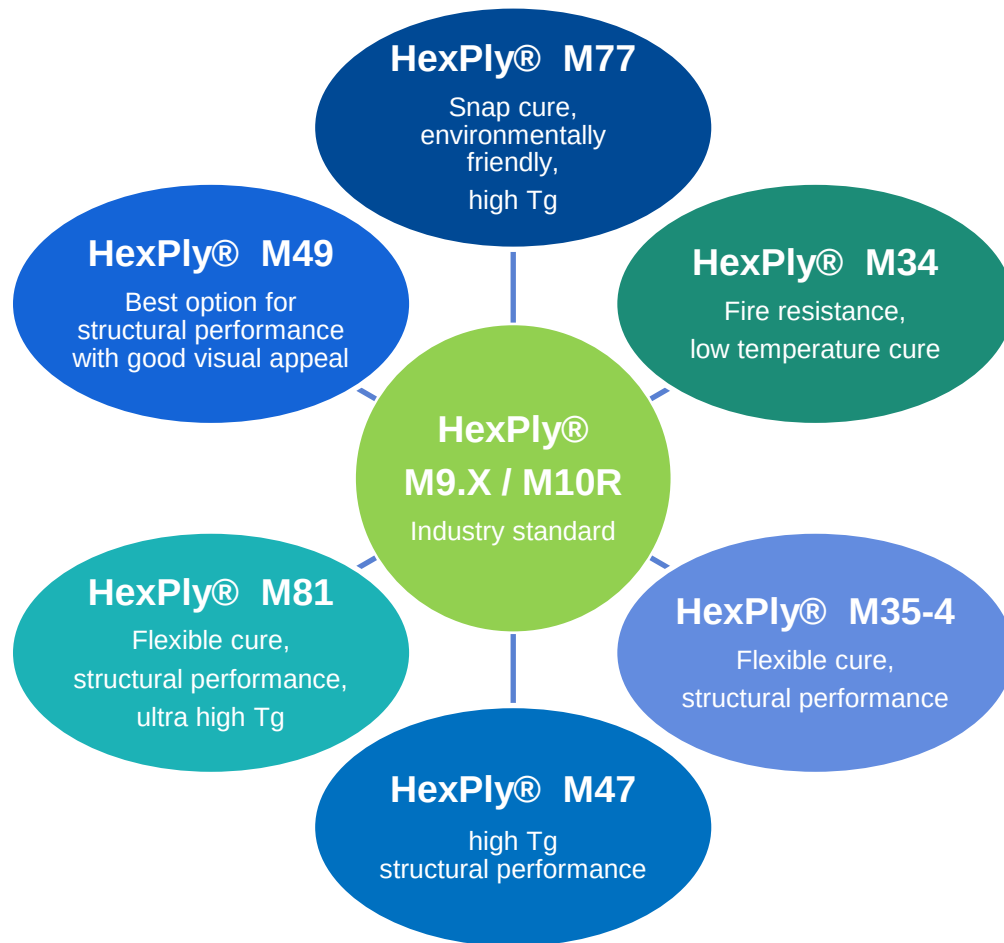


M77 Profile



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

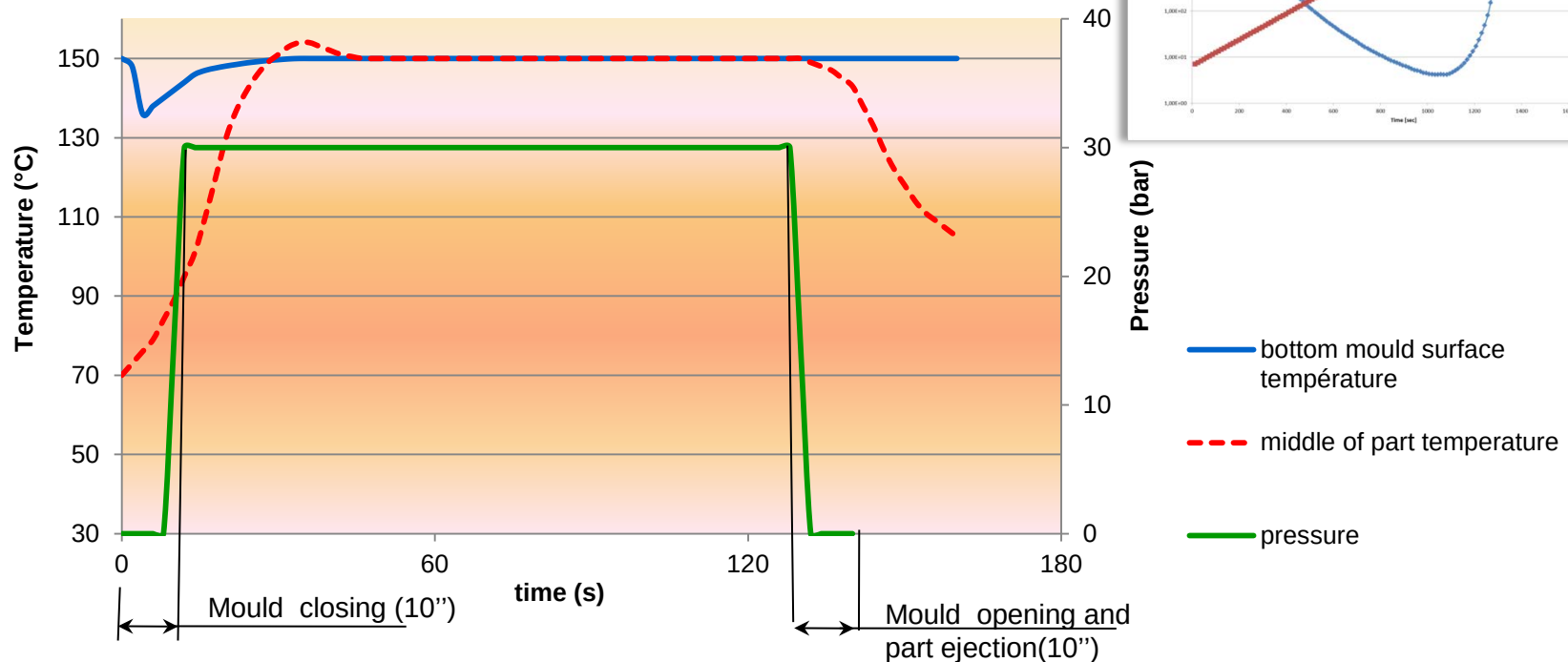
M77 in the Industrial Product Range



M77: unique 'snap cure'

