PB 170, PB 250, PB 400, PB 600

Cellular Epoxy Foam Production System

PB products are 2 component epoxy foaming formulations developed for “in situ” low density epoxy foam production. Foam final density is depends only on the choice of the resin. These systems are white but can be coloured by adding any epoxy compatible pigments.
PB 170, **PB 250**, **PB 400** and **PB 600** respectively provide approximately 170, 250, 400 and 600 kg/m^3 foams. The hardener has only an influence on the curing time and thus the potential thickness of the one shot cast part.
The mixes evolves in two separate steps:

1 Fast expansion of the casting.
2 Slow hardening of the mass.

Performances

“in situ” low density foam manufacturing.
No hollow microspheres handling.
Good adhesion onto all type of materials.
PB can be cast onto prepregs and wet epoxy resins curing.
Homogeneous density.
Very low water absorption.

Applications

Production of epoxy foam.
Casting “in situ” of epoxy core materials.
Floating volume.
Increase the density of foams and honey comb.
Thermal insulation.
Machinable bloks for models.

Foaming epoxy resins PB xxx

	PB 170	PB 250	PB 400	PB 600
Aspect	Thixotropic liquid	Thixotropic liquid	Thixotropic liquid	Thixotropic liquid
Colour	White	White	White	Cream
Viscosity (mPa.s) Rheometer PP 50mm 20 °C Shear rate 10 s^{-1} 25 °C 30 °C 40 °C	 15 000 ± 3 000 8 000 ± 1 500 4 500 ± 1 000 1 800 ± 350	 22 000 ± 4 000 12 000 ± 2 000 7 500 ± 1 500 3 800 ± 800	 22 000 ± 4 000 12 000 ± 2 000 7 000 ± 1 400 3 000 ± 600	 32 000 ± 6 000 16 000 ± 3 000 10 000 ± 2 000 4 000 ± 800
Density Picnometer ISO 2811-1	1.12 ± 0.01	1.10 ± 0.01	1.14 ± 0.01	1.17 ± 0.01

Hardeners DM 0x

	DM 03	DM 02
Aspect / colour	**Light yellow liquid**	**Clear to light yellow liquid**
Reacivity	**"Standard"**	**"Slow"**
Viscosity (mPa.s)		
Rheometer PP 50 mm 15 °C	320 ± 60	190 ± 40
Shear rate 10 s^{-1} 20 °C	210 ± 40	130 ± 25
25 °C	150 ± 30	100 ± 20
30 °C	100 ± 20	70 ± 15
40 °C	60 ± 10	40 ± 10
Density 20 °C Picnometer ISO 2811-1	1.00 ± 0.01	0.98 ± 0.01

Mixing ratios

	PB 170	PB 250	PB 400	PB 600
DM 03 (standard)	100 g / 31 g	100g / 31g	100g / 32g	100g / 30g
DM 02 (slow)	100 g / 36 g	100g / 36 g	100g / 37g	100g / 35 g

Exothermic parameters

Thermal conductivity of substrate.
Open or closed moulding.
Temperature of components and ambient temperature.
Geometry, thickness, volume and mass of the casting.
For casting onto a laminate that is curing, the heat produces by the resin can influence the reactivity of the foaming system, on a thick laminate.

Recommendations for use

In order to homogenise the PB resins, mix thoroughly with a helicoidal agitator before quantity determination(take a special care to the side and base of the container).
The quantity determination have to be done by weight, with a precise scale adapted to the quantity used.
The expansion is much faster than the polymerisation: mixing and casting operations must be done as quick as possible, especially with the low density foaming systems. The maximum working time of mixes is 4 minutes.

While mixing PB resin and hardener, air is usually included. Most of these bubbles can be eliminated by simply passing the blend trough a 1 to 2 mm stainless steel net.

Expansion ratios

	Finale density after free expansion @ 20°C	Expansion ratio @ 20°C
PB 170	170 ± 20 kg / m^3	x 6.2
PB 250	250 ± 25 kg / m^3	x 4
PB 400	400 ± 30 kg / m^3	x 2.5
PB 600	600 ± 40 kg / m^3	x 1.7

For example, if the volume to fill up is 10 litres, you need :

- 10 / 6.2 = 1.62 kg **PB 170** / **DM 0x** mix
- 10 / 4 = 2.5 kg **PB 250** / **DM 0x** mix
- 10 / 2.5 = 4 kg **PB 400** / **DM 0x** mix
- 10 / 1.7 = 5.9 kg **PB 600** / **DM 0x** mix

Prepare 10 % more of mix for the waste.
Be aware of the problem of exothermal peak with large volume (see graph: Measure of the exothermal peak of the casting relative to the thickness @ 20°C, page 3 & 4.

Curing

For medium to large volume wait until every parts of the casting is hard.
If possible leave in the mould.
A minimum post cure of 6 hrs @ 40°C. is required to get a dimensional stability.

