Toray TC380

Toray Advanced Composites

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 $G_IC/G_{II}C$ properties. It features low moisture absorption with outstanding hot/wet mechanical properties to 121°C (250°F). TC380 is optimized for out-of-autoclave/vacuum bag only (OOA/VBO) cures, facilitating construction of large or complex composite parts and assemblies. Unlike some other highly toughened systems, there is no need to sequence the prepreg front and back face, assuring robustness and simplifying lay-up. TC380 out life are 21 and 28 days, respectively.

FEATURES

- **Outstanding toughness, open hole, and compression after impact (CAI) properties**
- **Excellent hot/wet strength retention**
- **Robust processing and low voids under vacuum bag only cure pressure**
- **Long out time and out life for extended shop floor handling**
- **Tackand 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)

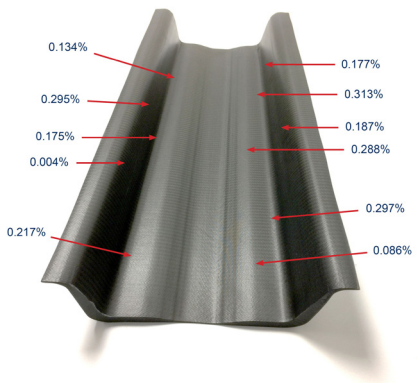
Out life is the maximum time allowed at ambient temperature before cure. *Ambient is 18–22°C (65–72°F)

**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_g (DMA) with 180°C (356°F) cure	201°C (394°F)
Total Mass Loss (TML)	0.83%
Collected Volatile Condensable Material (CVCM)	0.01%
Water Vapor Recovered (WVR)	0.75%

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.

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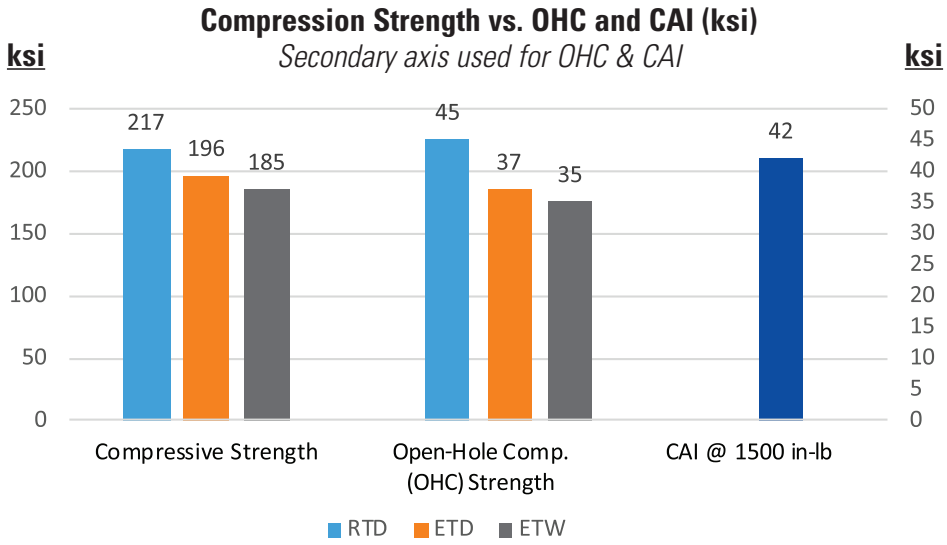
EXCELLENT STRENGTH RETENTION FROM RTD TO ETW