M77: Designed for Press Processing

M77 cure cycle for 3mm thick part

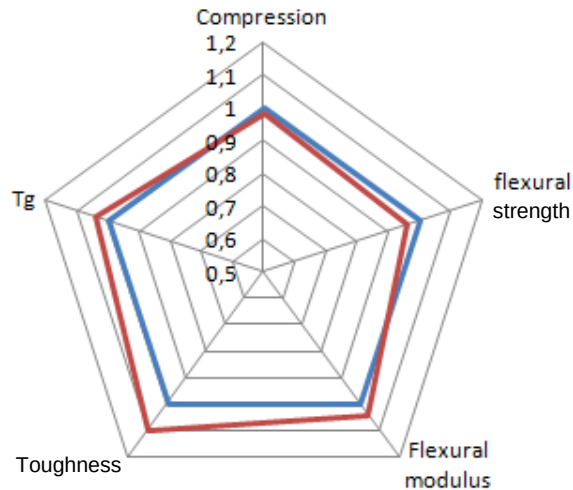


Designed for high production rates

M77 Prepreg: Mechanical Performance

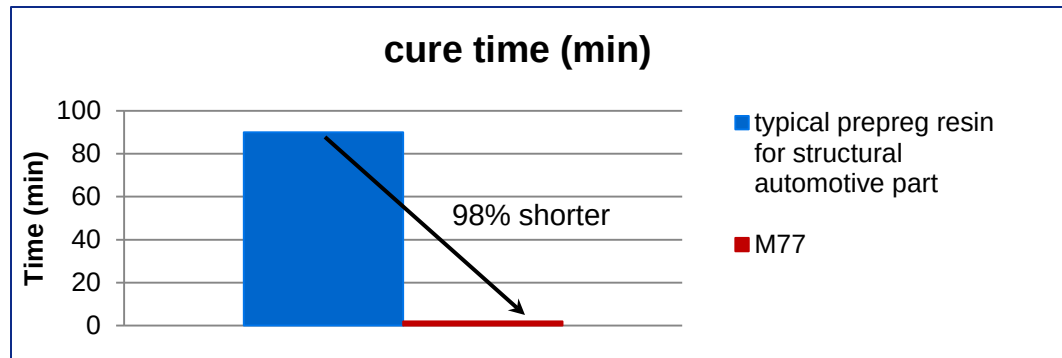
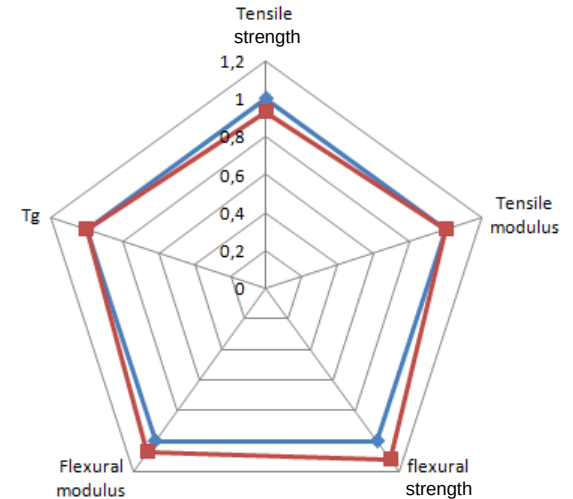
200gsm twill 2X2 3k carbon fabric

150 gsm unidirectional carbon tape



