Toray TC350-1

Toray Advanced Composites

PRODUCT DATA SHEET

DESCRIPTION

Toray TC350-1 is a toughened matrix for structural advanced composite applications. TC350-1 offers an excellent balance of toughness, mechanical property translation, and hot/wet performance. It is easily processed via out-of-autoclave or press curing operations. TC350-1 develops a 191°C (376°F) T_g after a 177°C (350°F) cure, which coupled with low moisture absorption translates into excellent hot/wet performance. TC350-1 is available with virtually all fiber reinforcements in uni-directional tape, slit uni-directional tape, woven, and non-woven prepreg formats.

FEATURES

- **Robust under vacuum bag only (VBO) processing (very low void content)**
- **Excellent mechanical property translation**
- **High toughness**
- **Easy processing**
- **Excellent tack properties**
- **Good surfacing properties**

PRODUCT TYPE

177°C (350°F) Cure, Toughened Epoxy Prepreg

TYPICAL APPLICATIONS

- Aircraft structures
- Space structures
- Radomes and antennas
- Reflectors

SHELF LIFE

Out Life:	45 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 a 15 x 15 cm (6 x 6") laminate, cured in an out-of-autoclave/vacuum bag only (OOA/VBO) environment with 914–948 Mbar (27–28 inHg). Users may need to separately evaluate out life limits on thicker, larger, and more complex parts.*

TYPICAL NEAT RESIN PROPERTIES

Density	1.3 g/cc
Dry T_g (by DMA)	191°C (376°F) cured at 177°C (350°F)
Wet T_g (by DMA)	160°C (320°F) cured at 177°C (350°F) after saturation at 85% RH and 71°C (160°F)
Gel Time	10–12 minutes at 177°C (350°F)

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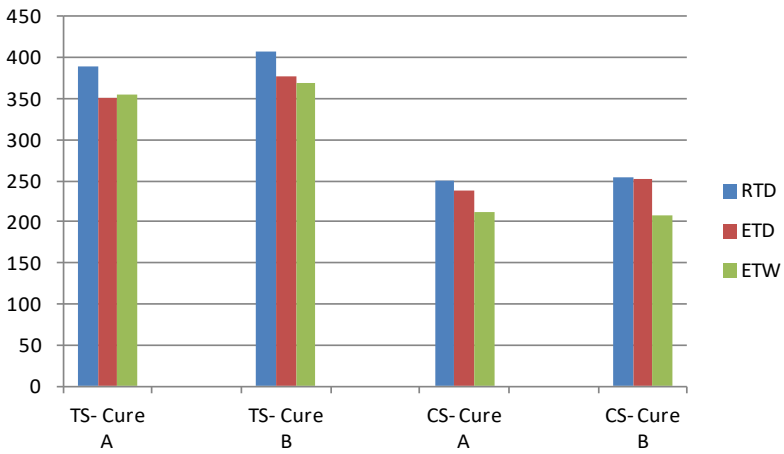
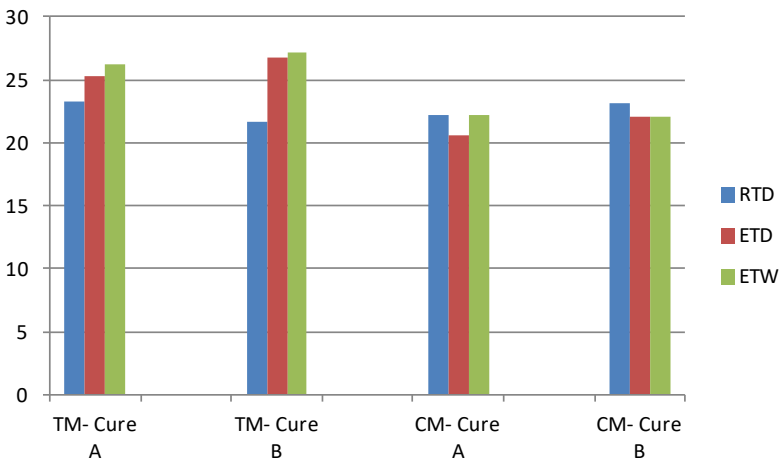
LAMINATE MECHANICAL PROPERTY COMPARISON STRENGTH IM-7 12K. FAW 150GSM, 36% RC



