

## PRODUCT DATA SHEET

### DESCRIPTION

Toray TC380 sets a new benchmark for toughened epoxy prepreg systems. TC380 is extremely tough with an excellent balance of OHC, OHT, CAI, and G<sub>IC</sub>/G<sub>II</sub>C properties. It features low moisture absorption with outstanding hot/wet mechanical properties to 121°C (250°F). TC380 is optimized for low pressure autoclave and out-of-autoclave/vacuum bag only (OOA/VBO) cures, facilitating construction of large or complex composite parts and assemblies.

### FEATURES

- ▶ Outstanding toughness, open hole, and compression after impact (CAI) properties
- ▶ Excellent hot/wet strength retention, with composite moisture uptake <1%
- ▶ Robust processing and low voids under vacuum bag only cure pressure
- ▶ Long out time and out life for extended shop floor handling
- ▶ Tack and handling qualities are well-suited to both automated and hand lay-up methods
- ▶ Can be processed with initial cure at 135°C (275°F), followed by freestanding post cure at 180°C (356°F), increasing process flexibility and tool material options
- ▶ Exceptional fracture toughness

### PRODUCT TYPE

180°C (356°F) Cure, Toughened Epoxy Resin System

### TYPICAL APPLICATIONS

- ▶ Aircraft structures
- ▶ Thick parts cured under low pressure
- ▶ Honeycomb stiffened parts
- ▶ Automated and hand lay-up fabrication processes

### SHELF LIFE

**Out Life:** Up to 28 days at ambient

**Frozen Storage Life:** 12 months at -18°C (< 0°F)

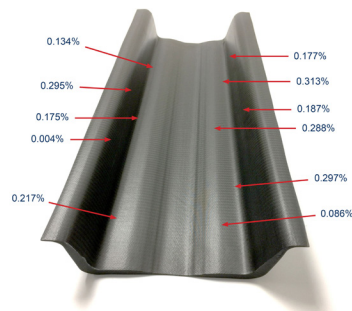
Out life is the maximum time allowed at ambient temperature before cure. \*Ambient is 18–22°C (65–72°F)

\*Out life tested by SBS on 8-ply 15 x 15 cm (6 x 6") fabric laminate, cured in an out-of-autoclave/vacuum bag only (OOA/VBO) environment with 914–948 mbar (27–28 in Hg). Users may need to separately evaluate out life limits on thicker, larger, and more complex parts.

### NEAT RESIN PROPERTIES

Resin Density	1.18 g/cc
Dry T <sub>g</sub> (DMA) with 180°C (356°F) cure	201°C (394°F)
Wet T <sub>g</sub> (DMA) with 180°C (356°F) cure	167°C (332°F)
Coefficient of Thermal Expansion	72.8 ppm/°C* (40.4 ppm/°F)
Total Mass Loss (TML)	0.83%
Collected Volatile Condensable Material (CVCM)	0.01%
Water Vapor Recovered (WVR)	0.75%
*3 lots of data	

### TC380 91-PLY WING SPAR



**Part Shown:** 76 x 28 x 1.9 cm (30" x 11" x 0.75")

Toray measured void content in various locations on a 91-ply wing spar, showing a high degree of consolidation under OOA/VBO processing.



Contact us for more information:

**North America/Asia/Pacific**

**e** [explore@toraytac-usa.com](mailto:explore@toraytac-usa.com)

**t** +1 408 465 8500

**Europe/Middle East/Africa**

**e** [explore@toraytac-europe.com](mailto:explore@toraytac-europe.com)

**t** +44 (0)1773 530899

## PRODUCT DATA SHEET

### UNI-DIRECTIONAL MECHANICAL PROPERTIES

Property	Symbol	Method	Units	TC380/T1100G-71E				
				120 gsm, 35% RC		150 gsm, 35% RC		
				Autoclave Cure <small>NCAMP Qualifications in Process</small>		OOA/VBO		
				RTD	ETW1	RTD	ETD	ETW2
0° Tensile Strength	$F_{1t}$	ASTM D3039	Ksi (MPa)	508 (3506)	485 (3341)	511 (3523)	514 (3545)	507 (3496)
90° Tensile Strength	$F_{2t}$	ASTM D3039	Ksi (MPa)	8.4 (58.4)	5.5 (38.2)	8.0 (55.2)	6.2 (43.1)	3.1 (21.6)
0° Tensile Modulus	$E_{1t}$	ASTM D3039	Msi (GPa)	26.0 (179.4)	25.6 (176.6)	31.4 (216.9)	29.1 (200.9)	27.6 (190.3)
90° Tensile Modulus	$E_{2t}$	ASTM D3039	Msi (GPa)	1.10 (7.58)	0.92 (6.34)	1.13 (7.79)	0.88 (6.07)	0.78 (5.38)
0° Compressive Strength (Backed Out)	$F_{1c}$	ASTM D6641	Ksi (MPa)	248 (1713)	192 (1324)	234 (1612)	208 (1435)	191 (1317)
90° Compressive Strength	$F_{2c}$	ASTM D6641	Ksi (MPa)	28 (194)	23 (156)	29 (200)	24 (162)	17 (120)
0° Compressive Modulus	$E_{1c}$	ASTM D6641	Msi (GPa)	24.5 (169.2)	25.0 (172.7)	-	-	-
90° Compressive Modulus	$E_{2c}$	ASTM D6641	Msi (GPa)	1.19 (8.20)	1.28 (8.83)	-	-	-
0° Compressive Strength	$F_{1c}$	ASTM D695 <sup>1</sup>	Ksi (MPa)	-	-	182 (1253)	163 (1120)	163 (1127)
90° Compressive Strength	$F_{2c}$	ASTM D695 <sup>1</sup>	Ksi (MPa)	-	-	33 (225)	27 (187)	20 (140)
0° Compressive Modulus	$E_{1c}$	ASTM D695 <sup>1</sup>	Msi (GPa)	-	-	24.0 (165.8)	22.7 (156.8)	23.7 (163.8)
90° Compressive Modulus	$E_{2c}$	ASTM D695 <sup>1</sup>	Msi (GPa)	-	-	1.28 (8.83)	1.36 (9.38)	1.19 (8.20)
0° Flexural Strength	$\sigma_f$	ASTM D7264	Ksi (MPa)	254 (1752)	-	269 (1857)	210 (1446)	148 (1019)
0° Flexural Modulus	$E_f$	ASTM D7264	Msi (GPa)	24.2 (166.8)	-	19.7 (136.0)	18.5 (127.8)	16.8 (116.0)
Interlaminar Shear Strength	SBS	ASTM D2344	Ksi (MPa)	16.2 (111.9)	-	12.7 (88.0)	9.8 (67.9)	6.3 (43.5)
In-Plane Shear Strength Ultimate	$F_{12}$	ASTM D3518	Ksi (MPa)	22.0 (151.4)	9.1 (62.5)	17.0 (117.0)	11.8 (81.2)	8.6 (59.2)
In-Plane Shear Strength 0.2%Offset	$F_{12@0.2\%}$	ASTM D3518	Ksi (MPa)	6.2 (43.1)	4.4 (30.4)	-	-	-
In-Plane Shear Modulus	$G_{12}$	ASTM D3518	Msi (GPa)	0.50 (3.45)	0.41 (2.83)	0.43 (2.96)	0.37 (2.55)	0.30 (2.07)
V-Notch Shear Strength (0.5% Offset) (1,2)		ASTM D5379	Ksi (MPa)	-	-	8.3 (57.2)	6.9 (47.4)	6.0 (41.3)
V-Notch Shear Modulus (1,2)		ASTM D5379	Msi (GPa)	-	-	0.59 (4.07)	0.46 (3.17)	0.45 (3.10)

## PRODUCT DATA SHEET

### UNI-DIRECTIONAL MECHANICAL PROPERTIES - CONTINUED

Continued from page 2

Property	Symbol	Method	Units	TC380/T1100G-71E				
				120 gsm, 35% RC		150 gsm, 35% RC		
				Autoclave Cure NCAMP Qualifications in Process		OOA/VBO		
				RTD	ETW1	RTD	ETD	ETW2
Compression After Impact Strength 6.7 J/mm (1500in-lb/in) Impact Energy	CAI	ASTM D7136/ D7137	Ksi (MPa)	43 (295)	-	-	42 (293)	-
Mode I Fracture Toughness (G1c)	G1c	ASTM D5528	in-lb./sq in (kJ/m2)	2.7 (19.0)	-	2.3 (15.8)	-	-
Mode II Fracture Toughness (G2c)	G2c	ASTM D7905	in-lb./sq in (kJ/m2)	9.3 (64.6)	-	9.4 (64.8)	-	-
Open Hole Tensile Strength	OHT	ASTM D5766	Ksi (MPa)	95 (653)	-	87 (598)	97 (672)	98 (674)
Filled Hole Tensile Strength	FHT	ASTM D6742	Ksi (MPa)	94 (649)	-	83 (573)	-	-
Un-notched Compressive Strength	UNC	ASTM D6641	Ksi (MPa)	77 (532)	-	90 (619)	81 (562)	70 (485)
Un-notched Compressive Modulus	UNC	ASTM D6641	Msi (GPa)	8 (58)	-	8 (56)	9 (60)	8 (55)
Open Hole Compressive Strength <sup>2</sup>	OHC	ASTM D6484	Ksi (MPa)	39 (270)	-	44 (306)	35 (243)	32 (218)
Water Absorption %		N/A	%				0.85	
Laminate T <sub>g</sub> (onset, DMA, Dry)		DMA	°F (°C)	402 (205)			410 (210)	
Laminate T <sub>g</sub> (onset, DMA, Wet)		DMA	°F (°C)	335 (168)			329 (165)	