— typical prepreg resin for structural automotive part

■ M77



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

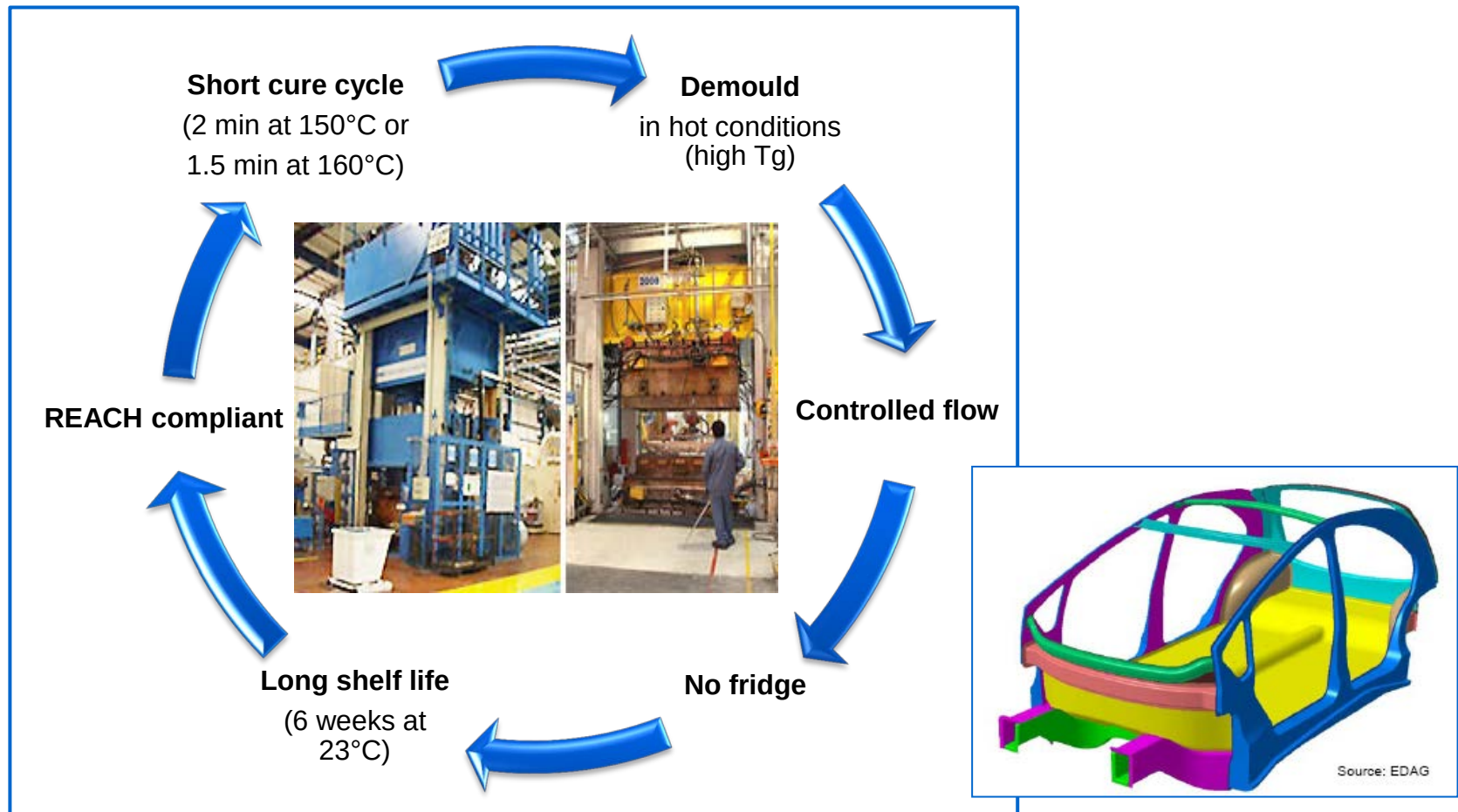
Product	Cure cycle	average	min	Max
M77/56%/200T2/CHS-3k	20 minutes at 120°C; 3 bar autoclave	37.1	34.4	42
	3 minutes at 150°C; 3 bar under press	32.3	28.7	36.5
Ref: 1454/54%/193P/3K	90 minutes at 125°C; 3 bar autoclave	33	28	38