MECHANICAL PROPERTIES

Property	Condition	Method	UD Tape (a)		2x2 Twill Carbon Fabric (b)	
Tensile Strength 0°	RTD	ASTM D 3039	2923 MPa	424 ksi	1051 MPa	152 ksi
Tensile Modulus 0°	RTD	ASTM D 3039	183 GPa	26.6 Msi	64 GPa	9.3 Msi
Tensile Strength 0°	ETD	ASTM D 3039	2785 MPa	404 ksi	1111 MPa	161 ksi
Tensile Modulus 0°	ETD	ASTM D 3039	195 GPa	28.3 Msi	77 GPa	11.2 Msi
Tensile Strength 0°	ETW	ASTM D 3039	2841 MPa	412 ksi	1061 MPa	154 ksi
Tensile Modulus 0°	ETW	ASTM D 3039	205 GPa	29.8 Msi	71 GPa	10.3 Msi
Poisson's Ratio	RTD	ASTM D 3039	-	0.37	-	-
Tensile Strength 90°	RTD	ASTM D3039	76.5 MPa	11.1 ksi	1067 MPa	154 ksi
Tensile Modulus 90°	RTD	ASTM D 3039	7.9 GPa	1.2 Msi	68.2 GPa	9.9 Msi
Tensile Strength 90°	ETD	ASTM D 3039	62.7 MPa	9.1 ksi	1067 MPa	155 ksi
Tensile Modulus 90°	ETD	ASTM D 3039	6.8 GPa	1.0 Msi	78.1 GPa	11.3 Msi
Tensile Strength 90°	ETW	ASTM D 3039	33.1 MPa	4.8 ksi	1028 MPa	149 ksi
Tensile Modulus 90°	ETW	ASTM D 3039	5.1 GPa	0.7 Msi	74.8 GPa	10.9 Msi
Compressive Strength 0°	RTD	ASTM D 6641	1496 MPa	217 ksi	-	-
Compressive Modulus 0°	RTD	ASTM D 6641	143 GPa	20.7 Msi	-	-
Compressive Strength 0°	ETD	ASTM D 6641	1351 MPa	196 ksi	-	-
Compressive Modulus 0°	ETD	ASTM D 6641	141 GPa	20.5 Msi	-	-
Compressive Strength 0°	ETW	ASTM D 6641	1276 MPa	185 ksi	-	-
Compressive Modulus 0°	ETW	ASTM D 6641	134 GPa	19.4 Msi	-	-