Post cure cycle:

-For small volume:
You can put directly the casting in the oven after pouring and following the schedule describe below.
-For large volume:
6 - 24 hours after the mix of the two components at ambient temperature (18 - 23°C), this will limit the exothermal peak and the risk of "burning" the material.
+ 6 hrs. at 40 °C Achieving a Tg1 of above 50 °C
+ 12 hrs. at 60 °C Achieving a Tg1 of above 70 °C

Colour

PB 170, PB 250, PB 400, PB 600 are white, coloration possible according to customer's specifications

Other versions

- **PB 350 S** / **SD 1249.17** : Sprayable version for lightened laminates. Require a machine with 2/1 pump ratio by volume and mixing in the nozzle

- **PB 270 i** / **DM 0x**, **PB 370 i** / **DM 0x** Fire retardant auto extinguishing version of PB. Fire resistance according FAR 25 § 25-853 (a)

Other blends

PB	SD	Weight ratios	Tg 1 max (°C)
PB 170	**SD 2505**	100 / 30	97
	SD 8203	100 / 30	115
	SD 7820	100 / 30	129
	DM 06	100 / 40 (2 / 1 volume)	90
PB 250	**SD 8205**	100 / 27	96
	SD 7820	100 / 30	125
	SD 2630	100 / 27	137
	DM 06	100 / 40 (2 / 1 volume)	90
PB 400	**SD 7820**	100 / 28	133
	SD 2630	100 / 27	135
	DM 06	100 / 40 (2 / 1 volume)	90
PB 600	**SD 7820**	100 / 27	137
	SD 2630	100 / 26	142
	DM 06	100 / 40 (2 / 1 volume)	90

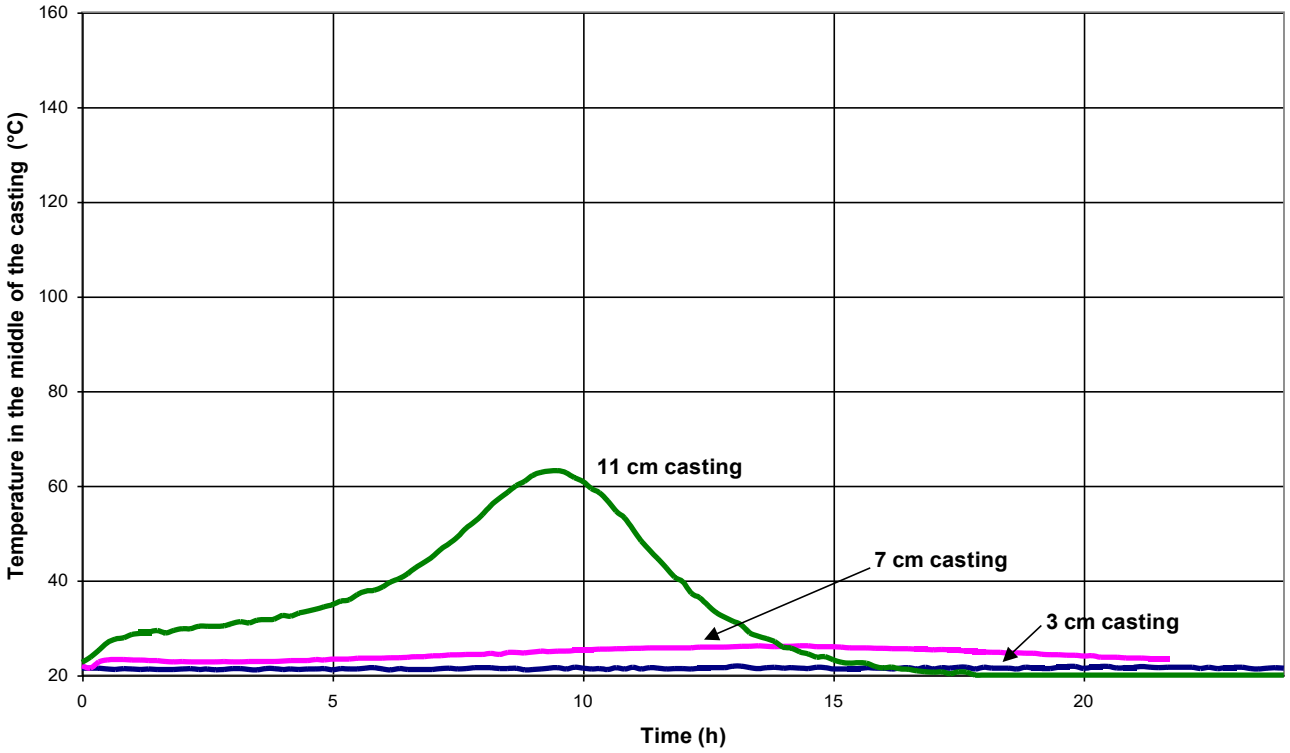
Material thermal conductivity

Materials	Density (kg / m³)	Thermal Conductivity at 20 °C (W / m x °C)
Copper	8800	380
Composite Carbon / carbon	1700 – 2000	300
Aluminium (AU 4G)	2800	140
Steel	7800	20 to 100
Carbon fiber: HR or HM	1800	200
E glass fiber	2600	1
Aramid fiber	1450	0.03
Concrete	2000 to 2500	1 to 1.5
Plaster		0.37
Expanded PVC (Forex)	650	0.12
PB 600 epoxy foam	**600**	**0.157**
PB 400 epoxy foam	**400**	**0.130**
PB 250 epoxy foam	**250**	**0.065**
Extruded polyethylene foam	35 to 150	0.05
Herex C70.33 C70.75 C70.200	33, 80 and 200	0.030, 0.033 and 0.048
Airex R82.80 R 82.110	80 and 110	0.037 and 0.040
Airex R63.80 R63.140	90 and 140	0.034 and 0.039
Kapex C51	60	0.036
Non-filled thermoset resins Epoxy, polyester, phenolic	1100 to 1300	0.2
Polyethylene LD / HD	960	0.25 to 0.34
Laminate E glass / epoxy		0.3 to 0.8
Wood	400 to 700	0.12 to 0.2
Balsa	100 to 250	0.051 to 0.090
Expanded Polystyrene	20	0.035
Extruded Polystyrene	28 to 45	0.033 to 0.025
Air		0.021

