Unit 4
The Reservation
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FRVC411

Flame Retardant Epoxy Component Prepreg

Introduction

FRVC411 is a toughened, flame retardant epoxy resin system designed to cure between 65°C and 140°C allowing flexibility in component manufacture. It can be supplied on a variety of fabrics and in UD format to meet your cost and manufacturing requirements. This resin system colour is opaque white.

Product variants: *FRVC411B* *Black pigmented, default on all carbon reinforcements.*

Typical applications: *Flame retardant – Aerospace / Rail*

Key Features & Benefits

- Cure temperature from **65°C** to **140°C**
- Service temperature up to **150°C** after post cure
- Low CTE and shrinkage
- Work life at 20°C: **21 days**
- Storage life at -18°C: **12 months**
- Very low VOC content – no added solvents during manufacture
- ***Snap cure*** *available for hot press moulding – consult SHD for details*
- **FST properties**:
    - **CS 25.853** compliant
    - **EN 45545 HL1** – rated **HL3** for flame propagation, smoke and toxicity
    - Rated **UL94 V0**

Storage & Out Life

This material should be kept frozen at -18°C. It must be kept sealed in a polythene bag which must not be opened until fully thawed to room temperature. If the material is not fully used, then the material must be resealed in the polythene bag to prevent moisture absorption.

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Cure Cycles & performances

- Recommended Initial cure:
  - 1st dwell at **85°C** for **15 min**, at a ramp rate of **2-3°C/min**
  - 2nd dwell at **120°C** for **1h**, at a ramp rate of **2-3°C/min**
- Recommended Post cure: **150°C** for **1h**, at a ramp rate of **0.3°C/min** *(if required to develop Tg)*

CURE CYCLE OPTIONS:

Temperature		Duration		Tg
65°C	(minimum)	16	hours	80°C
80°C		5	hours	90°C
100°C		2	hours	110°C
120°C		1	hour	135°C
140°C	(maximum)	15	mins	150°C
150°C	Post Cure	1	hour	155°C

- Curing Schedule is meant to be a guide only and is subject to local conditions.
- To avoid exotherm particular care must be taken with thick laminates.
  Ramp rates must not exceed **3.0°C** per minute during **initial cure**.
  Ramp rates must not exceed **0.3°C** per minute during **post cure** (free standing).

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Cured Material Properties

Flame, Smoke and Toxicity properties

CS 25.853		**Results**	**Limit**		
60s vertical burn		**1.2**	6.0	*in*	*PASS*
15s horizontal burn		**0.0**	2.5	*in/min*	*PASS*
Heat release	Peak	**42.9**	65	*kW/m2*	*PASS*
	2 min average	**35.5**	65	*kW.min/m2*	
Smoke emission		**138.89**	200		*PASS*
Toxic gas emission	CO	**22**	1000		
	HCN	**< 1**	150		
	HF	**< 1**	100		*PASS*
	HCL	**< 1**	150		
	SO2	**< 1**	100		
	NOx	**5**	100		

Material tested: 8 plies of FRVC411-G300-8HS-38%RW prepreg
Autoclave cured (6bar) 1h@120°C

EN 45545		**Results**	**Limits for category R1**			**Rating**
			HL1	**HL2**	**HL3**	
ISO 5658-2	CFE *(kW/m2)*	**22.6**	20 *(min)*	20 *(min)*	20 *(min)*	*HL1, HL2, HL3*
ISO 5660-1	MAHRE *(kW/m2)*	**106.0**	N/A	90	60	*HL1*
ISO 5659-2	DS4	**419.06**	600	300	150	*HL1*
	VOF4	**934.54**	1200	600	300	*HL1*
EN 45545-2	CITG (4min)	**0.063**	1.2	0.9	0.75	*HL1, HL2, HL3*
Annex C.1	CITG (8min)	**0.067**	1.2	0.9	0.75	*HL1, HL2, HL3*

Material tested: 8 plies FRVC411-G300-8HS-38%RW prepreg
Autoclave cured (6bar) 1h@120°C

Tests completed independently by a UKAS approved organisation. Tests results can be supplied upon request.

