

OPTIMAT BLADES	Document type:	Document no.:
	Material specification	-
	Document title:	Revision no.:
	Reference material (OPTIMAT)	1
	Glass-epoxy material	Date:
	Author: Torben K. Jacobsen	07/05/02

1 Glass reinforcement:

Two materials are supplied for the project. One is a non-woven unidirectional glass rovings with a minor amount of off-axis reinforcement. The other is a non-woven glass roving in 2 layers, - one layer in +45° and one layer in -45° (biaxial material). The reinforcement is stitch-bonded with PES yarn. A datasheet for the main glass reinforcement is provided in Appendix B.

2 Unidirectional reinforcement material (1258 g/m²):

Id	Layer	Unit	1	2	3	Stitching
2.1	Fibre orientation (alignment)	°	0±1 (warp)	90±3 (weft)	Chopped Strand Mat	-
2.2	Nominal area weight	g/m ²	1150	50	50	8
2.3	Material type	-	E-glass	E-glass	E-glass	PES sizing free
2.4	Filament diameter	:m	17	17	17	-
2.5	Roving type	-	PPG 2002	-	-	-
2.6	Resin compatibility*	-	UP, EP, VE	UP, EP, VE	UP, EP, VE	-

* UP: unsaturated polyester, EP: epoxy, VE: vinylester.

2 Biaxial reinforcement material (810 g/m²)

Non-woven stitch-bonded (chain) glass rovings in 2 layers, - one layer in +45° and one layer in -45°.

Id	Layer	Unit	1	2	3	4	Stitching
2.1	Fibre orientation	°	-45	+45	0	90	-
2.2	Nominal area weight	g/m ²	400	400	2	2	6
2.3	Material type	-	E-glass	E-glass	E-glass	E-glass	PES sizing free
2.4	Filament diameter	:m	17	17	17	17	-
2.5	Roving type	-	PPG2002	PPG2002	-	-	-
2.6	Resin compatibility	-	UP, EP, VE	UP, EP, VE	UP, EP, VE	UP, EP, VE	-

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3 Resin

Prime 20 from SP Systems mixed with slow hardener. Data sheet shown in Appendix A. Mix ratio by weight 100:25.

4 Laminate and processing:

The dry laminate package is infused with epoxy resin by vacuum assisted resin transfer moulding.

Laminate is post-cured at 80 °C for 4 hours.

Unidirectional material:

Fibre content by weight: 73 ± 3 wt %

Fibre content by volume: 55 ± 3 %.

Average thickness of one layer of laminate: 0.88 mm.

Biaxial material ($\pm 45^\circ$):

Fibre content by weight: 70 ± 3 wt %.

Fibre content by volume: 52 ± 3 %.

Average thickness of one layer of laminate: 0.61 mm.

The variation in fibre content by weight is more pronounced for thin laminates, whereas for thicker laminates the variation will be smaller (in the order of 1.5 wt %). Therefore, also thickness of plates may vary accordingly to variation in fibre content by weight.

Combinations of unidirectional and multi-directional material can be manufactured according to requirements from the Task groups. Surface of the laminates will as standard be manufactured with a peel-ply surface giving a thin slightly rough resin rich surface promoting a more stable attachment of extensometers.

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5. Laminate quality

Before shipment of specimens the following items are measured at LM and compared to the stated acceptance criteria:

Id	Property	Unit	Accept criterion
5.1	Glass transition temperature (DSC)	°C	> 80
5.2	Void content*	vol%	< 3
5.3	Glass content*	vol% wt%	Measured and compared to limits for actual lay-up
5.4	Resin content*	vol%	Measured and compared to limits for actual lay-up
5.5	Tensile strength Tensile stiffness Tensile strain-to-failure	MPa MPa %	Measured and compared with properties measured during reference tests. 6 tensile specimens cut in main fibre direction (reference geometry t.b.d.).
5.6	Interlaminar shear strength (Short beam shear test)	MPa	Measured and compared with properties measured during reference tests. 6 ILSS specimens cut in main fibre direction (reference geometry t.b.d.).
5.7	Straightness of specimens	°	± 1

*ASTM D2584.

6. Links to datasheets

Link to data sheets in PDF format:

Resin (Appendix A):

[SP Systems - Product Information - Laminating Systems](#)

Fibre (Appendix B):

PPG 2002 fibre:

http://www.ppg.com/fgs_main/ftp/rp/thermoset/europe/2002.pdf

E-glass properties:

http://www.ppg.com/fgs_main/product_overview.htm

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Appendix A: Resin system.