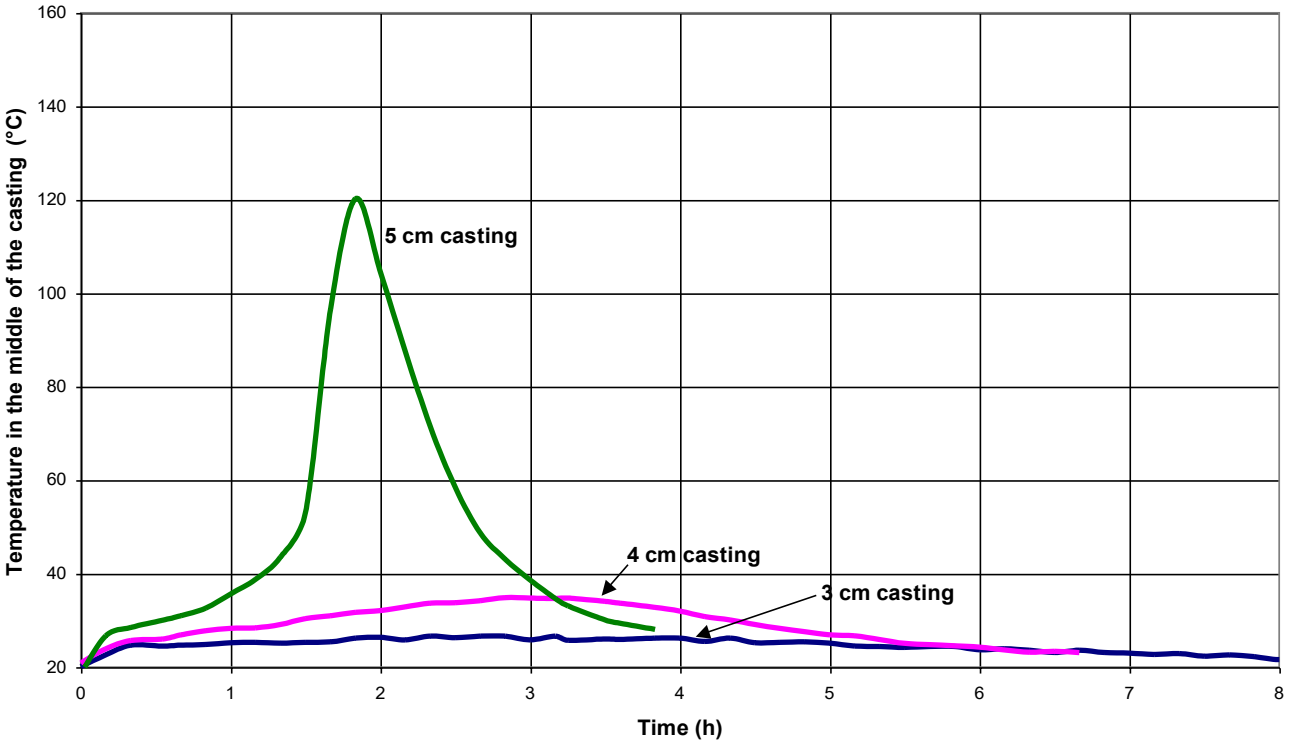
Exothermal of cast relative to thickness at 20°C , open mould 480x 480 mm