LAMINATE MECHANICAL PROPERTY COMPARISON MODULUS IM-7 12K. FAW 150gsm, 36% RC



MECHANICAL PROPERTIES

Property	Condition	Method	UD Tape (1) (a)		UD Tape (2) (b)	
Tensile Strength 0°	RTD	ASTM D 3039	2689 MPa	390 ksi	2806 MPa	407 ksi
Tensile Modulus 0°	RTD	ASTM D 3039	160.6 GPa	23.3 Msi	149.6 GPa	21.7 Msi
Tensile Strength 0°	ETD	ASTM D 3039	2417 MPa	351 ksi	2600 MPa	377 ksi
Tensile Modulus 0°	ETD	ASTM D 3039	174.4 GPa	25.3 Msi	184.8 GPa	26.8 Msi
Tensile Strength 0°	ETW	ASTM D 3039	2448 MPa	355 ksi	2475 MPa	359 ksi
Tensile Modulus 0°	ETW	ASTM D 3039	180.6 GPa	26.2 Msi	186.8 GPa	27.1 Msi
Tensile Strength 90°	RTD	ASTM D 3039	68.9 MPa	10.0 ksi	94.5 MPa	13.7 ksi
Tensile Modulus 90°	RTD	ASTM D 3039	10.3 GPa	1.5 Msi	9.0 GPa	1.3 Msi
Tensile Strength 90°	ETD	ASTM D 3039	49.6 MPa	7.2 ksi	62.7 MPa	9.1 ksi
Tensile Modulus 90°	ETD	ASTM D 3039	10.3 GPa	1.5 Msi	8.9 GPa	1.3 Msi
Tensile Strength 90°	ETW	ASTM D 3039	42.0 MPa	6.1 ksi	25.5GPa	3.7 ksi
Tensile Modulus 90°	ETW	ASTM D 3039	10.3 GPa	1.5 Msi	6.9 GPa	1.0 Msi
Compressive Strength 0°	RTD	ASTM D 695	1731 MPa	251 ksi	1758 MPa	255 ksi
Compressive Modulus 0°	RTD	ASTM D 695	153.1 GPa	22.2 Msi	159.3 GPa	23.1 Msi
Compressive Strength 0°	ETD	ASTM D 695	1642 MPa	238 ksi	1744 MPa	253 ksi
Compressive Modulus 0°	ETD	ASTM D 695	142.0 GPa	20.6 Msi	151.7 GPa	22 Msi
Compressive Strength 0°	ETW	ASTM D 695	1469 MPa	213 ksi	1434 MPa	208 ksi
Compressive Modulus 0°	ETW	ASTM D 695	152.9 GPa	22.2 Msi	152.4 GPa	22.1 Msi
Compressive Strength 90°	RTD	ASTM D 695	337 MPa	48.9 ksi	342 MPa	49.6 ksi
Compressive Modulus 90°	RTD	ASTM D 695	10.3 GPa	1.5 Msi	10.3 GPa	1.5 Msi
Compressive Strength 90°	ETD	ASTM D 695	252 MPa	36.6 ksi	236 MPa	34.3 ksi
Compressive Modulus 90°	ETD	ASTM D 695	9.7 GPa	1.4 Msi	9.0 GPa	1.3 Msi
Compressive Strength 90°	ETW	ASTM D 695	192 MPa	27.8 ksi	184 MPa	26.7 ksi
Compressive Modulus 90°	ETW	ASTM D 695	9.0 GPa	1.3 Msi	8.3 GPa	1.2 Msi
Compression Strength	RTD	ASTM D 6641	1744 MPa	253 ksi	1565 MPa	227 ksi
Compression Strength	ETD	ASTM D 6641	1550 MPa	225 ksi	1448 MPa	210 ksi
Compression Strength	ETW	ASTM D 6641	1303 MPa	189 ksi	1276 MPa	185 ksi
Open-Hole Tensile Strength	RTD	ASTM D 5766	472 MPa	68.4 ksi	-	-
Open-Hole Tensile Strength	ETD	ASTM D 5766	496 MPa	71.9 ksi	-	-
Open-Hole Tensile Strength	ETW	ASTM D 5766	469 MPa	68.0 ksi	-	-
Open-Hole Comp. Strength	RTD	ASTM D 6484	323 MPa	46.8 ksi	-	-
Open-Hole Comp. Strength	ETD	ASTM D 6484	296 MPa	42.9 ksi	-	-