PRIME™ 20 Epoxy Infusion System



- Very low viscosity
- Variable infusion times
- Lloyds and Germanischer Lloyds approved

SP PRIME™ 20 is an epoxy infusion resin from SP Systems specifically designed for use in a variety of resin infusion processes including RTM, SCRIMP™ and RIFT. It has a very low mixed viscosity and long working time, allowing large parts with complex reinforcements to be infused successfully in one operation. It has an exceptionally low exotherm characteristic, which allows thick sections to be manufactured without risk of premature gelation due to exothermic temperature rises. The low exotherm also helps to extend the life of mould tools.

PRIME™ 20 has been used successfully for the single-operation moulding of components ranging in size from narrow carbon yacht masts, to 80' yacht hulls. It develops excellent mechanical and physical properties from moderate (50°C) postcures, enabling laminate properties to be produced which lie between those obtained by hand-lamination, and those obtained by low-temperature cure prepreg processes.

PRIME 20 is available with a Standard Hardener, for small to medium size parts, and a Slow Hardener for large parts. A Fast Hardener is available to increase the speed of the Standard Hardener, while the speed of the Slow Hardener can be increased by partial substitution of Standard Hardener. This enables the geltime of the resin to be matched to the required infusion time of any particular size of moulded part.

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PRIME™ 20

Availability

Resin Size	Order Code	Hardener Size	Order Code
3.2 kg Resin	F160-006	0.8 kg Fast	F16D-009
30 kg Resin	F160-005	0.8 kg Standard	F16D-010
220 kg Resin	F160-007	0.8 kg Slow	F16D-011
1000 kg Resin	F160-008	7.5 kg Fast	F16D-012
		7.5 kg Standard	F16D-013
		7.5 kg Slow	F16D-014
		20 kg Fast	F16D-015
		20 kg Standard	F16D-016
		20 kg Slow	F16D-017
		180 kg Fast	F16D-018
		180 kg Standard	F16D-019
		180 kg Slow	F16D-020

Notes: BDC sizes (900 kg) for hardeners can be made to order.

For details of other ancillary products that may be useful when using PRIME™ 20, please see the separate Ancillary Products section.

Applicable Risk & Safety Phrases

Resin
R 36/38, 43, e2
S 24, 26, 28, 37/39

Slow Hardener
R 20/21, 34, 43
S 9, 26, 36/37/39, 45

Standard Hardener
R 22, 34, 43
S 20, 26, 36/37/39, 45

Fast
R 21/22, 34, 43
S 20, 26, 36/37/39, 45

P20-0-1600-2

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PRIME™ 20 Properties

Component Properties

	Resin	Fast Hardener	Standard Hardener	Slow Hardener
Mix Ratio (by weight)	100	25	25	25
Mix Ratio (by volume)	100	30	30	31
Viscosity @ 15°C (cP)	1226	30	34	34
Viscosity @ 20°C (cP)	904	25	47	30
Viscosity @ 25°C (cP)	560	21	40	26
Viscosity @ 30°C (cP)	236	17	33	22
Shelf Life (in months)	12	12	12	12
Colour (Gardner)	2	7	8	8
Mixed Colour (Gardner)	-	3	3	3
Component Dens. (g/cm ³)	1.127	0.953	0.950	0.942
Mixed Liq. Density (g/cm ³)	-	1.058	1.058	1.090
Hazard Category	Xi, N	C	C	C
Risk Phrases	35/38, 43, 52	21/22, 34, 43	22, 34, 43	20/21, 34, 43
Safety Phrases	24, 25, 28 37/39	20, 26 36/37/39, 45	20, 26, 35/37/39, 45	9, 25 36/37/39, 45

Cured System Properties with Standard & Slow Hardener*

	Cured (28 days @ 21°C)			Cured (24 hrs @ 21°C + 16 hrs 50°C)		
	Fast*	Standard	Slow	Fast*	Standard	Slow
Tg DMTA (Peak Tan δ) (°C)	72.4	68.6	72.7	84.9	85.0	85.8
Tg UK - DMTA (°C)	85.6	99.0	96.5	87.6	99.7	95.0
AH - DSC (J/g)	7.7	25.9	25.9	-	2.1	7.5
Tg1 - DMTA (°C)	62.0	62.5	63.8	74.8	75.4	75.0
Est. HDT (°C)	57.4	53.6	57.7	69.9	71.0	70.8
Moisture Absorption (%)	2.827	0.994	1.127	2.925	1.003	1.165
Cured Density (g/cm ³)	1.153	1.148	1.145	1.149	1.150	1.143
Linear Shrinkage (%)	1.7	1.6	1.7	1.6	1.7	1.7
Barcol Hardness	20	24	23	19	24	26
Casting Tensile Strength (MPa)	64.5	64.8	61.9	74.9	74.8	74.2
Casting Tensile Mod. (GPa)	3.35	3.46	3.32	3.46	3.35	3.20
Casting Strain to Failure (%)	2.94	2.37	2.23	4.31	4.20	3.70
Lam. Comp. Strength (MPa)	465	444	415	478	428	441
Laminate ILSS (MPa)	54.4	45.7	43.9	57.7	51.6	51.7
ILSS Wet Retention (%)	68.0	90.2	92.6	67.6	87.6	82.5

*Fast Hardener not usually used alone, but premixed with Standard Hardener to accelerate it.