- **PB 250**

PB 250 / DM 02

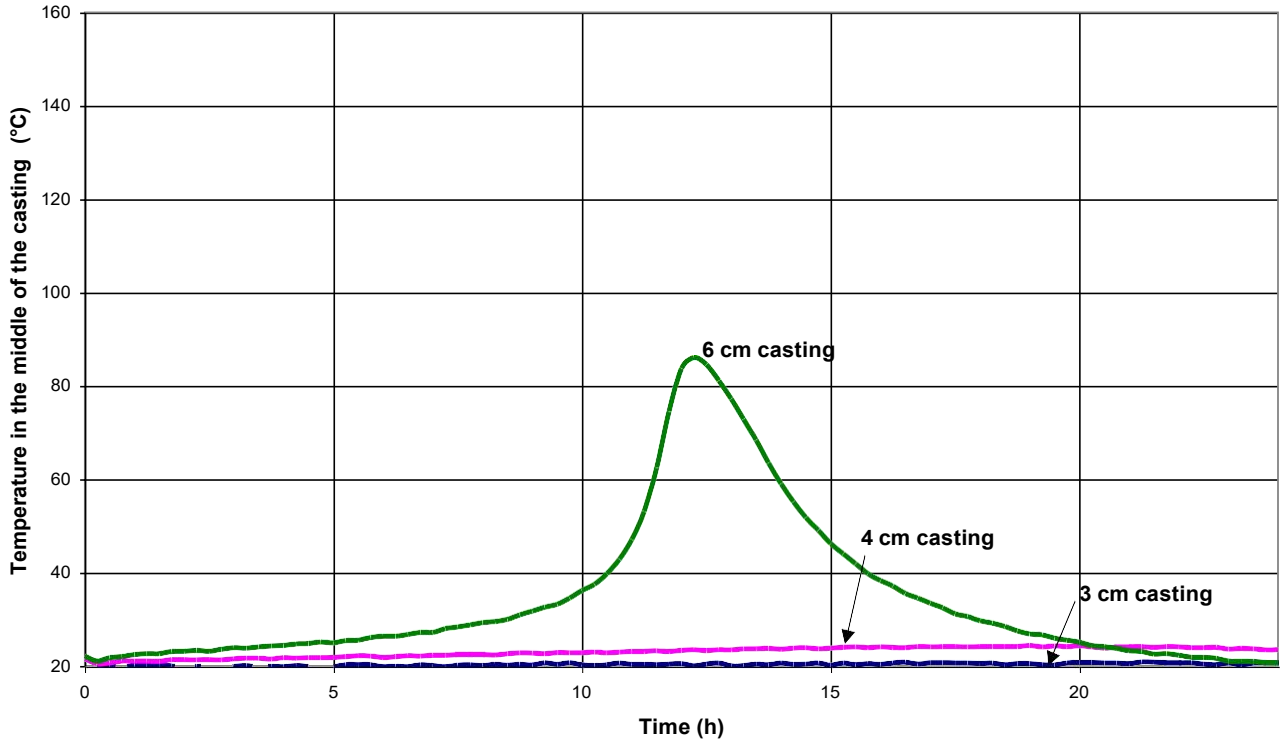


PB 250 / DM 03

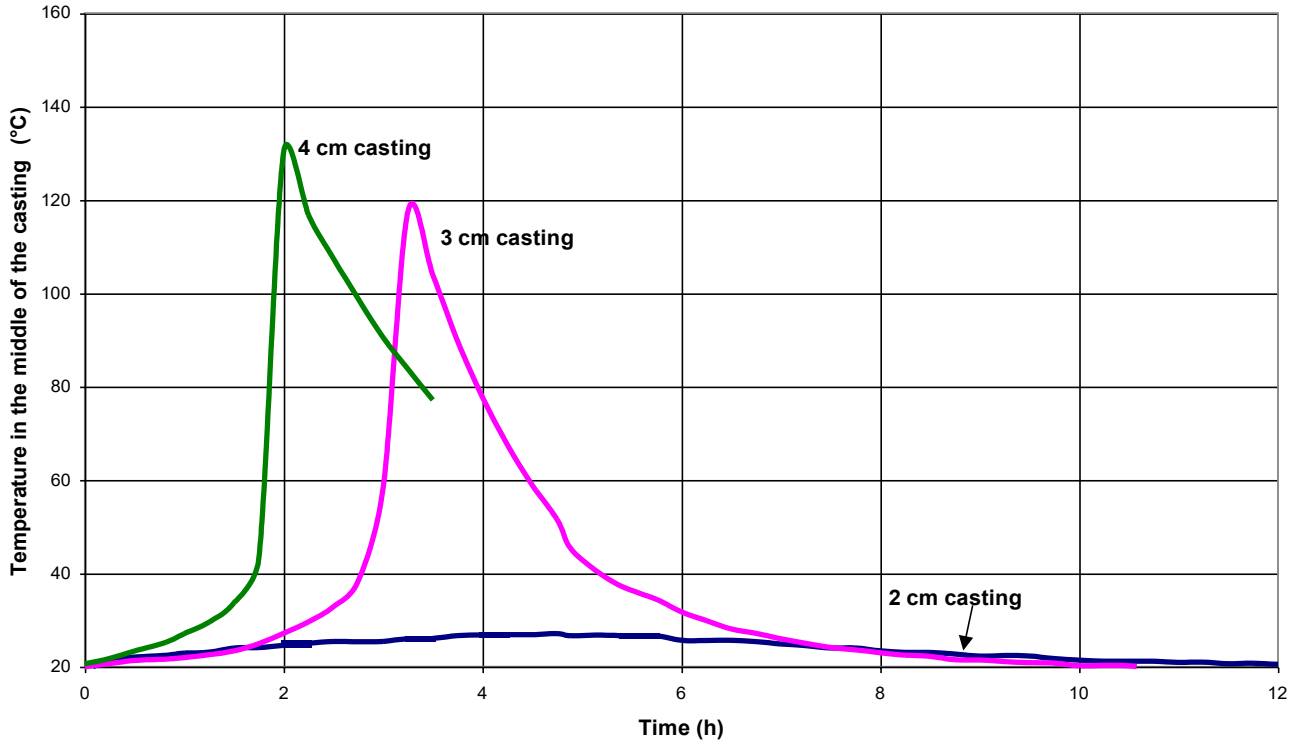


- PB 400

PB 400 / DM 02

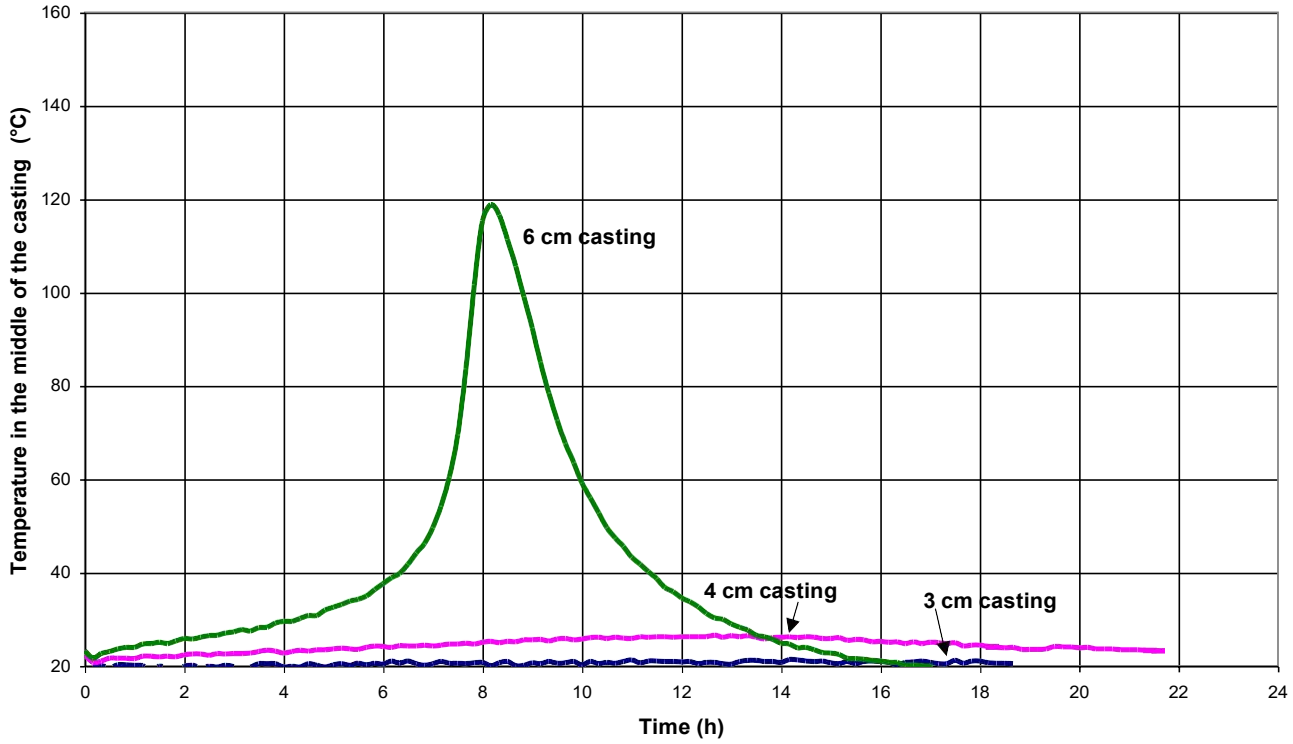


PB 400 / DM 03

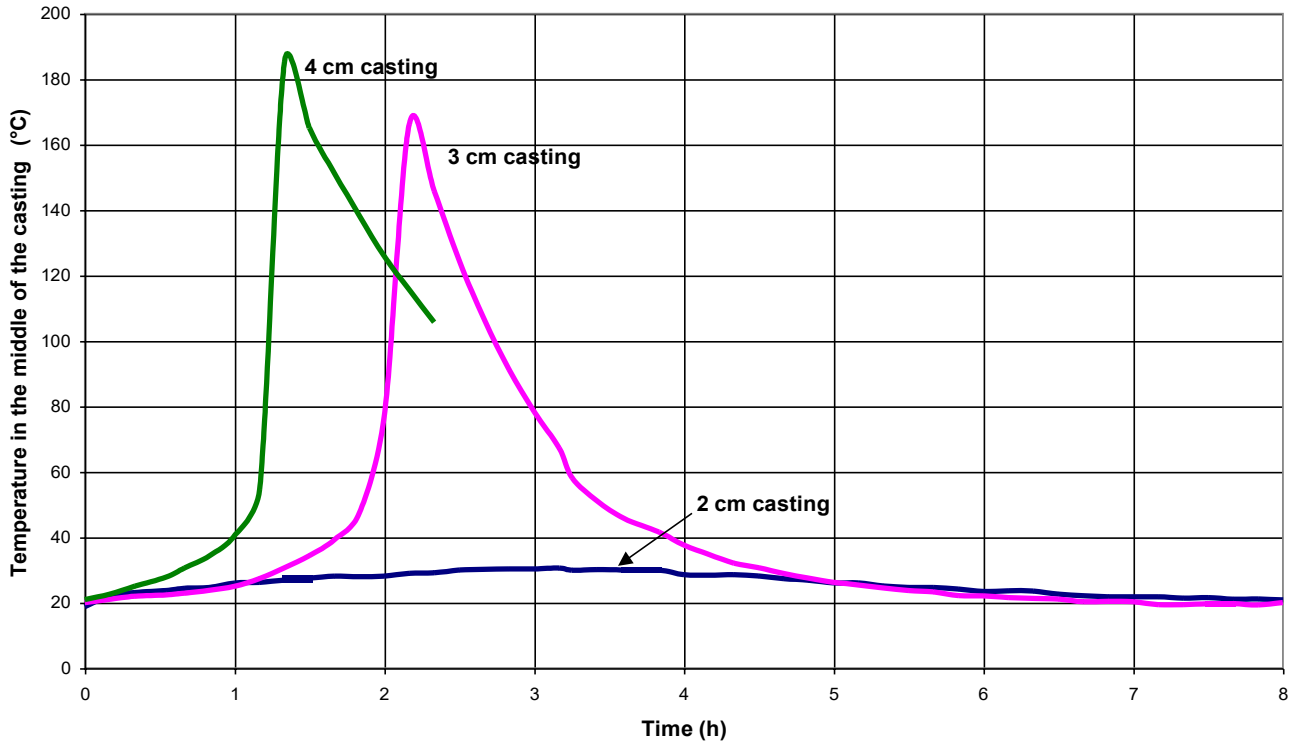


- PB600

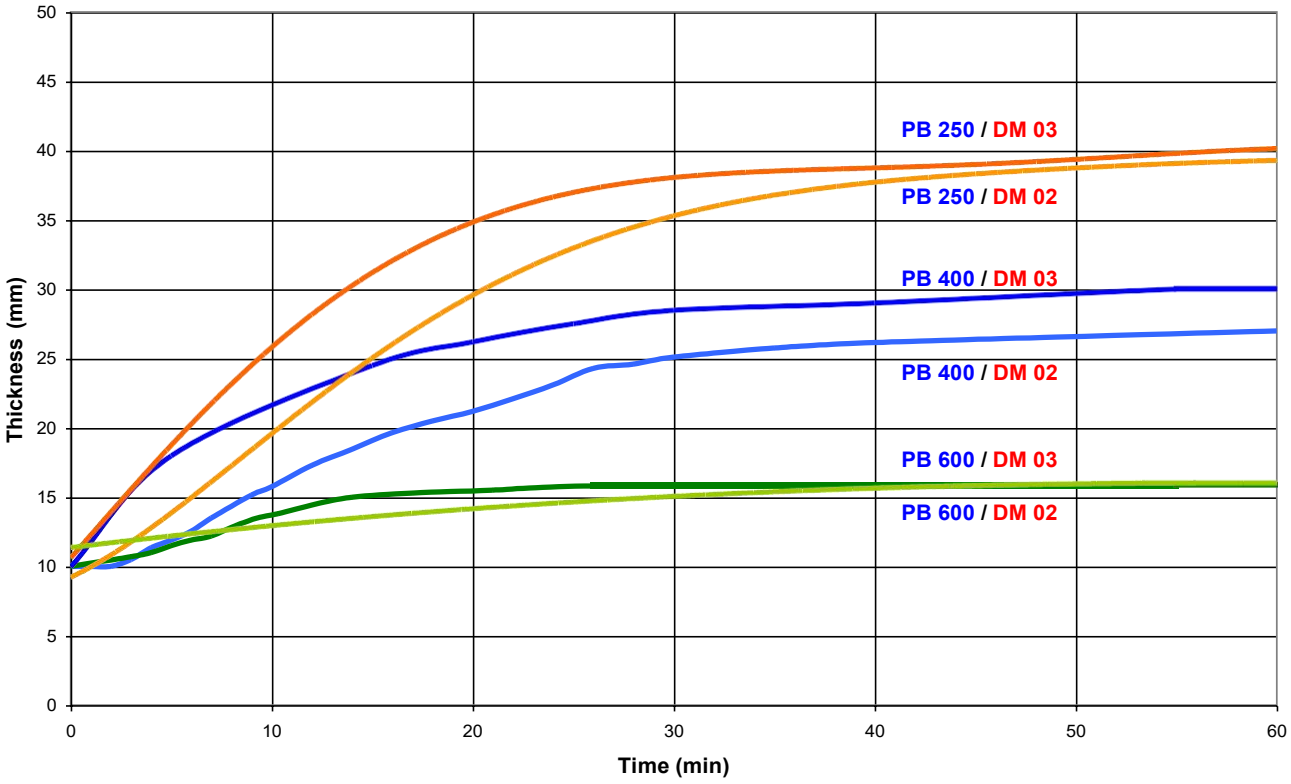
PB 600 / DM 02



PB 600 / DM 03



Expansion speed of a 10 mm cast at 20 °C



Mechanical Properties of cured foam

		PB 170 / DM 02		PB 170 / DM 03	