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Flame propagation properties

UL94 vertical burn test ratings and requirements:

Conditions	**V0**	**V1**	**V2**
Afterflame time for each individual specimen A or B	≤ 10 s	≤ 30 s	≤ 30 s
Total afterflame time for any condition set (A+B) for 5 specimens	≤ 50 s	≤ 250 s	≤ 250 s
Afterflame plus afterglow time for each individual specimen after the second flame application (B+C)	≤ 30 s	≤ 60 s	≤ 60 s
Afterflame or afterglow of any specimen up to the holding clamp	No	No	No
Cotton indicator ignited by flaming particles or drops	No	No	Yes

Test results:

FRVC411-C200T-3K-45%RW-1250
9 plies (approx. 2mm)

Specimen	A	B	C	D	E
1	0	0	0	No	No
2	0	0	0	No	No
3	0	0	0	No	No
4	0	0	0	No	No
5	0	9	0	No	No

Rating: ***UL94 V0***

FRVC411-C200T-3K-45%RW-1250
5 plies (approx. 1mm)

Specimen	A	B	C	D	E
1	0	2	0	No	No
2	0	3	0	No	No
3	0	0	0	No	No
4	3	1	0	No	No
5	3	1	0	No	No

Rating: ***UL94 V0***

FRVC411-G300-8HS-7781-42%RW-1270
8 plies (approx. 2mm)

Specimen	A	B	C	D	E
1	0	6	0	No	No
2	0	0	0	No	No
3	0	3	0	No	No
4	0	0	0	No	No
5	0	0	0	No	No

Rating: ***UL94 V0***

FRVC411-G300-8HS-7781-42%RW-1270
4 plies (approx. 1mm)

Specimen	A	B	C	D	E
1	0	4	0	No	No
2	0	2	0	No	No
3	1	2	0	No	No
4	0	0	0	No	No
5	2	2	0	No	No

Rating: ***UL94 V0***

Tests completed independently by a UKAS approved organisation. Tests results can be supplied upon request.

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Mechanical properties

PLY: ***200gsm 2x2 twill fabric, T300 3K carbon fibre, 45% resin weight***

Material description: *FRVC411-C200T-3K-45%RW-1250 (SHD3410-1250)*
FRVC411B-C200T-3K-45%RW-1250 (SHD2538-1250)

Test	Results			*Standard*
Vf	Fibre volume fraction	**50.05**	**%**	*BS EN ISO 14127 Method B*
CPT	Cured ply thickness	**0.230**	**mm**	*BS EN ISO 14127 Method B*
Tensile 0°	Tensile strength	**673**	**MPa**	*BS EN ISO 527-4*
	Tensile modulus	**58.1**	**GPa**	
	Poisson's ratio	**0.05**		
Compressive 0°	Compressive strength	**686**	**MPa**	*prEN 2850 Type B*
	Compressive modulus	**53.7**	**GPa**	
Flexural 0°	Flexural strength	**847**	**MPa**	*BS EN ISO 14125*
	Flexural modulus	**54.3**	**GPa**	
In-Plane Shear ±45°	In-Plane shear strength (5% strain)	**74.4**	**MPa**	*BS EN ISO 14129*
	In-Plane shear strength (ultimate)	**104.2**	**MPa**	
	In-Plane shear modulus	**4.06**	**GPa**	
Interlaminar Shear 0°	Interlaminar shear strength	**70.7**	**MPa**	*BS EN ISO 14130*
DMA – Dry Tg	Tg E' Onset	**146**	**°C**	*Modified ASTM D7028 (Single Cantilever)*
	Tg Peak Tan δ	**169**	**°C**	
DMA – Wet Tg	Tg E' Onset	**92**	**°C**	
14 days in water at 70°C	Tg Peak Tan δ	**119**	**°C**	

Cure schedule: 15mins @ 85°C then 1hr @ 120°C, 2°C/min ramp rate (solid release, autoclave cured, 6 bar). All figures in this table are actual test results and have not been normalised. Complete test reports can be supplied independently upon request.

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PLY: ***300gsm 8 harness satin fabric, E-glass fibre, 42% resin weight***
Material description: *FRVC411-G300-8HS-7781-42%RW-1270 (SHD2335-1270)*