Working Properties vs. Temperature

	PRIME™ 20 Resin / Fast Hardener				PRIME™ 20 Resin / Standard Hardener				PRIME™ 20 Resin / Slow Hardener			
	15°C	20°C	25°C	30°C	15°C	21°C	25°C	30°C	15°C	20°C	25°C	30°C
Initial Mixed Viscosity (cP)	415	349	281	219	719	551	375	211	359	278	185	106
†Gel Time - 100g Mix in Water (hrs:min)	0:45	0:35	0:27	0:20	3:50	2:20	1:25	0:50	10:30	6:25	3:35	2:25
†Pot Life - 500g Mix in Air (hrs:min)	-	0:26	-	-	-	1:10	-	-	-	2:20	-	-
†Latest Vacuum Flow Time (hrs:min)	3:50	2:53	2:10	1:40	4:20	3:20	2:35	2:00	7:20	6:00	5:00	4:10
†Earliest Vacuum Off Time (hrs:min)	5:15	4:50	3:00	2:15	5:50	4:25	3:20	2:30	11:00	10:30	7:30	5:20
†Demould Time (hrs:min)	6:45	4:45	3:20	2:25	9:20	6:40	4:45	3:20	29:00	21:30	15:00	11:00

Notes: For an explanation of test methods used see 'SP Systems' Formulated Products Technical Characteristics'.
All figures quoted are indicative of the properties of the product concerned. Some batch to batch variation may occur.
† All times are measured from when resin and hardener are first mixed together.

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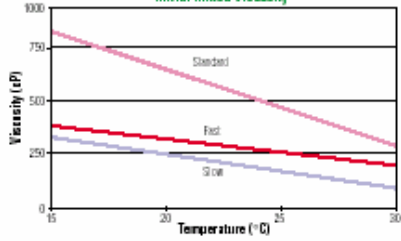
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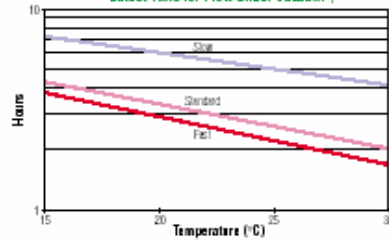
07/05/02

PRIME™ 20 Properties

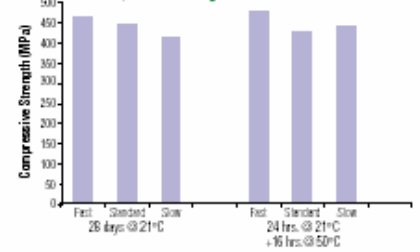
Initial Mixed Viscosity



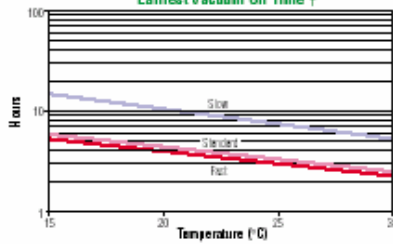
Latest Time for Flow Under Vacuum †



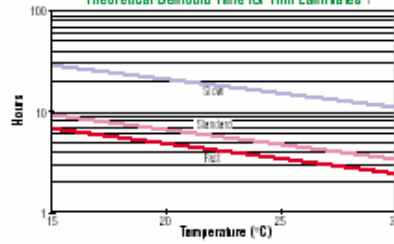
Compressive Strength of RE300 Glass Laminate



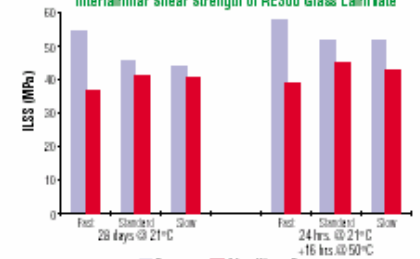
Earliest Vacuum Off Time †



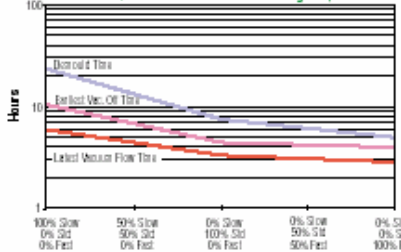
Theoretical Demould Time for Thin Laminates †