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



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

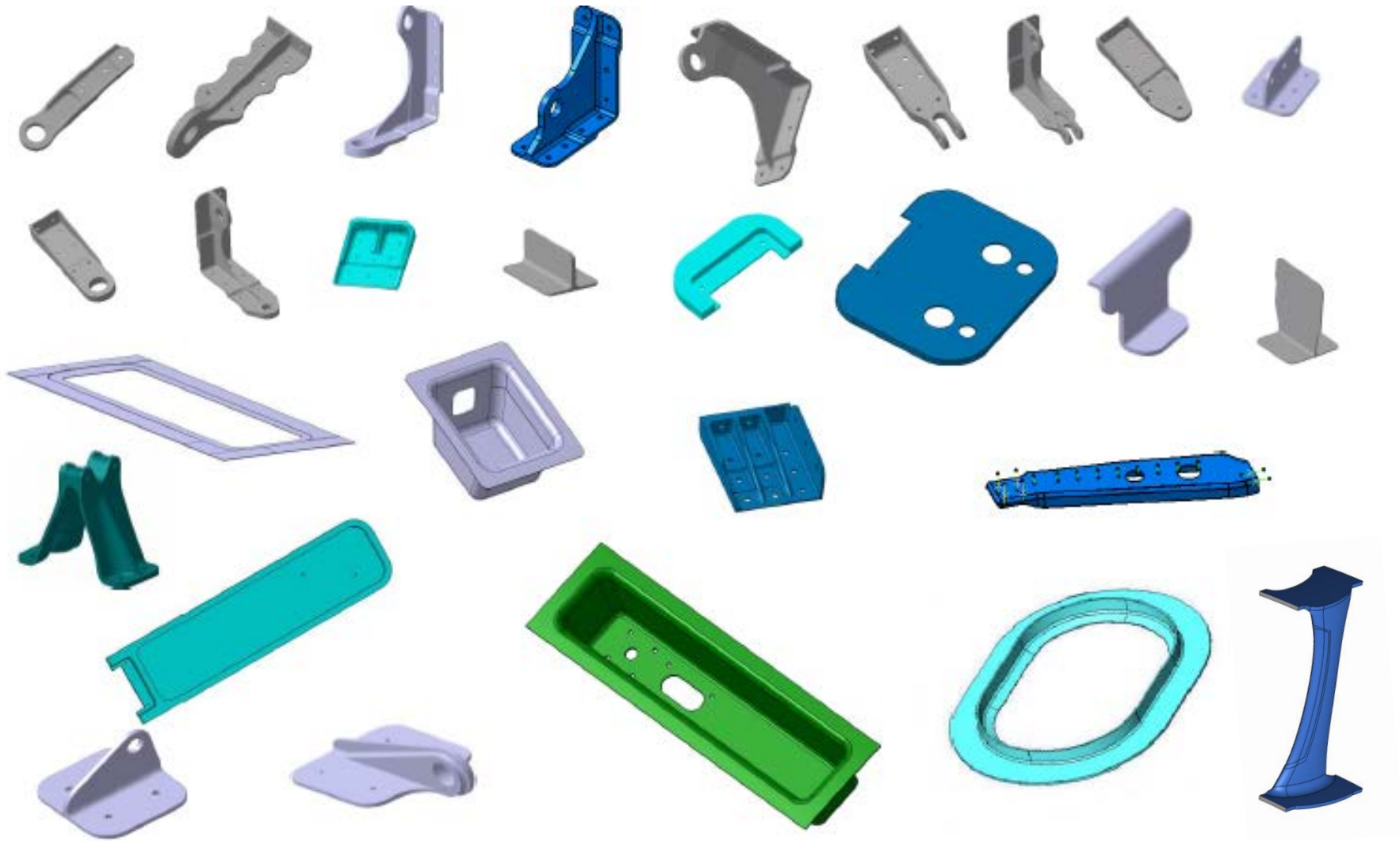
**HexMC®: a quasi-isotropic molding compound
for structural applications**

