Introduction

Advanced Composites Group (ACG) developed the VTM®260 (Variable Temperature Moulding) range of low viscosity epoxy prepregs specifically for the manufacture of large components by vacuum bag oven cure processing. All prepregs in the VTM260 series share the same basic resin chemistry and can be cured between 65 and 120°C.

VTM260 series resins are formulated to specific viscosity profiles that optimise handling characteristics and reinforcement impregnation. VTM260 series resins can be impregnated into a range of fibres and formats, typically carbon, glass and aramid in unidirectional (UD), multiaxial (NCF), woven fabric and ZPREG® partially impregnated configurations. These materials are applicable to many marine applications, including hulls, masts, decking, superstructures, bulkheads, floors, frames and stiffeners.

VTM264 and VTM267 resins are also available in flame-retarded (FR) variants.

VTM260 Series

VTF261	Flow modified resin for use with ZPREG partial impregnation surface technology
VTM264	Medium viscosity resin for UD and fabric prepregs
VTM266	Low to medium viscosity resin for heavier weight UD and fabric prepregs
VTM267	Reduced tack version for differential coating of heavy reinforcements
VTA®260	Film adhesive

All resins can be co-cured sharing common process cycles.

ZPREG

ACG's ZPREG is a partial impregnation material format for the rapid manufacture of high performance composite components, and is specifically aimed at markets which would potentially use resin infusion or wet lay-up. ZPREG offers significant advantages over standard prepregs, creating a material format which has the tack and cleanliness associated with a standard prepreg, while retaining the handling and drape characteristics of a dry fabric. ZPREG is presented as a multilayer format. The resin, in stripe or film format, is partially impregnated into the reinforcement layers, providing channels for air release during the curing process, thereby eliminating the need for vacuum de-bulking cycles. This novel resin/fabric architecture significantly speeds-up and simplifies the lamination of composite structures.

Resin	Viscosity @ 65°C/Pas	Application
VTA260	300	Film adhesive
VTF261	300	ZPREG partial impregnation surface products
VTM264	30	UD and fabric prepregs and ZPREG
VTM266	13	Heavy UD and fabric prepregs and ZPREG
VTM267	20	Reduced tack/controlled flow variant for prepregs and ZPREG

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Registered Office
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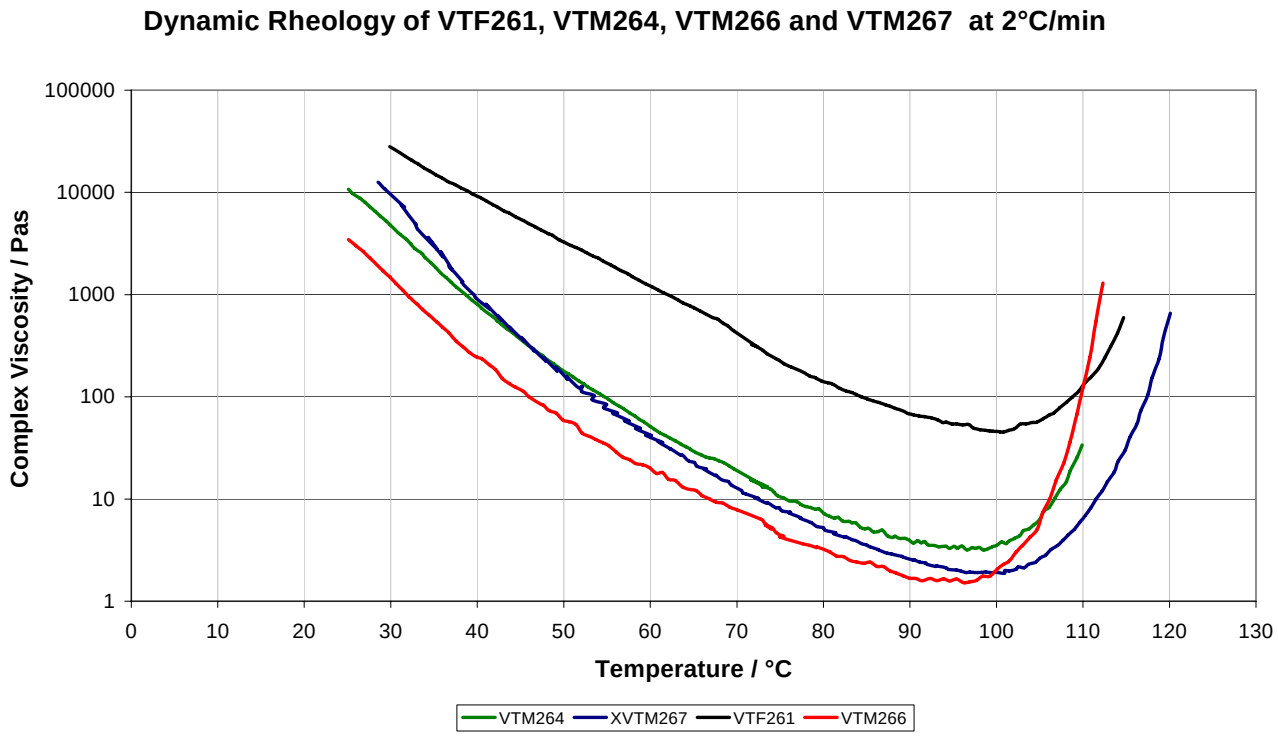
VTM260 Resin Viscosities