Continued on page 3

MECHANICAL PROPERTIES

Continued from page 2

Property	Condition	Method	UD Tape (a)		2x2 Twill Carbon Fabric (b)	
Tensile Strength 0°	RTD	ASTM D 3039	2923 MPa	424 ksi	1051 MPa	152 ksi
Tensile Modulus 0°	RTD	ASTM D 3039	183 GPa	26.6 Msi	64 GPa	9.3 Msi
Tensile Strength 0°	ETD	ASTM D 3039	2785 MPa	404 ksi	1111 MPa	161 ksi
Tensile Modulus 0°	ETD	ASTM D 3039	195 GPa	28.3 Msi	77 GPa	11.2 Msi
Tensile Strength 0°	ETW	ASTM D 3039	2841 MPa	412 ksi	1061 MPa	154 ksi
Tensile Modulus 0°	ETW	ASTM D 3039	205 GPa	29.8 Msi	71 GPa	10.3 Msi
Poisson's Ratio	RTD	ASTM D 3039	-	0.37	-	-
Tensile Strength 90°	RTD	ASTM D 3039	76.5 MPa	11.1 ksi	1067 MPa	154 ksi
Tensile Modulus 90°	RTD	ASTM D 3039	7.9 GPa	1.2 Msi	68.2 GPa	9.9 Msi
Tensile Strength 90°	ETD	ASTM D 3039	62.7 MPa	9.1 ksi	1067 MPa	155 ksi
Tensile Modulus 90°	ETD	ASTM D 3039	6.8 GPa	1.0 Msi	78.1 GPa	11.3 Msi
Tensile Strength 90°	ETW	ASTM D 3039	33.1 MPa	4.8 ksi	1028 MPa	149 ksi
Tensile Modulus 90°	ETW	ASTM D 3039	5.1 GPa	0.7 Msi	74.8 GPa	10.9 Msi
Compressive Strength 0°	RTD	ASTM D 6641	1496 MPa	217 ksi	-	-
Compressive Modulus 0°	RTD	ASTM D 6641	143 GPa	20.7 Msi	-	-
Compressive Strength 0°	ETD	ASTM D 6641	1351 MPa	196 ksi	-	-
Compressive Modulus 0°	ETD	ASTM D 6641	141 GPa	20.5 Msi	-	-
Compressive Strength 0°	ETW	ASTM D 6641	1276 MPa	185 ksi	-	-
Compressive Modulus 0°	ETW	ASTM D 6641	134 GPa	19.4 Msi	-	-
Compressive Strength 90°	RTD	ASTM D 6641	245 MPa	35.6 ksi	-	-
Compressive Modulus 90°	RTD	ASTM D 6641	8.1 GPa	1.2 Msi	-	-
Compressive Strength 90°	ETD	ASTM D6641	194 MPa	28.2 ksi		-
Compressive Modulus 90°	ETD	ASTM D 6641	7.7 GPa	1.1 Msi	--	-
Compressive Strength 90°	ETW	ASTM D 6641	181 MPa	26.2 ksi	-	-
Compressive Modulus 90°	ETW	ASTM D6641	8.1 GPa	1.2 Msi	-	-
Compressive Strength 0°	RTD	ASTM D 695	-	-	810 MPa	117 ksi
Compressive Modulus 0°	RTD	ASTM D 695	-	-	67 GPa	9.7 Msi
Compressive Strength 0°	ETD	ASTM D 695	-	-	691 MPa	100 ksi
Compressive Modulus 0°	ETD	ASTM D 695	-	-	63 GPa	9.1 Msi
Compressive Strength 0°	ETW	ASTM D 695	-	-	657 MPa	95.3 ksi
Compressive Modulus 0°	ETW	ASTM D 695	-	-	63 GPa	9.1 Msi
Compressive Strength 90°	RTD	ASTM D 695	-	-	843 MPa	122 ksi
Compressive Modulus 90°	RTD	ASTM D 695	-	-	67.8 GPa	9.8 Msi
Compressive Strength 90°	ETD	ASTM D 695	-	-	741 MPa	107 ksi
Compressive Modulus 90°	ETD	ASTM D 695	-	-	64.0 GPa	9.3 Msi