Material highlights



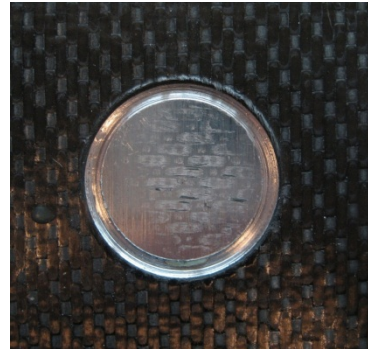
- Stiffness comparable to a QI UD lay-up
- CTE compatible with carbon fiber structures
- Excellent fatigue and thermo-cycling resistance
- Notch insensitive (OHC, OHT)
- Very tolerant to damage and defects
- Unidirectional prepreg or fabric can be co-cured to improve stiffness / strength if needed

Examples of HexMC® Parts



M77 and HexMC®

- Conventional HexMC® is formulated to cure at 120°C in 15 minutes and can be de-moulded immediately
- M77 HexMC® can be cured at 150°C 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

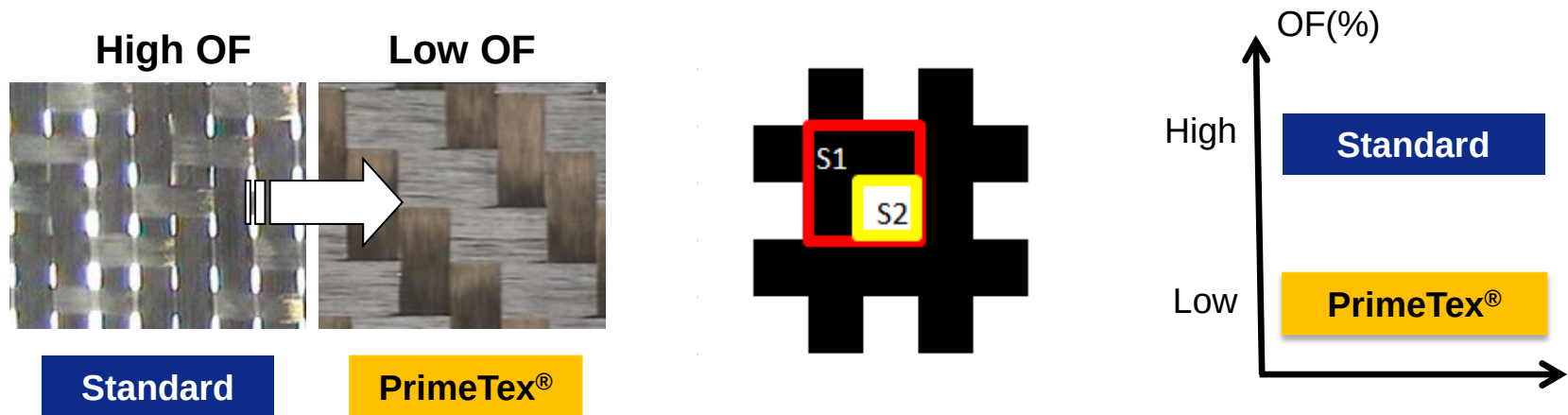
Excellent surface finish with 'snap cure'