Reinforcements

The VTM260 series is available on a range of reinforcements and fibre types, including UD, woven fabrics and multi-axials (NCF), and can be supplied fully or partially (ZPREG) impregnated.

Correlation of reinforcement weights with resin weight

Resin	Tack @15°C(60°F)	Tack @21°C (70°F)	Glass UD	Carbon UD	Glass Woven	Carbon Woven
VTM264	Low	Medium	<400gsm	<600gsm	<900gsm	<900gsm
VTM266	Medium	High	<600gsm	<600gsm	>900gsm	>900gsm
VTM267	Very low	low	Differential coating of heavy reinforcements			

* The practical work life at 21°C (70°F) will depend on a number of factors, including fibre type, reinforcement weight, degree of impregnation and cure temperature. The work life may be reduced for heavy or partially impregnated reinforcements, perhaps leading to incomplete wet out.

For oven vacuum bag curing, the following minimum resin weights are recommended for the production of low voidage laminates:

- Carbon Unidirectional: 37% RW (54% Vf)
- Carbon Fabrics and Biaxial: 41% RW (50% Vf)
- Glass Unidirectional: 29% RW (54% Vf)
- Glass Fabrics and Biaxial: 32% RW (50% Vf)

Development of Glass Transition (Tg) Temperature

VTM260 series resins will develop glass transition temperatures (Tg) ahead of the cure temperature.

Laminates can be further post-cured away from the mould to develop the glass transition temperature. The maximum Tg achievable is 125°C.

VTM RESINS	CURE SCHEDULE	MAXIMUM Tg ACHIEVED /°C
VTM264, VTM266, VTM267	16 hours @ 65°C	80
	5 hours @ 80°C	105
	1 hour @ 120°C	125

VTA260 Adhesive Film

VTA260 adhesive film is used for bonding foam and honeycomb cores and is available in a range of film weights. For most core bonding operations the recommended product weight is 313gsm (300gsm adhesive + 13gsm PK13 carrier). Films can be supplied without a carrier, but this makes handling much more difficult. Note: Very light film (less than 150gsm) can only be supplied unsupported.

VTA260 can also be supplied pre-combined with a prepreg to aid handling and reduce laminating time.

VTA260 offers high lap shear and climbing drum peel strengths. VTA260 is a medium tack system which adheres well to core materials during lay-up.