MECHANICAL PROPERTIES

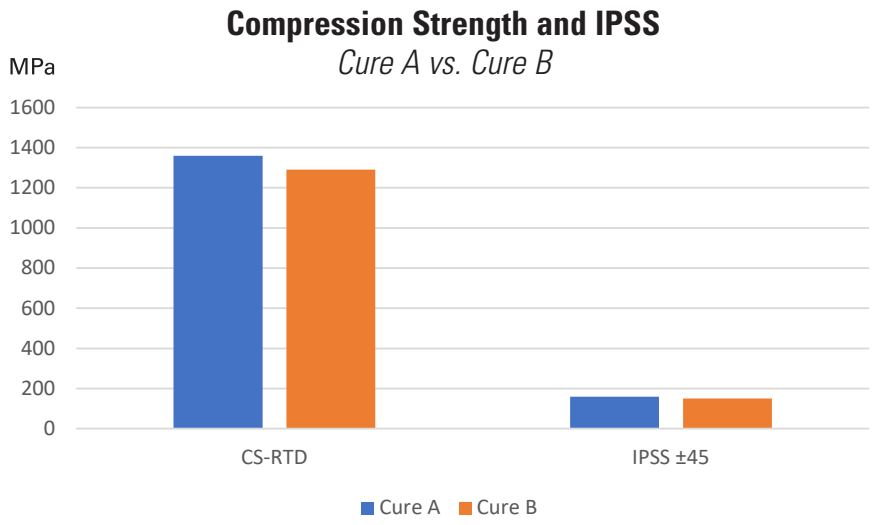
Continued from page 3

Property	Condition	Method	UD Tape (a)		2x2 Twill Carbon Fabric (b)	
Compressive Strength 90°	ETW	ASTM D 695	-	-	692 MPa	100 ksi
Compressive Modulus 90°	ETW	ASTM D 695	-	-	61.8 GPa	9.0 Msi
Flexural Strength 0°	RTD	ASTM D 7264	2055 MPa	300 ksi	1068 MPa	155 ksi
Flexural Modulus 0°	RTD	ASTM D 7264	136 GPa	19.7 Msi	57 GPa	8.2 Msi
Flexural Strength 0°	ETD	ASTM D 7264	1517 MPa	220 ksi	859 MPa	125 ksi
Flexural Modulus 0°	ETD	ASTM D 7264	119 GPa	17.3 Msi	43 GPa	6.2 Msi
Flexural Strength 0°	ETW	ASTM D 7264	1234 MPa	179 ksi	735 MPa	107 ksi
Flexural Modulus 0°	ETW	ASTM D 7264	121 GPa	17.5 Msi	41 GPa	5.9 Msi
Interlaminar Shear Strength	RTD	ASTM D 2344	105 MPa	15.3 ksi	73 MPa	10.6 ksi
Interlaminar Shear Strength	ETD	ASTM D 2344	76 MPa	11.0 ksi	61 MPa	8.8 ksi
Interlaminar Shear Strength	ETW	ASTM D 2344	61 MPa	8.9 ksi	49 MPa	7.2 ksi
Open-Hole Tensile Strength	RTD	ASTM D 5766	459 MPa	66.5 ksi	399 MPa	57.8 ksi
Open-Hole Tensile Strength	ETD	ASTM D 5766	478 MPa	69.4 ksi	402 MPa	58.3 ksi
Open-Hole Tensile Strength	ETW	ASTM D 5766	506 MPa	73.4 ksi	394 MPa	57.2 ksi
Open-Hole Comp. Strength	RTD	ASTM D 6484	312 MPa	45.3 ksi	308 MPa	44.6 ksi
Open-Hole Comp. Strength	ETD	ASTM D 6484	253 MPa	36.7 ksi	279 MPa	40.5 ksi
Open-Hole Comp. Strength	ETW	ASTM D 6484	240 MPa	34.8 ksi	258 MPa	37.4 ksi
Compression After Impact Strength 6.7 J/mm (1500 in-lb/in) Impact Energy	RTD	ASTM D 7136/7137	290 MPa	42.1 ksi	320 MPa	46.5 ksi
In-Plane Shear Str. (+/-45)	RTD	ASTM D 3518	159 MPa	23.1 ksi	151 MPa	22.0 ksi
In-Plane Shear Mod. (+/-45)	RTD	ASTM D 3518	3.7 GPa	0.54 Msi	3.1 GPa	0.45 Msi
In-Plane Shear Str. (+/-45)	ETD	ASTM D 3518	104 MPa	15.1 ksi	105 MPa	15.2 ksi
In-Plane Shear Mod. (+/-45)	ETD	ASTM D 3518	3.9 GPa	0.57 Msi	2.9 GPa	0.42 Msi
In-Plane Shear Str. (+/-45)	ETW	ASTM D 3518	81 MPa	11.8 ksi	88 MPa	12.8 ksi
In-Plane Shear Mod. (+/-45)	ETW	ASTM D 3518	3.7 GPa	0.54 Msi	3.1 GPa	0.45 Msi
Mode I Interlaminar Fracture Toughness (G_{IC} Strain Energy Release Rate)	RTD	ASTM D 5528	490 J/m^2	2.8 in-lb/in^2	-	-
Mode II Interlaminar Fracture Toughness (G_{IIC} Strain Energy Release Rate)	RTD	ASTM D 7905	1821 J/m^2	10.4 in-lb/in^2	-	-
Water Absorption %	ETW	N/A	0.8%	-	0.7%	-
Laminate T_g (Onset, DMA, Dry)	RTD	ASTM D 7028	208°C (407°F)		207°C (405°F)	
Laminate T_g (Onset, DMA, Wet)	RTD	ASTM D 7028	160°C (320°F)		165°C (329°F)	