**Notes**  
 RTD: 72°F/22°C, as-received  
 ETD: 250°F/121°C, as-received  
 ETW1: 180°F/82°C, 2 week water soak at 160°F water temperature, followed by humidity chamber at 145°F/85% RH until 0.02% equilibrium  
 ETW2: 250°F/121°C, 2 week water soak at 160°F water temperature  
 Axial Strengths/Moduli and Flexural properties are normalized to 60% FV, shear and transverse properties as-tested unless noted otherwise  
 Axial Strengths/Moduli properties are normalized to 0.0044" CPT for Autoclave Cure  
 1 Modified for 3.18" Sample Size  
 2 OHC Autoclave Layup [45/0/-45/90]2S, 16 ply; Oven Layup [45/-45/0/90]4s, 32 ply

### FABRIC MECHANICAL PROPERTIES

Property	Symbol	Method	Units	TC380/T800HB 6K 2x2 Twill 200gsm, 40% RC <sup>1</sup> NCAMP Qualifications in Process		
				RTD	ETW1	ETW2
0° Tensile Strength	F <sub>1t</sub>	ASTM D3039	Ksi (MPa)	149 (1030)	140 (962)	136 (940)
90° Tensile Strength	F <sub>2t</sub>	ASTM D3039	Ksi (MPa)	149 (1025)	130 (899)	126 (865)
0° Tensile Modulus	E <sub>1t</sub>	ASTM D3039	Msi (GPa)	10.6 (73.0)	10.4 (71.7)	10.4 (71.7)
90° Tensile Modulus	E <sub>2t</sub>	ASTM D3039	Msi (GPa)	10.5 (72.3)	10.3 (71.0)	10.1 (69.6)

## PRODUCT DATA SHEET

### FABRIC MECHANICAL PROPERTIES - CONTINUED

Continued from page 3

Property	Symbol	Method	Units	TC380/T800HB 6K 2x2 Twill 200gsm, 40% RC <sup>1</sup> NCAMP Qualifications in Process		
				RTD	ETW1	ETW2
0° Compressive Strength	F <sub>1c</sub>	ASTM D6641	Ksi (MPa)	89 (614)	72 (495)	61 (423)
90° Compressive Strength	F <sub>2c</sub>	ASTM D6641	Ksi (MPa)	84 (578)	72 (493)	63 (433)
0° Compressive Modulus	E <sub>1c</sub>	ASTM D6641	Msi (GPa)	9.3 (64.1)	9.3 (64.1)	9.5 (65.5)
90° Compressive Modulus	E <sub>2c</sub>	ASTM D6641	Msi (GPa)	9.2 (63.4)	9.5 (65.5)	9.4 (64.8)
Interlaminar Shear Strength	SBS	ASTM D2344	Ksi (MPa)	10.7 (73.7)	7.1 (53.0)	5.9 (40.6)
In-Plane Shear Strength 0.2%Offset	F <sub>12@0.2%</sub>	ASTM D3518	Ksi (MPa)	6.2 (42.7)	4.1 (28.3)	2.9 (20.0)
In-Plane Shear Modulus	G <sub>12</sub>	ASTM D3518	Msi (GPa)	0.50 (3.45)	0.50 (3.45)	0.50 (3.45)
Laminate T <sub>g</sub> (onset, DMA, Dry)		DMA	°F (°C)	417 (214)		
Laminate T <sub>g</sub> (onset, DMA, Wet)		DMA	°F (°C)	343 (173)		

**Notes**

RTD: 72°F/22°C, as-received  
 ETW1: 180°F/82°C, conditioned per SACMA-SRM11R-94 at 160 ± 5°F / 85 ± 5% RH until 0.02% equilibrium  
 ETW2: 250°F/121°C, conditioned per SACMA-SRM11R-94 at 160 ± 5°F / 85 ± 5%RH until 0.02% equilibrium  
<sup>1</sup>As-tested, not normalized

### CARBON SPREAD FABRIC MECHANICAL PROPERTIES

Property	Symbol	Method	Units	T1100 Spread PW 196gsm, 36% RC <sup>1,2</sup>			T700 Spread PW 88gsm, 40% RC <sup>1,2</sup>		T700 Spread PW 192gsm, 40% RC	
				RTD	ETW1	ETW2	RTD	ETW3	RTD	ETW3
0° Tensile Strength	F <sub>1t</sub>	ASTM D3039	Ksi (MPa)	216 (1492)	-	-	-	-	-	-
90° Tensile Strength	F <sub>2t</sub>	ASTM D3039	Ksi (MPa)	202 (1394)	130 (899)	-	166 (1141)	-	157 (1085)	-
0° Tensile Modulus	E <sub>1t</sub>	ASTM D3039	Msi (GPa)	11.1 (76.5)	-	-	-	-	-	-
90° Tensile Modulus	E <sub>2t</sub>	ASTM D3039	Msi (GPa)	11.6 (80.1)	-	-	10.3 (71.0)	-	10.3 (71.0)	-
0° Compressive Strength	F <sub>1c</sub>	ASTM D6641	Ksi (MPa)	87 (603)	66 (458)	-	-	-	-	-
90° Compressive Strength	F <sub>2c</sub>	ASTM D6641	Ksi (MPa)	83 (571)	-	50 (348)	81 (559)	67 (462)	80 (549)	59 (405)