Trials indicate that VTA260 is compatible with the following foam cores:

- Core-Cell P and T grades
- Airex C70, C71 grades
- Airex R63 grades
- Divinycell H and HP grades

VTF261 Surfacing Film

VTF261 surfacing film is based on ACG's ZPREG selective impregnation surfacing technology. VTF261 complements the VTM260 flexible cure prepreg series by offering controlled flow surface ply formats for the rapid lay-up of high quality cosmetic and paint-ready finishes after vacuum only cure.

VTF261DC offers a high clarity cosmetic finish.

VTF261 offers a high integrity paint-ready finish requiring minimal surface preparation

VTF261W, a white pigmented variant, is available pre-formatted as a gelcoat interface/print blocker interface.

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VTM Data Sheets and MSDS

The following documents are available and MUST be consulted before using these products.

Product	Data Sheet	MSDS
VTM264	PDS 1154	MSDS 338
VTM266		MSDS 339
VTM267		MSDS 483
VTF261	PDS 1194	MSDS 457
VTA260	PDS 1170	MSDS 397

VTM260 Processing

The VTM260 series has been specifically developed for low pressure oven vacuum bag curing (OVBC). Void contents of less than 2% are readily achievable if processed correctly.

The prepreg should be removed from the freezer, thawed and allowed to reach room temperature before removal from the polythene protective bag. Condensation may form on the surface ff the material is not fully thawed. Moisture within a curing laminate may be detrimental to final part quality and appearance.

De-bulking during lay-up:

During lay-up, de-bulking is necessary to prevent bridging in corners and to ensure consolidation over the whole laminate surface area. It is recommended that de-bulking be carried out after every two plies. The lay-up should be vacuum debulked for approximately 15 minutes with 880 to 948mbar (26 to 28in Hg) of vacuum. The laminate stack should be covered with a perforated release film, a suitable breather and a low cost membrane. On large structures, an additional mesh layer can be introduced on top of the breather to assist air bleed.

Bagging consumables:

The recommended consumables pack for a general oven vacuum bag cure is as follows:

- Apply one layer of non-perforated release film over the entire back face of the laminate and extending approximately 25mm beyond the edge of the lay-up. A perforated release film can be used, but VTM resins are of low viscosity and resin bleed can occur. It is recommended that a trial laminate be made with the perforated film to determine the amount of resin removed and whether this could induce porosity in the laminate. Recent trials indicate that semi-permeable release films may be beneficial when processing VTM260 series resins as they assist air release without risk of resin bleed.

- Apply one layer of breather fabric over the entire lay-up. An additional mesh layer can be introduced on top of the breather to encourage air bleed. Extra plies of breather may be fitted at vacuum breach positions as required.

- Nylon vacuum membrane, which is sealed to the tool with a suitable sealant tape.

The highest available vacuum, typically 980mbar (29in Hg), must be used during cure. This critical check must be performed to ensure that the laminate is exposed to this vacuum. Check this using a gauge positioned at the opposite side of the laminate to that of the vacuum port.

The minimum vacuum level on the laminate should be 813mbar (24in Hg). If the vacuum is lower than this the consolidation of the laminate may be inadequate.

A vacuum drop test should be performed prior to curing of the component. The test must show no more than 68mbar (2in Hg) pressure lost within 10 minutes once vacuum is removed. Contact ACG's Technical Department for further information.

Recommended Cure Cycles for VTM260 Series Products used in Marine Structures

Heat up Ramp rates

The recommended ramp up rate for the VTM260 series is 0.5 to 3.0°C/minute. However, for large marine structures, the ramp up rate will generally be at the lower end of this range.

Note: Very slow ramp rates (<.2°C/minute) can lead to reduced flow and poor consolidation.

Cure cycles

VTM260 series prepregs can be cured between 65 and 120°C. However, it is anticipated that large marine structures will be cured between 65 and 80°C.

Note: The times shown below are the actual times AT the cure temperature, NOT simply the time in the oven. The temperature should be independently monitored and the oven time adjusted so that the laminate is exposed to the full cure cycle.