Curing cycle		48 h Tamb + 24 h 40 °C	48 h Tamb + 6 h 40 °C +16 h 60 °C	48 h Tamb + 24 h 40 °C	48 h Tamb + 6 h 40 °C + 16 h 60 °C
Compressive strength					
Modulus of elasticity	N/mm^2	75	61	90	100
Compressive yield strength	N/mm^2	2	1.8	2.4	2.4
Offset compressive yield	%	3.9	4.7	4.8	5.7
Flexion					
Modulus of elasticity	N/mm^2	128	115	122	105
Maximum resistance at break	N/mm^2	1.7	1.4	1.9	2.3
Elongation at maximum load	%	2	1.8	2.4	1.7
Shear strength					
Modulus of elasticity	N/mm^2	82	72	79	85
Shear load at break	N/mm^2	1.3	1.1	1.5	1.6
Elongation at break	%	5.8	5.7	6.2	6.7
Glass transition					
Tg1	°C	64	85	69	85
Tg1 max.	°C		90		92

Tests carried out on samples of pure cast resin, without prior degassing, between steel plates.
Measures undertaken according to the following norms :

Flexion :	NF T 51-001
Compression:	NF T 51-101
Shear strength	ASTM 1041D
Glass transition DSC :	ISO 11357-2 : 1999 -5°C to 180°C under nitrogen gaz
	Tg1 or Onset : 1st point at 20 °C/mn
	Tg1 maximum or Onset : second passage