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### CARBON SPREAD FABRIC MECHANICAL PROPERTIES - CONTINUED

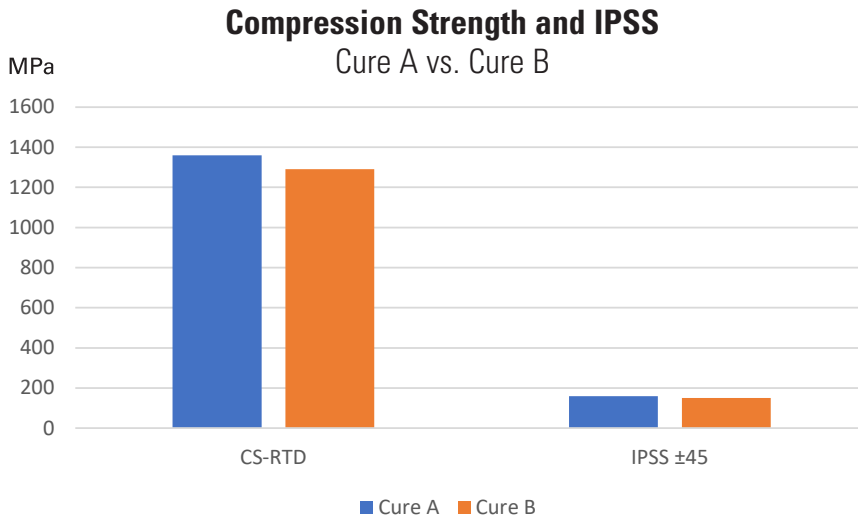
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Property	Symbol	Method	Units	T1100 Spread PW 196gsm, 36% RC <sup>1,2</sup>			T700 Spread PW 88gsm, 40% RC <sup>1,2</sup>		T700 Spread PW 192gsm, 40% RC	
				RTD	ETW1	ETW2	RTD	ETW3	RTD	ETW3
0° Compressive Modulus	E <sub>1c</sub>	ASTM D6641	Msi (GPa)	11.4 (78.7)	10.8 (74.6)	-	-	-	-	-
90° Compressive Modulus	E <sub>2c</sub>	ASTM D6641	Msi (GPa)	11.2 (77.2)	-	10.3 (71.3)	7.8 (53.7)	9.9 (68.2)	8.7 (59.9)	10.0 (68.9)
0° Flexural Strength	σ <sub>f</sub>	ASTM D7264	Ksi (MPa)	130 (899)	78 (540)	-	153 (1053)	-	139 (958)	-
0° Flexural Modulus	E <sub>f</sub>	ASTM D7264	Msi (GPa)	10.4 (71.7)	10.8 (74.4)	-	9.1 (62.7)	-	8.9 (61.3)	-
Interlaminar Shear Strength	SBS	ASTM D2344	Ksi (MPa)	9.4 (64.8)	-	4.0 (27.5)	10.5 (72.3)	5.0 (34.4)	10.6 (73.0)	5.2 (35.8)
In-Plane Shear Strength 0.2%Offset	F <sub>12 @ 0.2%</sub>	ASTM D3518	Ksi (MPa)	6.0 (41.4)	-	4.0 (27.6)	5.0 (34.5)	3.0 (20.7)	5.6 (38.6)	3.5 (24.1)
In-Plane Shear Strength 5% Strain	F <sub>12 @ 5%</sub>	ASTM D3518	Ksi (MPa)	10.0 (68.9)	6.1 (42.1)	-	-	-	-	-
In-Plane Shear Modulus	G <sub>12</sub>	ASTM D3518	Msi (GPa)	0.52 (3.59)	-	0.47 (3.24)	0.47 (3.24)	0.36 (2.48)	0.49 (3.38)	0.44 (3.03)
Compression After Impact Strength 6.7 J/mm (1500in-lb/in) Impact Energy	CAI	ASTM D136/ D7137	Ksi (MPa)	36 (247)	-	-	-	-	-	-
Open Hole Tensile Strength	OHT	ASTM D5766	Ksi (MPa)	-	-	-	61 (417)	65 (448)	64 (443)	73 (503)
Filled Hole Tensile Strength	FHT	ASTM D5766	Ksi (MPa)	-	-	-	126 (869)	-	104 (718)	-
Open Hole Compressive Strength	OHC	ASTM D6484	Ksi (MPa)	-	-	-	42 (292)	33 (228)	42 (292)	32 (222)
Unnotched Compressive Strength	UNC	ASTM D6484	Ksi (MPa)	-	-	-	89 (616)	-	77 (533)	-

**Notes**  
 RTD: 72°F/22°C, as-received  
 ETW1: 180°F/82°C, 2 week water soak at 160°F  
 ETW2: 250°F/121°C, conditioned per SACMA-SRM11R-94 at 160 ± 5°F / 85 ± 5% RH until 0.02% equilibrium  
 ETW3: 180°F/82°C, conditioned per SACMA-SRM11R-94 at 160 ± 5°F / 85 ± 5% RH until 0.02% equilibrium  
<sup>1</sup>As-tested data - Autoclave Cure  
<sup>2</sup>Tensile/Compression data normalized to 0.0087" CPT, Shear data reported as-tested - Autoclave Cure