- 16 hours @ 65°C
- 12 hours @ 70°C
- 5 hours @ 80°C
- 3 hours @ 90°C
- 2 hours @ 100°C
- 1 hour @ 120°C

****** 65°C is the minimum cure temperature for the VTM range******

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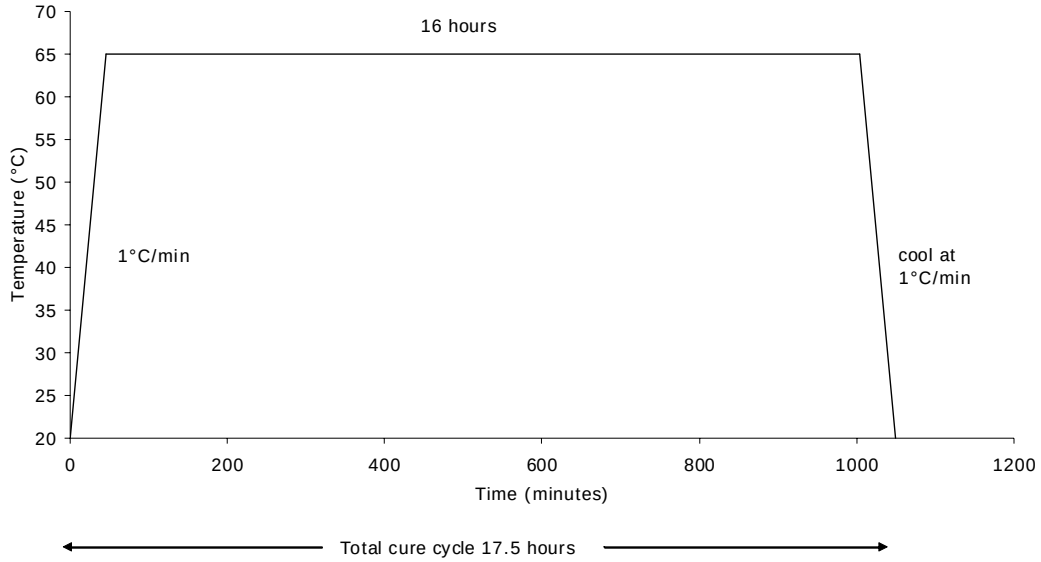
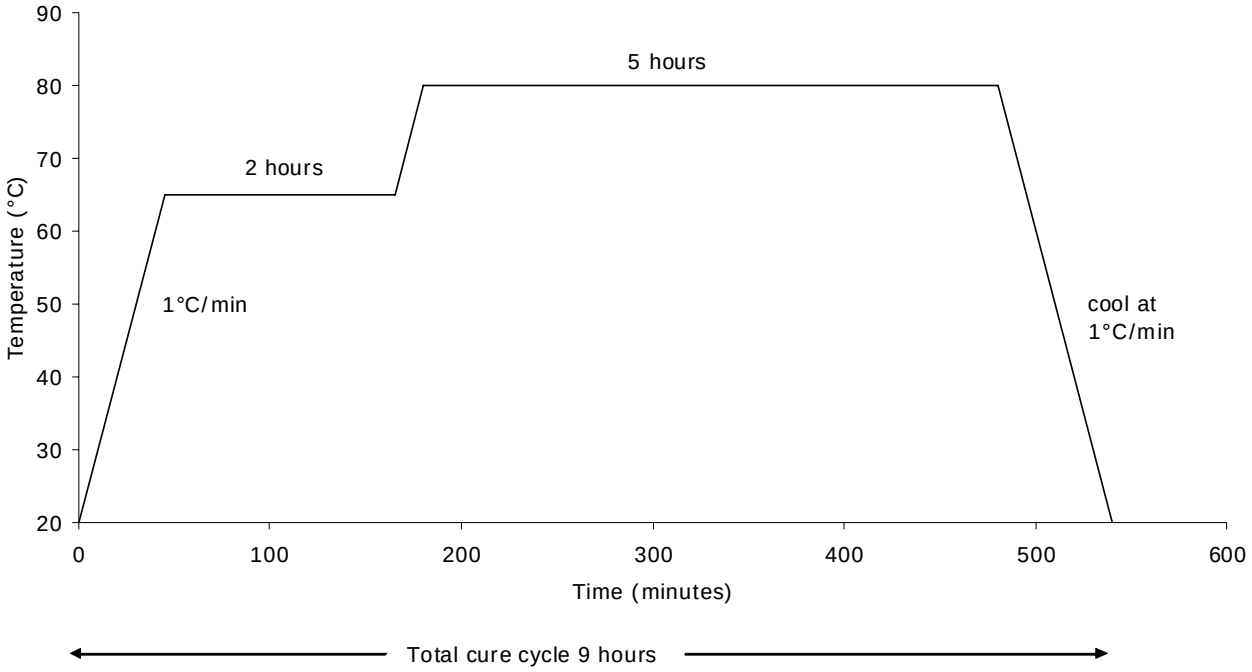
65°C Oven Vacuum Bag Cure Cycle:



- Apply full vacuum at room temperature, aiming for 982mbar (29 in Hg) vacuum pressure on the laminate.
- Heat to 65 ±2°C (150 ±3.5°F) at 0.5 to 2.0°C (1 to 5°F)/minute,
- Maintain at 65 ±2°C (150 ±3.5°F) under applied vacuum for 16 hours.
- Cool to room temperature at up to 3°C (5°F)/minute (maximum) under vacuum.
- Vent vacuum at room temperature.
- De-mould part.

80°C Oven Vacuum Bag Cure Cycle:



- Apply full vacuum at room temperature, aiming for 982mbar (29 in Hg) vacuum pressure on the laminate.
- Heat to 65±2°C at 0.5 to 3.0°C/minute,
- To ensure the laminate and mould tool reach an equilibrium temperature, maintain at 65±2°C under applied vacuum for 2 hours.
- Heat from 65±2°C to 80±2°C at 1°C/minute.
- Maintain at 80±2°C under applied vacuum for 5 hours to complete the cure.
- Cool to room temperature at 3°C/minute (maximum) under vacuum.
- Vent vacuum at room temperature.
- De-mould part.

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Exotherm Risk

The VTM products are designed for low temperature cure and are reactive formulations that can undergo exothermic heat build up during the initial curing process if incorrect cure schedules are applied.

For a 65°C cure, thicknesses of up to 25 to 30mm carbon or glass fibre VTM 260 series can be moulded without the risk of an exotherm. For an 80°C cure, the thickness of laminate should not exceed 10mm (0.4in) without modifying the cure cycle by extending the dwell period at 65°C. Please contact ACG Technical Department for advice on moulding thick sections.

Mechanical Properties for VTM260 Laminates

The following mechanical property data is presented for VTM products with carbon unidirectional, woven fabric and stitched biaxial reinforcements. Data is also available for glass fibre reinforcements.

Mechanical test data is available for other fabrics and fibres not detailed below, and can also be generated upon request from ACG. Contact ACG's Technical Department for further details.