Mechanical Properties of cured foam

		PB 250 / DM 02				PB 250 / DM 03			
Curing cycle		48 h Tamb + 6 h 40 °C	48 h Tamb + 6 h 40 °C + 48 h water	48h Tamb + 6 h 40 °C +16 h 60 °C	48 h Tamb + 6 h 40 °C + 16 h 60 °C + 48 h water	48 h Tamb + 6 h 40 °C	48 h Tamb + 6 h 40 °C + 48 h water	48 h Tamb + 6 h 40 °C + 16 h 60 °C	48 h Tamb + 6 h 40 °C +16 h 60 °C + 48 h water
Compressive strength									
Modulus of elasticity	N/mm^2	205	155	135	140	240	160	180	175
Compressive yield strength	N/mm^2	6	6	5	5	6	6	6	7
Offset compressive yield	%	3.6	6.1	4.5	4.7	3.7	6.1	5.3	5.8
Flexion									
Modulus of elasticity	N/mm^2	275		240		255		235	
Maximum resistance at break	N/mm^2	5		6		5		5	
Elongation at maximum load	%	1.9		2.3		1.8		2.0	
Shear strength									
Modulus of elasticity	N/mm^2			100				120	
Shear load at break	N/mm^2			3				3	
Elongation at break	%			16				13	
Water absorption	%weight		+ 0.69		+ 1.0		+ 0.98		+ 1.0
Glass transition									
Tg1	°C	60	95	76	93	59	83	75	95
Tg1 max.	°C			94				88	

Tests carried out on samples of pure cast resin, without prior degassing, between steel plates.
Measures undertaken according to the following norms :

Flexion :	NF T 51-001
Compression:	NF T 51-101
Shear strength	ASTM 1041D
Water absorption:	Internal. Polymerisation according to cycle, machining, weighing, time spent in distilled water at 70 °C / 48 hours, weighing 1 hour after emerging,
Glass transition DSC :	ISO 11357-2 : 1999 -5°C to 180°C under nitrogen gaz Tg1 or Onset : 1st point at 20 °C/mn *Tg1 maximum or Onset : second passage*

Mechanical Properties of cured foam

		PB 400 / DM 03		PB 600 / DM 02				PB 600 / DM 03			
Curing cycle		48 h Tamb +24 h 40°C	48 h Tamb +6h 40 °C +16h 60°C	48 h Tamb +6 h 40 °C	48 h Tamb +6h40° C +48h water	48 h Tamb + 6h 40 °C +16h 60°C	48 h Tamb + 6h 40 °C +16h 60 °C + 48h water	48 h Tamb + 6h40°C	48 h Tamb + 6h 40°C +48h water	48h Tamb + 6h 40 °C +16h 60 °C	48h Tamb + 6h 40 °C +16h 60 °C + 48h water
Compressive strength											
Modulus of elasticity	N/mm^2	290	290	620	425	580	460	670	445	630	435
Compressive yield strength	N/mm^2	11	12	26	28	27	28	27	28	30	28
Offset compressive yield	%	7.7	8.0	6.4	13	8.1	11.2	6.3	11.2	8.6	11.6
Flexion											
Modulus of elasticity	N/mm^2	470	460	1160		1085		1230		1150	
Maximum resistance at break	N/mm^2	12	11	19		21		21		21	
Elongation at maximum load	%	3.0	2.9	1.8		2.0		1.8		2.0	
Shear strength											
Modulus of elasticity	N/mm^2	225	240								
Shear load at break	N/mm^2	6.9	7.1								
Elongation at break	%	12	12								
Water absorption	%weight				+ 0.44		+ 0.46		+ 0.61		+ 0.61
Glass transition											
Tg1	°C	62	79	62	92	77	93	59	82	74	81
Tg1 max.	°C		84			97				90	

Tests carried out on samples of pure cast resin, without prior degassing, between steel plates.
Measures undertaken accordi ng to the following norms :

Flexion :	NF T 51-001
Compression:	NF T 51-101
Shear strength	ASTM 1041D
Water absorption:	Internal. Polymerisation according to cycle, machining, weighing, time spent in distilled water at 70 °C / 48 hours, weighing 1 hour after emerging,
Glass transition DSC :	ISO 11357-2 : 1999 -5°C to 180°C under nitrogen gaz Tg1 or Onset : 1st point at 20 °C/mn Tg1 maximum or Onset : second passage

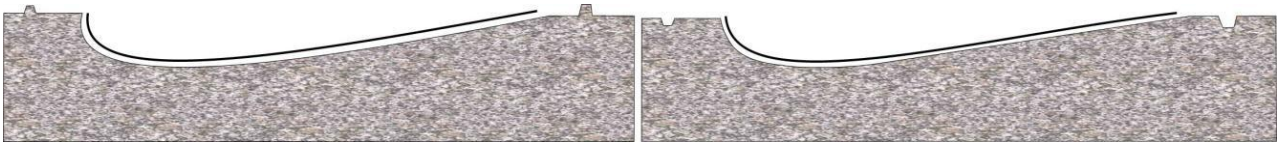
Mechanical Properties of cured foam with SD 2630