## PRODUCT DATA SHEET

### OOA/VBO CURE CYCLE A VS. CURE CYCLE B COMPARISON



**Cure A** is 180°C (356°F)  
**Cure B** is 135°C (275°F), with 180°C (356°F) post cure

### MECHANICAL PROPERTIES

Property	Symbol	Method	Results	
			Cure A	Cure B
			RTD	RTD
Compressive Strength 0°	F <sub>1c</sub>	ASTM D 695 <sup>1</sup>	198 ksi (1365 MPa)	187 ksi (1289 MPa)
Compressive Strength 90°	F <sub>2c</sub>	ASTM D 695 <sup>1</sup>	35 ksi (245 MPa)	33 ksi (229 MPa)
Interlaminar Shear Strength	SBS	ASTM D 2344	15.3 ksi (105.30 MPa)	14.7 ksi (101.35 MPa)
In-Plane Shear Strength Ultimate	F <sub>12</sub>	ASTM D 3518	23.1 ksi (159.3 MPa)	21.7 ksi (149.6 MPa)
In-Plane Shear Modulus	G <sub>12</sub>	ASTM D 3518	0.54 Msi (3.72 GPa)	0.51 Msi (3.52 GPa)
Compression After Impact Strength 6.7 J/mm (1500in-lb/in) Impact Energy	CAI	ASTM D 136 / D 7137	42 ksi (290 MPa)	43 ksi (294 MPa)
Laminate T <sub>g</sub> (Onset, DMA, Dry)		DMA	400°F (208°C)	393°F (201°C)

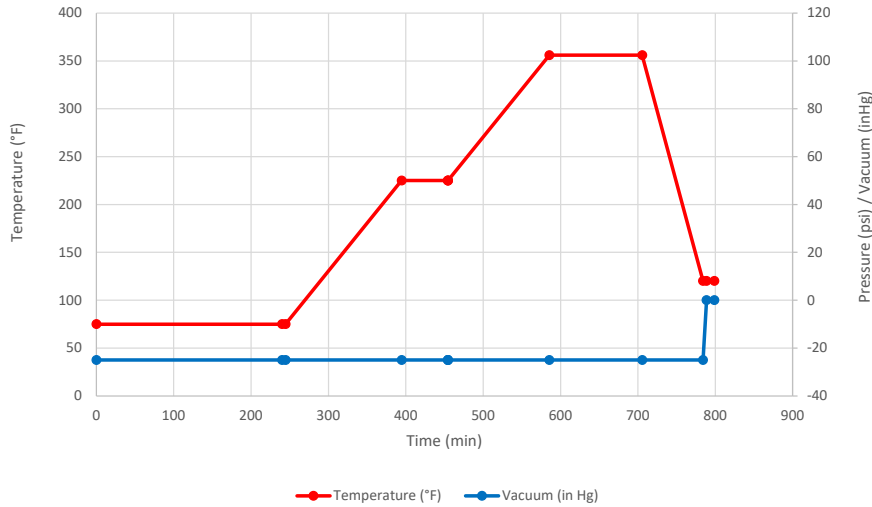
RTD: 72°F / 22°C, as -recieved

Cure A – 0.6°C (1°F) per minute to 107°C (225°F), hold for 1 hour, then 0.6°C (1°F) per minute to 180°C (356°F), hold 2 hours.  
 Cure B – 0.6°C (1°F) per minute to 107°C (225°F), hold for 1 hour, then 0.6°C (1°F) per minute to 135°C (275°F), hold 3 hours. Demold and post cure freestanding at 180°C (356°F) for 2 hours.

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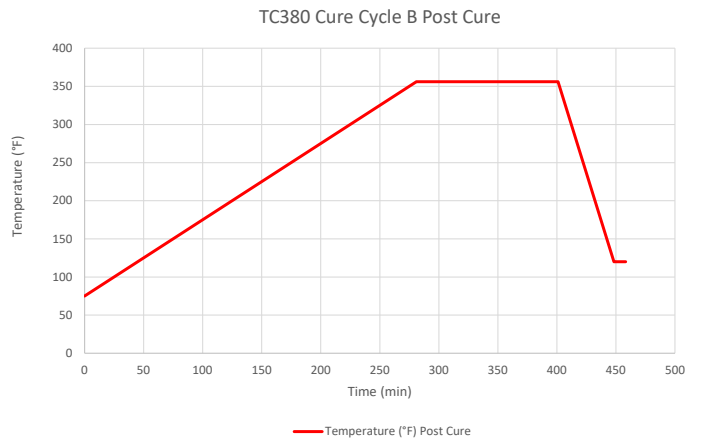
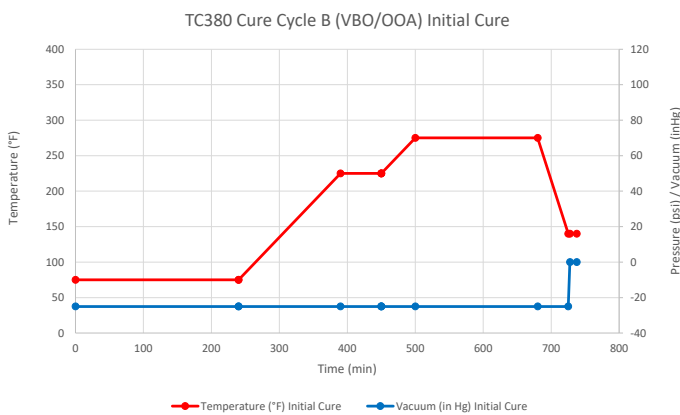
### TYPICAL CURE PARAMETERS - CURE A