ADVANCED COMPOSITES GROUP MATERIALS DATABASE

VTM™260 Product Range for Marine Applications

High Strength Carbon Fibre Fabrics : Nominal 50% Vf (41% RW)						
1) VTM266/CF0100 283gsm 3k 4 x 4 Twill			3) VTM264/CFM003 200gsm 3k 2 x 2 Twill			
2) VTM266/CF1100 410gsm 6k 2 x 2 Twill			4)			
Material			VTM266/ CF0100	VTM266/ CF1100	VTM264/ CFM003	
Oven Vacuum Bag Cure Cycle			16 hrs @ 65°C	16 hrs @ 65°C	5 hrs @ 80°C	
			Test Conditions			
Property	Test Method	Units	20°C dry	20°C dry	20°C dry	20°C dry
WARP Tensile Modulus	D 3039	GPa	60.0	57.3		
WARP Compressive Modulus	D 3410	GPa	54.1	50.4		
WEFT Tensile Modulus	D 3039	GPa			60.5	
WEFT Compressive Modulus	D 3410	GPa				
WARP Tensile Strength	D 3039	MPa	700	632		
WARP Compressive Strength	D 3410	MPa	541	389		
WEFT Tensile Strength	D 3039	MPa			745	
WEFT Compressive Strength	D 3410	MPa				
WARP Tensile Failure Strain	D 3039	%	1.17	1.11		
WARP Comp. Failure Strain	D 3410	%	1.00	0.77		
WEFT Tensile Failure Strain	D 3039	%			1.23	
WEFT Comp. Failure Strain	D 3410	%				
In-Plane Shear Modulus	D 3058	GPa	3.87	3.01		
In-Plane Shear Strength	D 3058	MPa	95.5	79.2		
Maj. Tensile Poisson's Ratio	D 3039	-	0.08	0.07		
Maj. Comp. Poisson's Ratio	D 3410	-	0.08	0.07		
Min. Tensile Poisson's Ratio	D 3039	-				
Min. Comp Poisson's Ratio	D 3410	-				
Flexural Modulus	CRAG 200	GPa	55.1	45.5	57.5	
Flexural Strength	CRAG 200	MPa	971	656	918	
ILSS	CRAG 100	MPa	71.4	54.8	71.4	
All fabric data normalised to 50% fibre volume fraction (except for ILSS and In-Plane Shear).						

Checked by: David Bashford Date: 10/07/2002

ADVANCED COMPOSITES GROUP MATERIALS DATABASE

VTM™260 Product Range for Marine Applications

High Strength Carbon Fibre BIAXIAL Fabrics : Nominal 50% Vf (41% RW)						
1) WARP VTM264/CFM010 400gsm 12k Biaxial			3) +45° VTM264/CFM010 400gsm 12k Biaxial			
2) WEFT VTM264/CFM010 400gsm 12k Biaxial			4) -45° VTM264/CFM010 400gsm 12k Biaxial			
	Property direction		WARP	WEFT	+45°	-45°
	Oven Vacuum Bag Cure Cycle		5 hrs @ 80°C	5 hrs @ 80°C	5 hrs @ 80°C	5 hrs @ 80°C
			Test Conditions			
Property	Test Method	Units	20°C dry	20°C dry	20°C dry	20°C dry
Tensile Modulus	D 3039	GPa	13.6	15.2	56.5	57.6
Compressive Modulus	D 3410	GPa				
Tensile Strength	D 3039	MPa	139	175	1024	1022
Compressive Strength	D 3410	MPa				
Tensile Failure Strain	D 3039	%				
Compressive Failure Strain	D 3410	%				
In-Plane Shear Modulus	D 3058	GPa	-	-		-
In-Plane Shear Strength	D 3058	MPa	-	-		-
Tensile Poisson's Ratio	D 3039	-				
Compressive Poisson's Ratio	D 3410	-				
Flexural Modulus	CRAG 200	GPa	13.5	15.5	52.2	45.5
Flexural Strength	CRAG 200	MPa	207	220	900	787
ILSS	CRAG 100	MPa	35.4	48.5	49.0	50.5
All fabric data normalised to 50% fibre volume fraction (except for ILSS and In-Plane Shear).						

NOTE: Property values are declared in respect of orientation of the biaxial fabric, i.e. WARP (0°), WEFT (90°), +45° and -45°. Fibres within the biaxial fabric are aligned in the +45° and -45° directions.