(a) Uni-directional tape data from IM7 12K, 150gsm/TC380, 34% resin content. All data was normalized to 60% fiber volume by acid digestion method except for ILSS, TS/TM 90°, and CS/CM 90°. CS6641 was back calculated to 0° properties. V-Notch strength results were offset to 0.5%. ETD and ETW specimens were tested at 121°C (250°F). ETW specimens were soaked for 14 days in 71°C (160°F) water. Cure A (see page 6) was used in mechanical data above.
(b) Fabric data represents HTS40 3K 2x2 Twill, 193gsm/TC380, 42% resin content. All data was normalized to 55% fiber volume by acid digestion method except for ILSS. V-Notch strength was tested at 0.5% offset. ETD and ETW specimens were tested at 121°C (250°F). ETW specimens were soaked for 14 days in 71°C (160°F) water. Cure A (see page 6) was used in mechanical data above.

All results except 90° TS/TM, 90° CS/CM, ILSS, have been normalized to 60%. 1. ETW testing conducted at 121°C (250°F) 2. ETD testing conducted at 121°C (250°F)

CURE A VS. CURE B



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

MECHANICAL PROPERTIES

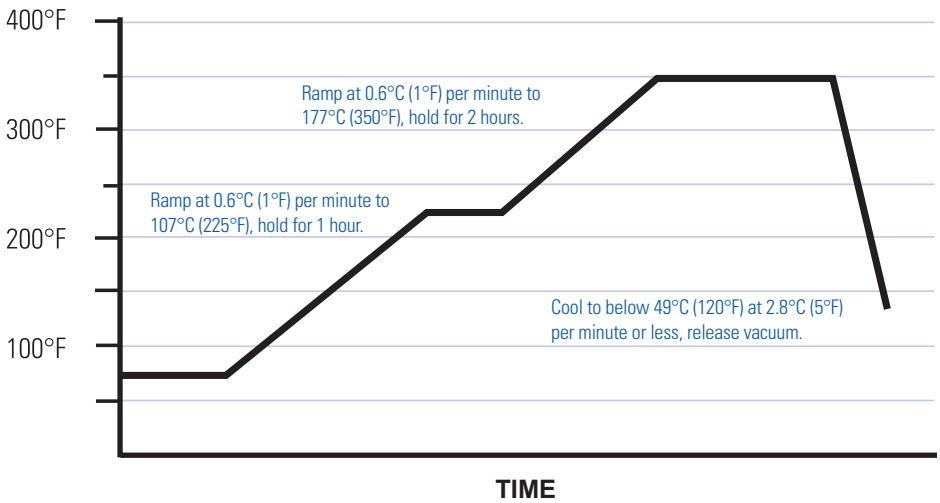
Property	Condition	Method	Results	
Compressive Strength 0°	RTD/Cure A	ASTM D 695	1362 MPa	198 ksi
Compressive Strength 0°	RTD/Cure B	ASTM D 695	1292 GPa	187 Msi
Compressive Strength 90°	RTD/Cure A	ASTM D 695	245 MPa	35.6 ksi
Compressive Strength 90°	RTD/Cure B	ASTM D 695	229 GPa	33.2 Msi
Interlaminar Shear Strength	RTD/Cure A	ASTM D 2344	105 MPa	15.3 ksi
Interlaminar Shear Strength	RTD/Cure B	ASTM D 2344	101 MPa	14.7 ksi
Compression After Impact Strength 6.7 J/mm (1500 in-lb/in) Impact Energy	RTD/Cure A	ASTM D 7136/7137	290 MPa	42.1 ksi
Compression After Impact Strength 6.7 J/mm (1500 in-lb/in) Impact Energy	RTD/Cure B	ASTM D 7136/7137	294 MPa	42.6 ksi
In-Plane Shear Str. (+/-45)	RTD/Cure A	ASTM D 3518	159 MPa	23.1 ksi
In-Plane Shear Mod. (+/-45)	RTD/Cure A	ASTM D 3518	3.7 GPa	0.54 Msi
In-Plane Shear Str. (+/-45)	RTD/Cure B	ASTM D 3518	150 MPa	21.7 ksi
In-Plane Shear Mod. (+/-45)	RTD/Cure B	ASTM D 3518	3.5 GPa	0.51 Msi
Laminate Tg (Onset, DMA, Dry)	RTD/Cure A	ASTM D 7028	208°C (407°F)	
Laminate Tg (Onset, DMA, Dry)	RTD/Cure B	ASTM D 7028	201°C (393°F)	