- ▶ Debulk under vacuum every 4 plies for 15 minutes.
- ▶ Apply vacuum pressure, hold for 4 hours at room temperature.
- ▶ Ramp at 0.6°C (1°F) per minute to 107°C (225°F), hold for 1 hour.
- ▶ Ramp at 0.6°C (1°F) per minute to 180°C (356°F), hold for 2 hours.
- ▶ Cool to below 49°C (120°F) at 3°C (5°F) per minute or less, release vacuum.



### TYPICAL CURE PARAMETERS - CURE B

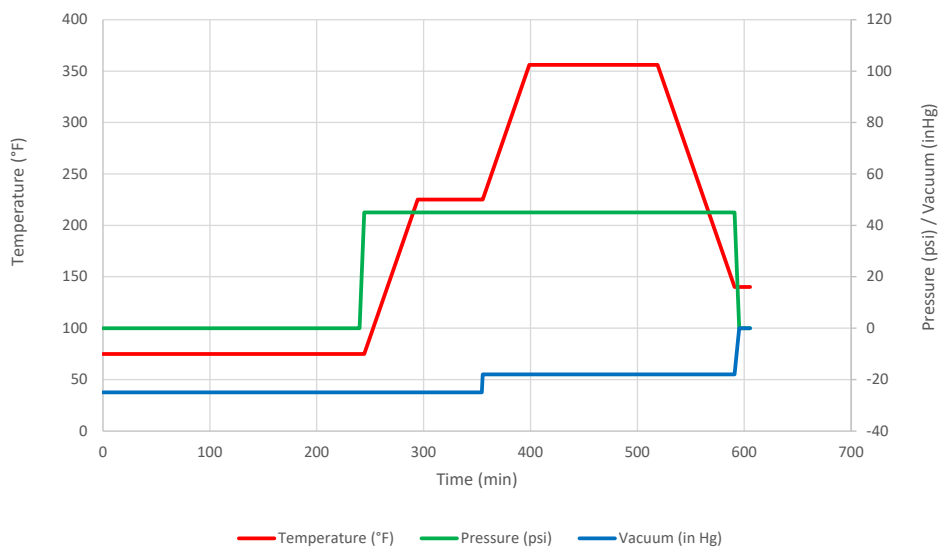
- ▶ Debulk under vacuum every 4 plies for 15 minutes.
- ▶ Apply vacuum, hold for 4 hours at room temperature.
- ▶ Ramp at 0.6°C (1°F) per minute to 107°C (225°F), hold for 1 hour.
- ▶ Ramp at 0.6°C (1°F) per minute to 135°C (275°F), hold for 3 hours.
- ▶ Remove from oven and debag.
- ▶ Post cure by placing in oven and ramp at 0.6°C (1°F) per minute to 180°C (356°F), hold for 2 hours.
- ▶ Cool to below 49°C (120°F) at 3°C (5°F) per minute or less, release vacuum.



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### TYPICAL CURE PARAMETERS - CURE C

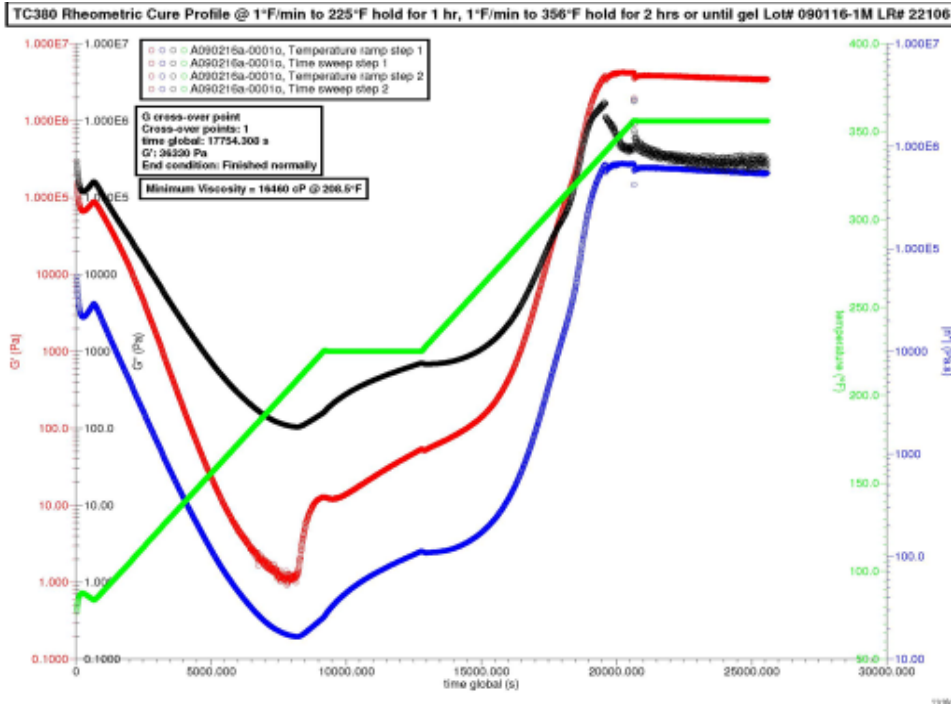
- ▶ Debulk under vacuum every 4 plies for 15 minutes.
- ▶ Apply vacuum pressure, hold for 4 hours at room temperature.
- ▶ Apply 45 psi autoclave pressure.
- ▶ Ramp at 0.6°C (1°F) per minute to 107°C (225°F), hold for 1 hour.
- ▶ Ramp at 0.6°C (1°F) per minute to 180°C (356°F), hold for 2 hours.
- ▶ Cool to below 49°C (120°F) at 3°C (5°F) per minute or less, release pressure and vacuum.