Continued on page 4

MECHANICAL PROPERTIES

Continued from page 3

Property	Condition	Method	UD Tape (1) (a)		UD Tape (2) (b)	
Open-Hole Comp. Strength	ETW	ASTM D 6484	253 MPa	36.7 ksi	-	-
Flexural Strength	RTD	ASTM D 7264	2275 MPa	330 ksi	2364 MPa	343 ksi
Flexural Modulus	RTD	ASTM D 7264	123.4 GPa	17.9 Msi	117 GPa	16.9 Msi
Flexural Strength	ETD	ASTM D 7264	1837 MPa	267 ksi	1820 MPa	264 ksi
Flexural Modulus	ETD	ASTM D 7264	105.5 GPa	15.3 Msi	115.8 GPa	16.8 Msi
Flexural Strength	ETW	ASTM D 7264	1299 MPa	188 ksi	1531 MPa	222.0 ksi
Flexural Modulus	ETW	ASTM D 7264	93.1 GPa	13.8 Msi	95.1 GPa	13.8 Msi
In-Plane Shear Strength (+/-45)	RTD	ASTM D 3518	137 MPa	19.0 ksi	118 MPa	17.1 ksi
In-Plane Shear Modulus (+/-45)	RTD	ASTM D 3518	4.8 GPa	0.7 Msi	4.8 GPa	0.7 Msi
In-Plane Shear Strength (+/-45)	ETD	ASTM D 3518	116 MPa	16.8 ksi	117 MPa	17.0 ksi
In-Plane Shear Modulus (+/-45)	ETD	ASTM D 3518	3.8 GPa	0.6 Msi	4.1 GPa	0.6 Msi
In-Plane Shear Strength (+/-45)	ETW	ASTM D 3518	80.0 MPa	11.6 ksi	79.3 MPa	11.5 ksi
In-Plane Shear Modulus (+/-45)	ETW	ASTM D 3518	2.3 GPa	0.4 Msi	4.1 GPa	0.6 Msi
ILSS 0°	RTD	ASTM D 2344	133.1 MPa	19.3 ksi	129.6 MPa	18.8 ksi
ILSS 0°	ETD	ASTM D 2344	93.1 MPa	13.5 ksi	88.3 MPa	12.8 ksi
ILSS 0°	ETW	ASTM D 2344	53.8 MPa	7.8 ksi	44.1 MPa	6.4 ksi
CAI 1500 in-lb/in	RTD	ASTM D 7137	220.6 MPa	32.0 ksi	-	-
Laminate DMA Onset T_g Dry	-	-	191°C (376°F)		189°C (372°F)	
Laminate DMA Onset T_g Wet	-	-	147°C (297°F)		145°C (293°F)	

(a) Uni-directional tape data from IM-7 12K, 150gsm/TC350-1, 36% RC. All data was normalized to 60% fiber volume except ILSS
(1) Vacuum cure. Cure A Used: 0.8°C (1.5°F)/min to 107°C (225°F) for 1 hour, followed by 1.1°C (2°F)/min to 177°C (350°F) for 2.5 hours. ETW is 121°C (250°F); Conditioning 85% RH at 160°F (71°C) until saturation. Data Normalized to 60% fiber volume except ILSS. ETD is 121°C (250°F)
(2) Cure B Used: 0.8°C (1.5°F)/min to 107°C (225°F) for 1 hour, followed by 1.1°C (2°F)/min to 135°C (275°F) for 3 hours (Freestanding post cure 177°C (350°F) for 2 hours). ETW is 121°C (250°F); Conditioning – 85% RH at 71°C (160°F) until saturation ETD is 121°C (250°F)
(3) Open-Hole Compression/Tensile Lay-Up Sequence – 32 Plies: (45/0/-45/90) 4S

MECHANICAL PROPERTIES

Property	Condition	Method	Plain Weave (a)	
Tensile Strength 0°	RTD	ASTM D 3039	958 MPa	139 ksi
Tensile Modulus 0°	RTD	ASTM D 3039	62.1 GPa	9.0 Msi
Tensile Strength 0°	ETD	ASTM D 3039	1007 MPa	146 ksi
Tensile Modulus 0°	ETD	ASTM D 3039	69.6 GPa	10.1 Msi
Tensile Strength 0°	ETW	ASTM D 3039	876 MPa	127 ksi
Tensile Modulus 0°	ETW	ASTM D 3039	68.3 GPa	9.9 Msi
Compressive Strength 0°	RTD	ASTM D 695	869 MPa	126 ksi
Compressive Modulus 0°	RTD	ASTM D 695	60.7 GPa	8.8 ksi
Compressive Strength 0°	ETD	ASTM D 695	814 MPa	118 ksi
Compressive Modulus 0°	ETD	ASTM D695	53.8 GPa	7.8 Msi
Compressive Strength 0°	ETW	ASTM D 695	763 MPa	111 ksi
Compressive Modulus 0°	ETW	ASTM D 695	579.1 GPa	8.4 Msi
Flexural Strength	RTD	ASTM D 7264	1096 MPa	159 ksi
Flexural Modulus	RTD	ASTM D 7264	56.5 GPa	8.2 Msi
Flexural Strength	ETD	ASTM D 7264	992.9 MPa	144 ksi
Flexural Modulus	ETD	ASTM D 7264	56.5 GPa	8.2 Msi
Flexural Strength	ETW	ASTM D 7264	799 MPa	116 ksi
Flexural Modulus	ETW	ASTM D 7264	53.1 GPa	7.7 Msi
ILSS 0°	RTD	ASTM D 2344	91.7 MPa	13.3 ksi
ILSS 0°	ETD	ASTM D 2344	77.9 MPa	11.3 ksi
ILSS 0°	ETW	ASTM D 2344	63.4 MPa	9.2 ksi