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.

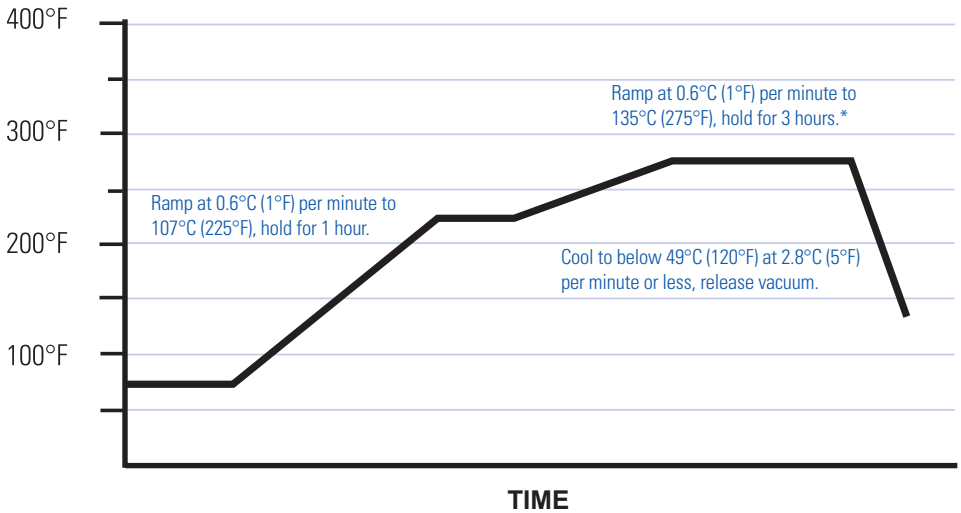
TYPICAL CURE PARAMETERS - CURE A

- 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.