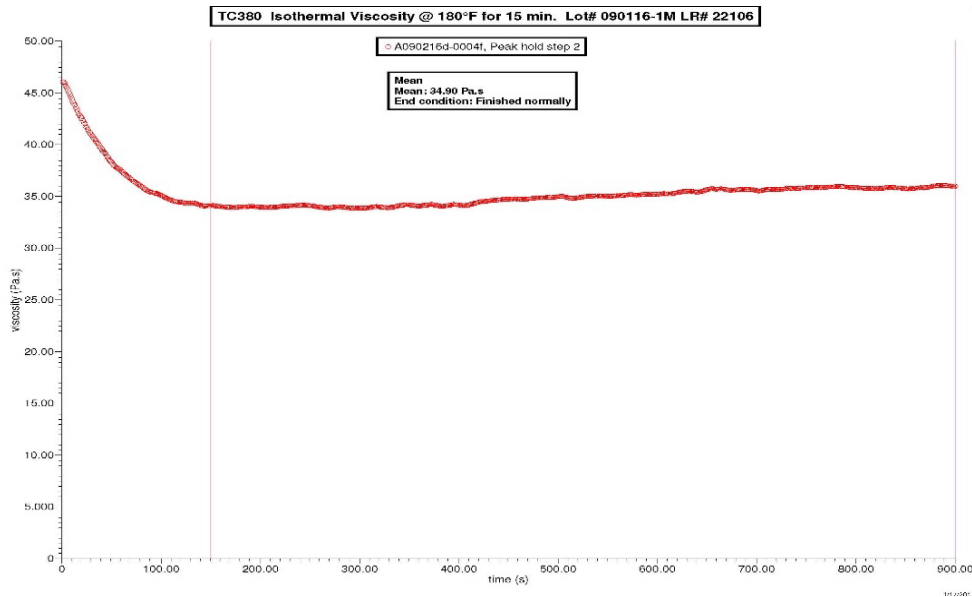


## PRODUCT DATA SHEET

### DYNAMIC VISCOSITY PROFILE FOR CURE A

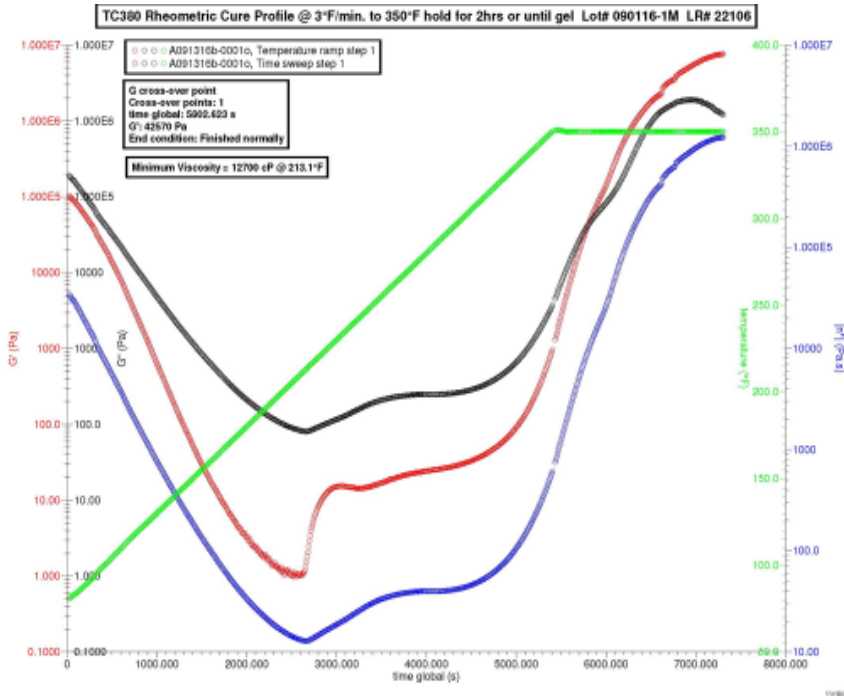


### ISOTHERMAL VISCOSITY @ 82°C (180°F)



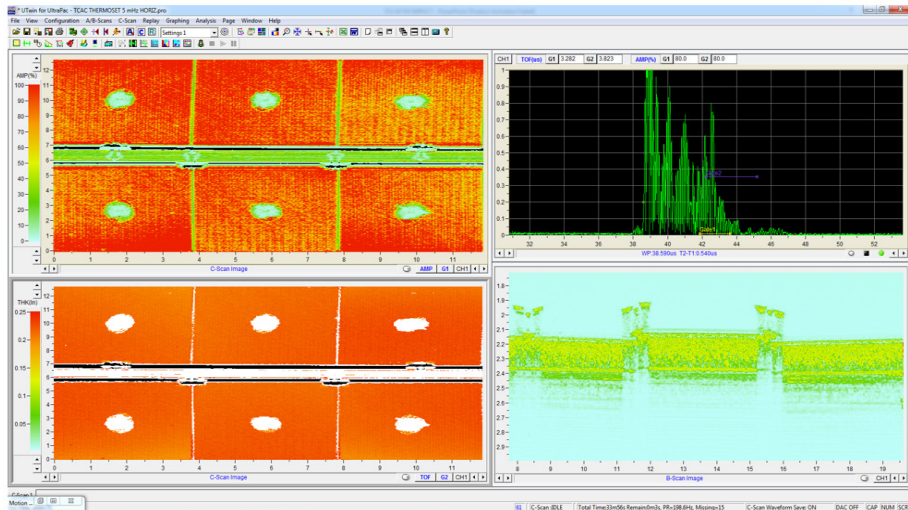
## PRODUCT DATA SHEET

### DYNAMIC VISCOSITY @ 1.5°C (3°F) TO 180°C (356°F)



### COMPRESSION AFTER IMPACT C-SCAN DEMONSTRATING HIGHLY RESTRICTED DAMAGE AREAS

HTS40 3K 2X2 TWILL 193 GSM/TC380 LR# 22764 LOT #:121316-1T3-1 GAIN: 23.9 VOLTAGE:400 ENERGY: 820



## PRODUCT DATA SHEET

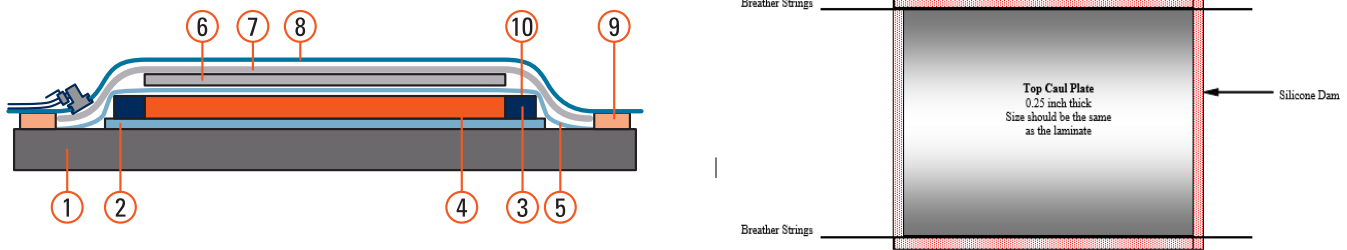
### TYPICAL COMPOSITE LAMINATE STACKING SEQUENCE

#### List of Materials

1. Tool—aluminum, steel, Invar, composite (tool plates must be release coated or film covered). See the list below
2. Release coat or film—Frekote 700NC or 770NC, FEP, TEDLAR. Lay-up part using standard debulking procedures
3. Silicone edge dams for cure—slightly thicker than laminate
4. Laminate
5. Release coat or film—Frekote 700NC or 770NC, FEP, TEDLAR
6. Caul plate—aluminum, steel, Invar, silicone rubber sheet (metal caul plates must be release coated or wrapped)
7. 2.2 oz/yd<sup>2</sup> polyester breather, 1 or more
8. Vacuum bag
9. Vacuum sealant
10. Glass yarn string (alternatively or additionally breather may wrap over top of dam to contact edge)

Follow the provided Toray Advanced Composites cure cycle for the particular resin system.

Figure 1



Note: The breather string must be in the edge of the part, must not lay on the top of the panel and must extend out past the seal to touch the breather pad as shown

### RECOMMENDED BAGGING PROCEDURE FOR CURE

Bagging of epoxy composite parts for cure should be performed as follows:

1. Properly prepare the tool surface with release coat or film.
2. Lay-up part using standard debulking procedures.
3. Dam the edges of the part for cure.
4. Place one ply of porous Teflon® or perforated Teflon onto the bag surface of the part.
5. Place bleeder layers over the porous Teflon material and trim to the part periphery.
6. Place a non-porous layer of Teflon over the part.
7. Utilize a breather cloth to assure a clear path for vacuum.
8. Install vacuum bag on the tool for cure.
9. Follow the provided Toray Advanced Composites cure cycle for the particular resin system.

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