PrimeTex®

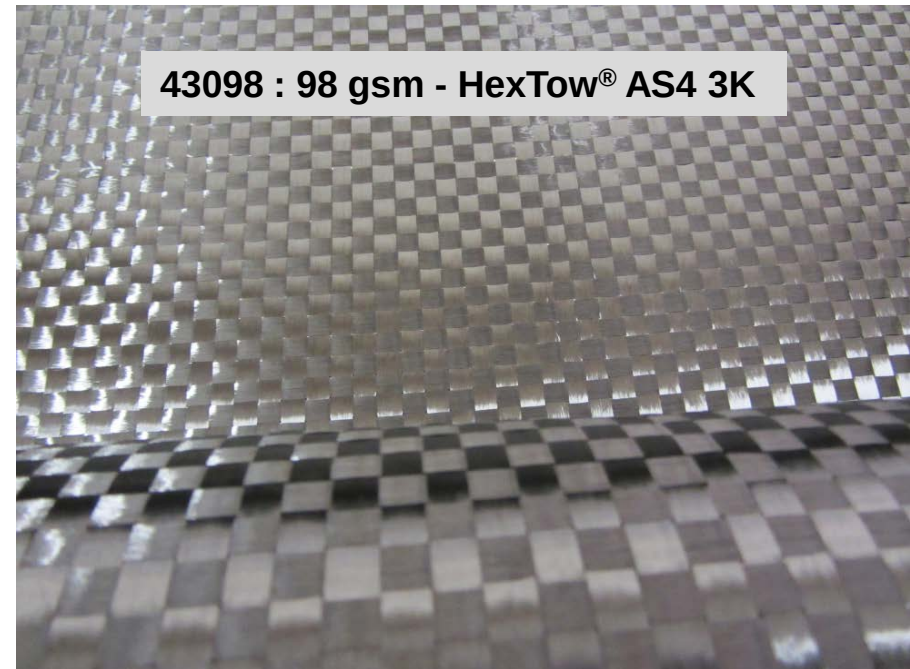
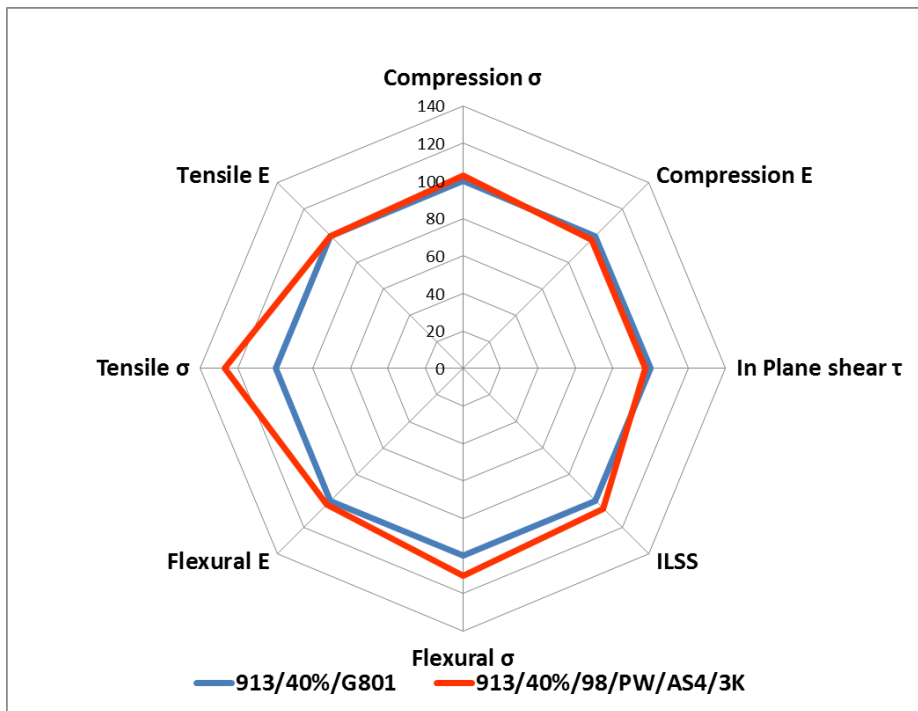
PrimeTex®: Innovative range of carbon fabrics which have been processed for a closed weave and uniform appearance

- 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



43098 : 98 gsm - HexTow® AS4 3K

Open Factor >99%

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



Inner Skin:
12K PrimeTex® 200 gsm PW



Outer Skin:
3K PrimeTex® 200 gsm PW

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°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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