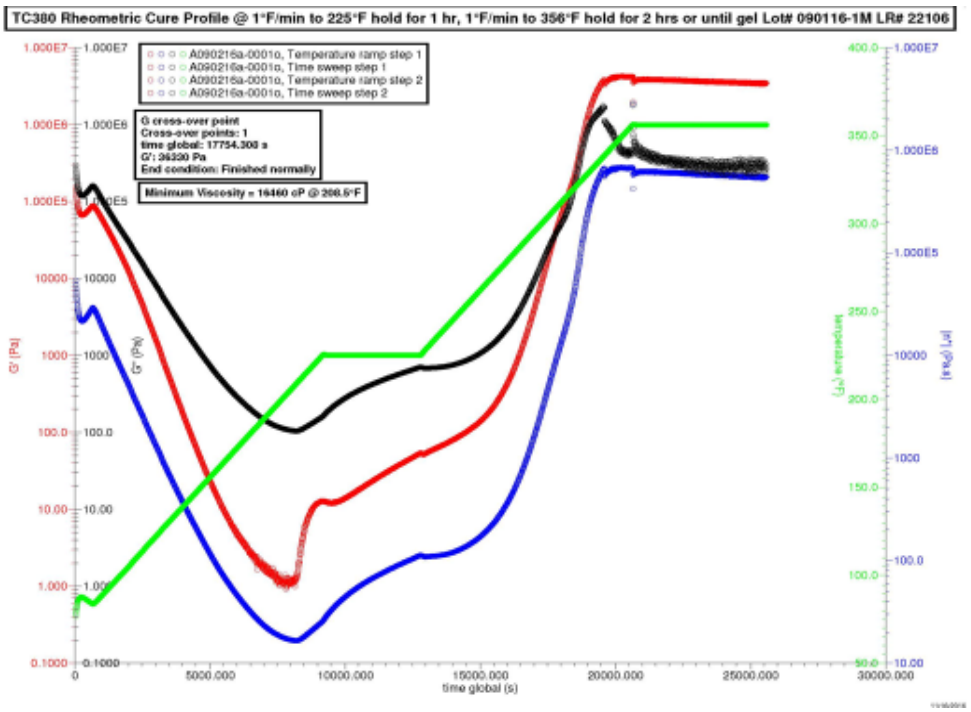
TYPICAL CURE PARAMETERS - CURE B

- 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.