Test	Results			*Standard*
Vf	Fibre volume fraction	**42.69**	**%**	*BS EN ISO 14127 Method B*
CPT	Cured ply thickness	**0.273**	**mm**	*BS EN ISO 14127 Method B*
Tensile 0°	Tensile strength	**467**	**MPa**	*BS EN ISO 527-4*
	Tensile modulus	**23.6**	**GPa**	
	Poisson's ratio	**0.14**		
Compressive 0°	Compressive strength	**531**	**MPa**	*prEN 2850 Type B*
	Compressive modulus	**24.8**	**GPa**	
Flexural 0°	Flexural strength	**670**	**MPa**	*BS EN ISO 14125*
	Flexural modulus	**23.5**	**GPa**	
In-Plane Shear ±45°	In-Plane shear strength (5% strain)	**63.5**	**MPa**	*BS EN ISO 14129*
	In-Plane shear strength (ultimate)	**113.2**	**MPa**	
	In-Plane shear modulus	**3.91**	**GPa**	
Interlaminar Shear 0°	Interlaminar shear strength	**72.8**	**MPa**	*BS EN ISO 14130*
DMA – Dry Tg	Tg E' Onset	**159**	**°C**	*Modified ASTM D7028 (Single Cantilever)*
	Tg Peak Tan δ	**180**	**°C**	
DMA – Wet Tg	Tg E' Onset	**107**	**°C**	
14 days in water at 70°C	Tg Peak Tan δ	**124**	**°C**	

Cure schedule: 15mins @ 85°C then 1hr @ 120°C, 2°C/min ramp rate (solid release, autoclave cured, 6 bar). All figures in this table are actual test results and have not been normalised. Complete test reports can be supplied independently upon request.

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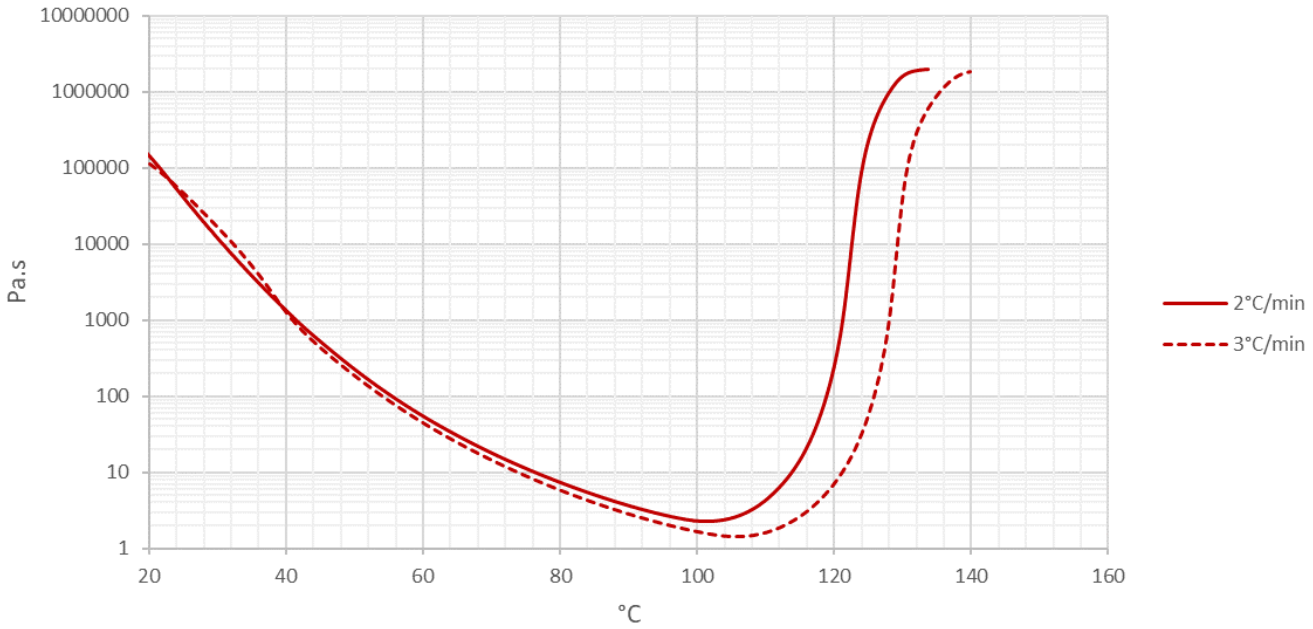
Viscosity Profile

Measured using a rotational rheometer



Health and Safety

This material contains epoxy resin which can cause allergic reactions with skin contact and must avoid repeated and prolonged skin contact.

Please refer to the product Safety Data Sheet before using this material. The following precautions must be taken when using epoxy resin prepregs:

- Overalls must be worn.
- Impervious gloves must be worn.
- Curing schedule is meant to be as a guide only and is subject to local conditions.
- To avoid exotherm, particular care must be taken with thick laminates.
- Ramp rates must not exceed 3.0°C/min during initial cure and 0.3°C/min during post cure.