		PB 250 / SD 2630	PB 400 / SD 2630	PB 600 / SD 2630
Cycles de polymérisation		48 h 23 °C + 4 h 40°C + 4 h 60°C + 4 h 80°C + 4 h 100°C + 12 h 130°C	48 h 23 °C + 4 h 40°C + 4 h 60°C + 4 h 80°C + 4 h 100°C + 12 h 130°C	48 h 23 °C + 4 h 40°C + 4 h 60°C + 4 h 80°C + 4 h 100°C + 12 h 130°C
Compressive strength				
Modulus of elasticity	N/mm^2	115	239	468
Compressive yield strength	N/mm^2	4.6	12.6	32.6
Offset compressive yield	%	6.6	15.8	17.1
Flexion				
Modulus of elasticity	N/mm^2	140	320	870
Maximum resistance at break	N/mm^2	3.1	7.6	16.8
Elongation at maximum load	%	2.1	2.3	2.0
Shear strength				
Modulus of elasticity	N/mm^2	106	205	332
Shear load at break	N/mm^2	2.9	6.5	13.4
Elongation at break	%	9.3	8.9	9.5
Glass transition				
Tg1	°C	147	147	151
Tg1 max.	°C	141	141	149

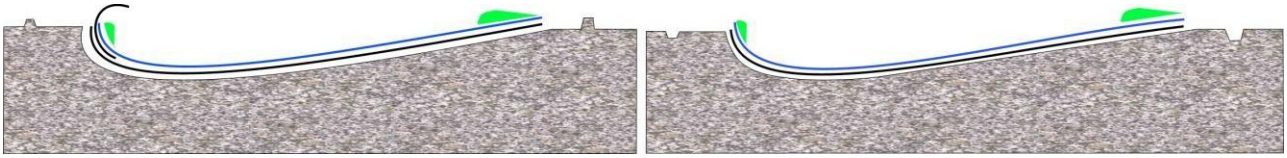
Tests carried out on samples of pure cast resin, without prior degassing, between steel plates.
Measures undertaken according to the following norms :

Flexion :	NF T 51-001
Compression:	NF T 51-101
Shear strength	ASTM 1041D
Glass transition DSC :	ISO 11357-2 : 1999 -5°C to 180°C under nitrogen gaz Tg1 or Onset : 1st point at 20 °C/mn Tg1 maximum or Onset : second passage

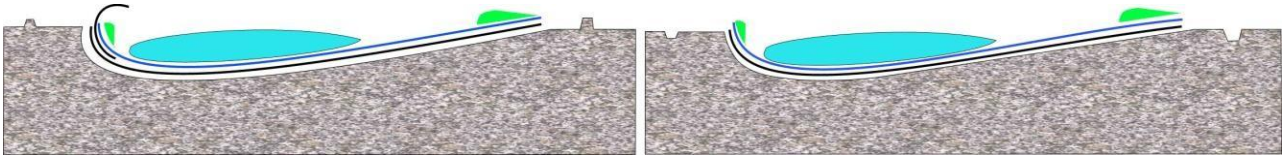
Use of PB epoxy foam for daggerboard or foil manufacturing



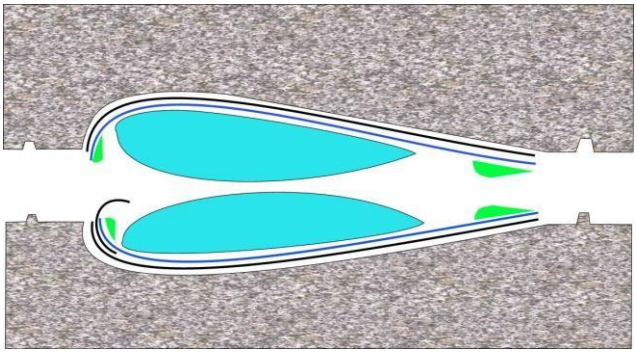
Hand laminating of the skins in the mould or bulking of the prepreg layers under vacuum.
After cure of the laminate take the peelply off
With polyester skins, finish the laminate with a dry CSM (mechanical key), post cure te skins in the mould to fully complete the cure of polyester.



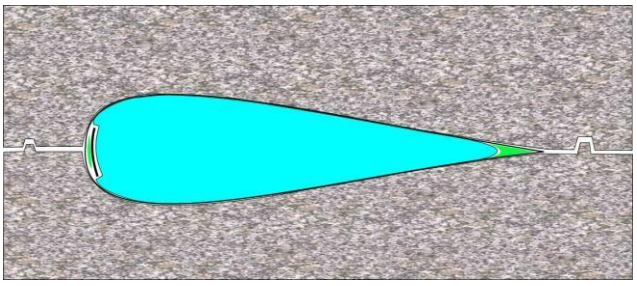
Front edge :
Application of film of bonding paste on the whole laminate, laminating of biaxial fabric.
For polyester skins : wet the csm out with laminating epoxy system.
Rear edge : apply a thixotropic epoxy resin .



Casting of PB in both halves. Wait till the foam raise up to the level of flanges



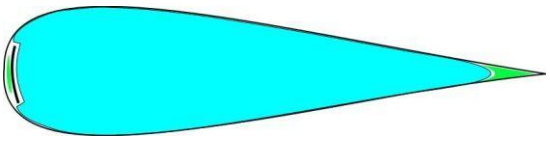
Assembling of the two parts mould.



Curing at ambient temperature.
Minimum post-cure of 6 hours @ 40 °C

Or

Post-curing @ 80 to 130°C for prepregs.



Release is then possible when back to ambient temperature.

Part finished.