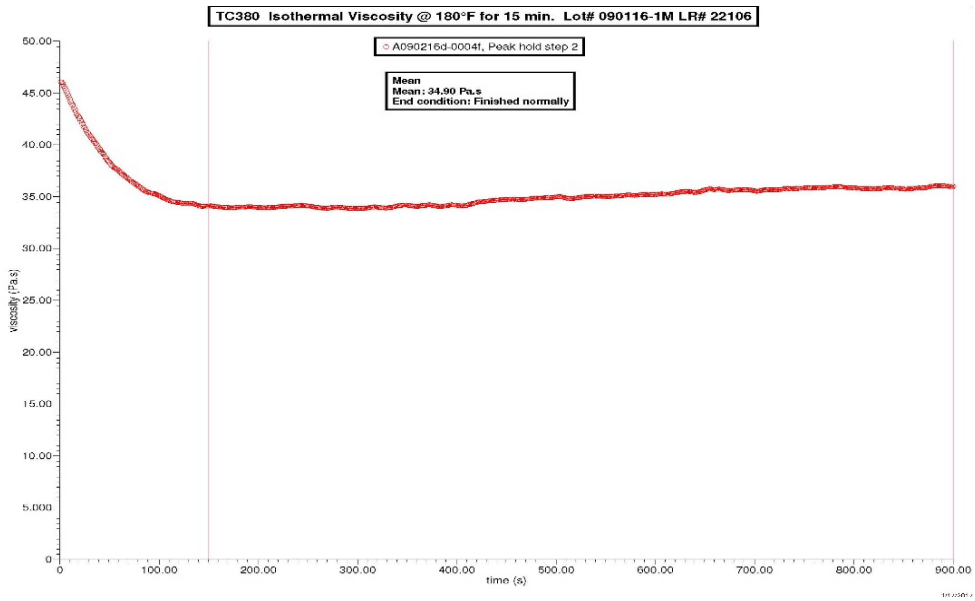


* Followed by 180°C (356°F) freestanding post cure

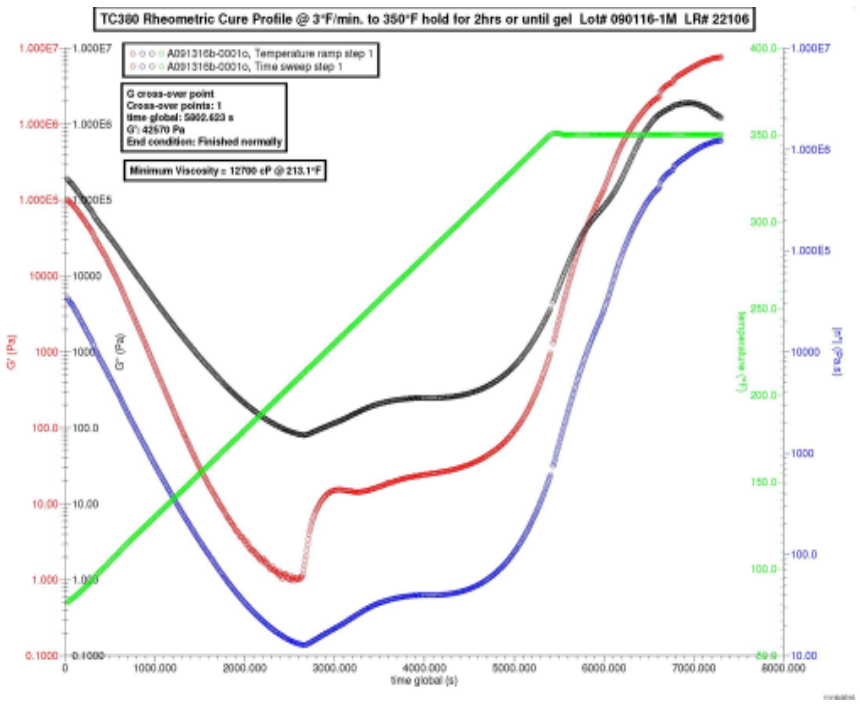
DYNAMIC VISCOSITY PROFILE FOR CURE A



ISOTHERMAL VISCOSITY @ 82°C (180°F)

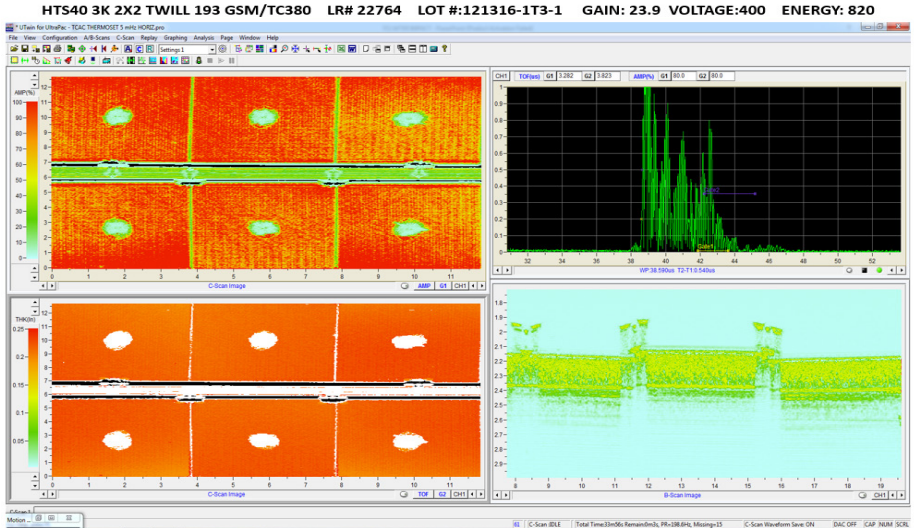


DYNAMIC VISCOSITY @ 1.5°C (3°F) TO 180°C (356°F)



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



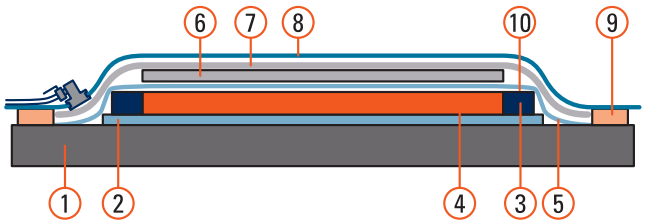
TYPICAL COMPOSITE LAMINATE STACKING SEQUENCE

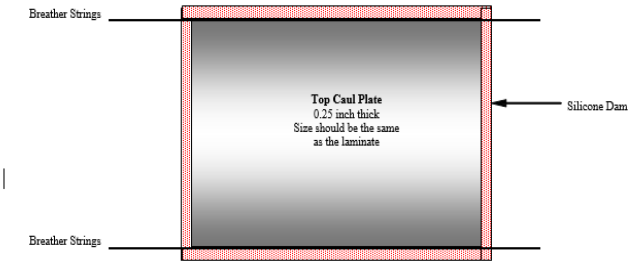
List of Materials

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^2 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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