In-Plane Shear properties are measured in the WARP (±45°) direction

Checked by: David Bashford Date: 10/07/2002

ADVANCED COMPOSITES GROUP MATERIALS DATABASE

VTM™260 Product Range for Marine Applications

High Strength Carbon Fibre UD Material : Nominal 54% Vf (37% RW)						
1) 300gsm VTM266/T700 24k			3) 300gsm VTM266/34-700WD			
2) 600gsm VTM266/T600			4) 160gsm VTM266/TRX50 12k			
		Material	T700	T600	34-700WD	TRX50
		Oven Vacuum Bag Cure Cycle	16 hrs @ 65°C	16 hrs @ 65°C	5 hrs @ 80°C	5 hrs @ 80°C
			Test Conditions			
Property	Test Method	Units	20°C dry	20°C dry	20°C dry	20°C dry
0° Tensile Modulus	D 3039	GPa	118	123	118	122
0° Compressive Modulus	D 3410	GPa	107	102	112	107
90° Trans. Tensile Modulus	D 3039	GPa		8.2	7.6	6.7
90° Trans. Comp. Modulus	D 3410	GPa			6.9	7.0
0° Tensile Strength	D 3039	MPa	2459	2022	2264	2108
0° Compressive Strength	D 3410	MPa	1102	991	1132	1106
90° Trans. Tensile Strength	D 3039	MPa		30.0	42.1	31.5
90° Trans. Comp. Strength	D 3410	MPa			145	112
0° Tensile Strain to Failure	D 3039	%	2.07	1.65	1.93	1.74
0° Comp. Strain to Failure	D 3410	%	1.03	0.97	1.01	1.03
90° Trans. Tensile Strain	D 3039	%		0.36	0.57	0.46
90° Trans. Comp. Strain	D 3410	%				
In-Plane Shear Modulus	D 3058	GPa	4.07	4.02	3.94	3.54
In-Plane Shear Strength	D 3058	MPa	83.6	56.3	85.6	118.3
Maj. Tensile Poisson's Ratio	D 3039	-	0.32	0.34	0.34	0.32
Maj. Comp. Poisson's Ratio	D 3410	-	0.34			
Min. Tensile Poisson's Ratio	D 3039	-		0.02	0.02	0.02
Min. Comp Poisson's Ratio	D 3410	-			0.03	0.02
Flexural Modulus	CRAG 200	GPa	110	115	119	135
Flexural Strength	CRAG 200	MPa	1677	1800	2019	1831
ILSS	CRAG 100	MPa	84.3	75.6	87.4	81.8
All UD data normalised to 54% fibre volume fraction (except for ILSS and In-Plane Shear).						

Checked by: David Bashford Date: 10/07/2002

ADVANCED COMPOSITES GROUP MATERIALS DATABASE

VTM™260 Product Range for Marine Applications

Glass Fibre Fabrics : Nominal 50% Vf (32% RW)						
1) VTM264/GFM001 162gsm 2 x 2 Twill			3) VTM266/GFM001 162gsm 2 x 2 Twill			
2) VTM264/GFM001 162gsm 2 x 2 Twill			4) VTM266/GFM001 162gsm 2 x 2 Twill			
	Material		264/GFM001	264/GFM001	266/GFM001	266/GFM001
	Oven Vacuum Bag Cure Cycle		5 hrs @ 80°C	5 hrs @ 80°C	5 hrs @ 80°C	5 hrs @ 80°C
Wet = 30 days immersion @ 35°C			Test Conditions			
Property	Test Method	Units	20°C dry	20°C Wet	20°C dry	20°C Wet
WARP Tensile Modulus	D 3039	GPa				
WARP Compressive Modulus	D 3410	GPa				
WEFT Tensile Modulus	D 3039	GPa	27.7	26.8	26.4	26.9
WEFT Compressive Modulus	D 3410	GPa				
WARP Tensile Strength	D 3039	MPa				
WARP Compressive Strength	D 3410	MPa				
WEFT Tensile Strength	D 3039	MPa	440	337	494	351
WEFT Compressive Strength	D 3410	MPa				
WARP Tensile Failure Strain	D 3039	%				
WARP Comp. Failure Strain	D 3410	%				
WEFT Tensile Failure Strain	D 3039	%	1.59	1.26	1.87	1.30
WEFT Comp. Failure Strain	D 3410	%				
In-Plane Shear Modulus	D 3058	GPa				
In-Plane Shear Strength	D 3058	MPa				
Maj. Tensile Poisson's Ratio	D 3039	-				
Maj. Comp. Poisson's Ratio	D 3410	-				
Min. Tensile Poisson's Ratio	D 3039	-				
Min. Comp Poisson's Ratio	D 3410	-				
Flexural Modulus	CRAG 200	GPa				
Flexural Strength	CRAG 200	MPa				
ILSS	CRAG 100	MPa				
All fabric data normalised to 50% fibre volume fraction (except for ILSS and In-Plane Shear).						