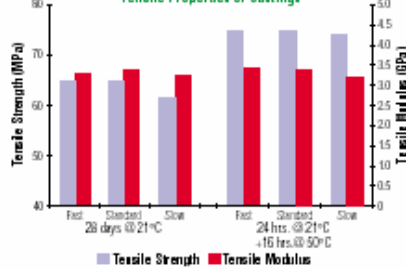
Interlaminar Shear Strength of RE300 Glass Laminate



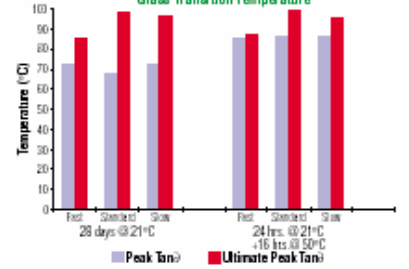
Effect of Standard/Slow Hardener Ratio Working Properties @ 20°C †



Tensile Properties of Castings



Glass Transition Temperature



Notes: For an explanation of test methods used see "SP Systems" Formulated Products Technical Characteristics".
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 † All times are measured from when resin and hardener are first mixed together.

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Appendix B: Fibre



Hybon 2002 Roving

(Revised 12/2000)

APPLICATION

Hybon 2002 roving is a continuous filament, single end (strand) roving designed for filament winding, pultrusion, weaving and non woven fabric applications. A combination of unique processing and proprietary sizing chemistry results in an extra-hard strand which is capable of withstanding considerable abuse without breakage. 2002 roving provides strand bundles without sacrificing rapid and complete wet-out. Hybon 2002 is designed to be compatible with polyester, vinylster and epoxy resin systems. The hard strand of 2002 roving can tolerate extreme processing conditions which would normally result in broken filaments and consequently high filamentation and broken strands.

USER BENEFITS

- Multi-compatible for polyester, vinylster and epoxy
- Hard strand tolerates difficult processing conditions without excessive filamentation.
- Single end roving which is free from catenary
- Wet out is rapid, complete and consistent
- Consistent test control and surface sizing system
- Excellent unwinding performance and transfer from package to package

PRODUCT DESCRIPTION

Property	Description					
Glass Type	E					
Type of Size	Silane					
Nominal Size Content	0.55%					
Tex Control (nominal)	± 7%					
Tex	300 ²	410	600	900	1200 ²	2400 ²
	320				2400	800
Filament Diameter – micron	14	16	22	15	17	25

PACKAGING

48 packages/pallet
 Each package in individual plastic (shrink) bag
 Cheese weight 21kg (Nominal) *
 Outside diameter 310mm
 Package height 265mm
 Pallets are stretch wrapped
 Caution: To avoid possibility of potential injury, maintain column stability by limiting pallet stacking to that noted on the individual pallets.
 * Note – minimum package weight 11kg

STORAGE

Hybon 2002 roving should be stored at room temperature and at a relative humidity of 65 ± 10%. To avoid problems with humidity or static electricity the glass fibres should be conditioned in the working area prior to use. If the contents of a packing unit are only partly used, the packing should be closed again. Three pallets high storage is not recommended. A first in first out stock control system is not strictly necessary, but will help to minimise the influence of adverse storage conditions.

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Properties

Specific Gravity (bare fiber)* 2.59

Density (bulk), lb/in³ 0.094
g/cm³ 2.59

Tensile Strength
@50% R.H. 72o F, psi 200-300x103
MPa 1380-2070

Modules of Elasticity, psi 10.5x106
Gpa 72.45

Elastic Recovery, % 100

Elongation at break, % 3-4

Poisson's Ratio 0.22

Linear Coeff. of Thermal Expansion
(25-300oC), in/in/oF 2.8-3.3x10-6
cm/cm/ oC 5.0-6.0x10-6

Thermal Conductivity (bulk)
@ 72oF, Btu/hr-ftoF 0.6-0.7
@22oC, cal/sec-cmoC 0.0025-0.003

Specific Heat (bulk)
Btu/lboF @ 72oF & cal/goC @22oC 0.197

Softening Point, oF 1540
oC 838

Dielectric Constant
@106 Hz & 72oF (22oC) 6.7

Index of Refraction @ 550 nanometers 1.559

Ultraviolet transmission opaque

Hardness (moh scale) (bulk) 6.5

* For commercial fiber glass products with sizing (binder), specific gravity and density are reduced by 0.02 (g/cm³) and 0.0007 lb/in³ respectively for each one percent by weight of sizing application.