Checked by: David Bashford Date: 10/07/2002

ADVANCED COMPOSITES GROUP MATERIALS DATABASE

VTM™260 Product Range for Marine Applications

High Strength Glass Fibre BIAXIAL Fabrics : Nominal 50% Vf (32% RW)						
1) WARP VTM264/GF1400 445gsm Biaxial			3) +45° VTM264/GF1400 445gsm Biaxial			
2) WEFT VTM264/GF1400 445gsm Biaxial			4) -45° VTM264/GF1400 445gsm Biaxial			
	Property direction		WARP	WEFT	+45°	-45°
	Oven Vacuum Bag Cure Cycle		5 hrs @ 80°C	5 hrs @ 80°C	5 hrs @ 80°C	5 hrs @ 80°C
			Test Conditions			
Property	Test Method	Units	20°C dry	20°C dry	20°C dry	20°C dry
Tensile Modulus	D 3039	GPa	12.7	14.4	26.2	26.5
Compressive Modulus	D 3410	GPa				
Tensile Strength	D 3039	MPa	172	194	315	272
Compressive Strength	D 3410	MPa				
Tensile Failure Strain	D 3039	%				
Compressive Failure Strain	D 3410	%				
In-Plane Shear Modulus	D 3058	GPa	-	-		-
In-Plane Shear Strength	D 3058	MPa	-	-		-
Tensile Poisson's Ratio	D 3039	-				
Compressive Poisson's Ratio	D 3410	-				
Flexural Modulus	CRAG 200	GPa	8.8	8.8	19.8	22.7
Flexural Strength	CRAG 200	MPa	382	406	555	483
ILSS	CRAG 100	MPa	38.6	40.5	51.9	59.1
All fabric data normalised to 50% fibre volume fraction (except for ILSS and In-Plane Shear).						

NOTE: Property values are declared in respect of orientation of the biaxial fabric, i.e. WARP (0°), WEFT (90°), +45° and -45°. Fibres within the biaxial fabric are aligned in the +45° and -45° directions.

In-Plane Shear properties are measured in the WARP (±45°) direction

Checked by: David Bashford Date: 10/07/2002

CERTIFICATE OF APPROVAL OF AN EPOXIDE RESIN

Certificate No. MATS/2744/2

This certificate is issued to the company named below. The resin described has been examined in accordance with the requirements of Lloyd's Register and is approved for use in constructions built under Lloyd's Register's survey. This approval is subject to Lloyd's Register being informed of any changes in or modifications to the resin and the product being used in accordance wit the manufacturer's instructions and with the relevant requirements of Lloyd's Register's Rules and Regulations.

Company	**ADVANCED COMPOSITES GROUP** **HEANOR** **UNITED KINGDOM**
Trade name	**VTM260 RANGE**
Resin	**PRE-PREG SERIES**
Application	**Laminating resin**
Type	**Epoxide**
Characteristics	**For use only with specified reinforcements** **Vacuum processing** **Manufacturer's recommendations for storage and curing/post curing must be adhered to**
Data	**Surveyor site inspection report, test data**
Applicable LR Rules	**Rules and Regulations for Classification of Special Service Craft**
Approved Variants	**VTM267** **High tack** **VTM264** **Medium viscosity** **VTM266** **Low – medium viscosity**
Valid until	**1 September 2014**
Date	**10 May 2010**

M Jogia
Surveyor to Lloyd's Register EMEA
member of the Lloyd's Register Group