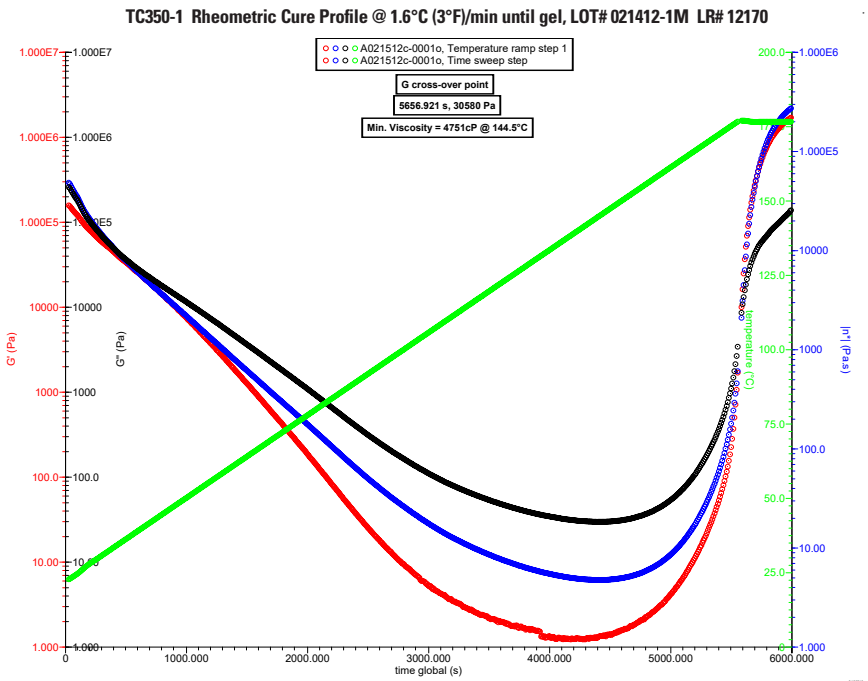
(a) Fabric data from AS-4C 3K, plain weave, 193gsm. All data normalized to 60% except for ILSS
ETD is 93°C (200°F); Cure used: 0.8°C (1.5°F)/min to 107°C (225°F) for 1 hour, followed by 1.1°C (2°F)/min to 177°C (350°F) for 2.5 hours
ETW is 93°C (200°F); Conditioning – 85% RH at 71°C (160°F) until saturation

CURE OPTIONS

Cure A - 0.6–1.1°C (1–2°F)/min to 107°C (225°F) and hold for 1 hour, then 0.6–1.1°C (1–2°F)/min to 177°C (350°F) for 2–2.5 hours, cool down at 2.8–5.6°C (5–10° F)/min to 49°C (< 120°F) before taking the parts out of the oven. Minimum vacuum required/recommended > 27 inHg.

Cure B - Alternate low temperature initial cure profile: 0.6–1.1°C (1–2°F)/min to 107°C (225°F) and hold for 60 min, then 0.6–1.1°C (1–2°F)/min to 135°C (275°F) and hold for at least 3 hours, cool 2.8–5.5°C (5–10°F)/min to 49°C (< 120°F) before taking the parts out of the oven. Minimum vacuum required/recommended > 27 inHg. Additional post cure at 177°C (350°F) for at least 2 hours is required. Freestanding post cure: 1.7–2.2°C (3–4°F)/min to 135°C (275°F) and then 0.6–1.1°C (1–2°F)/min to 177°C (350°F) and hold for at least 2 hours.

RHEOLOGY



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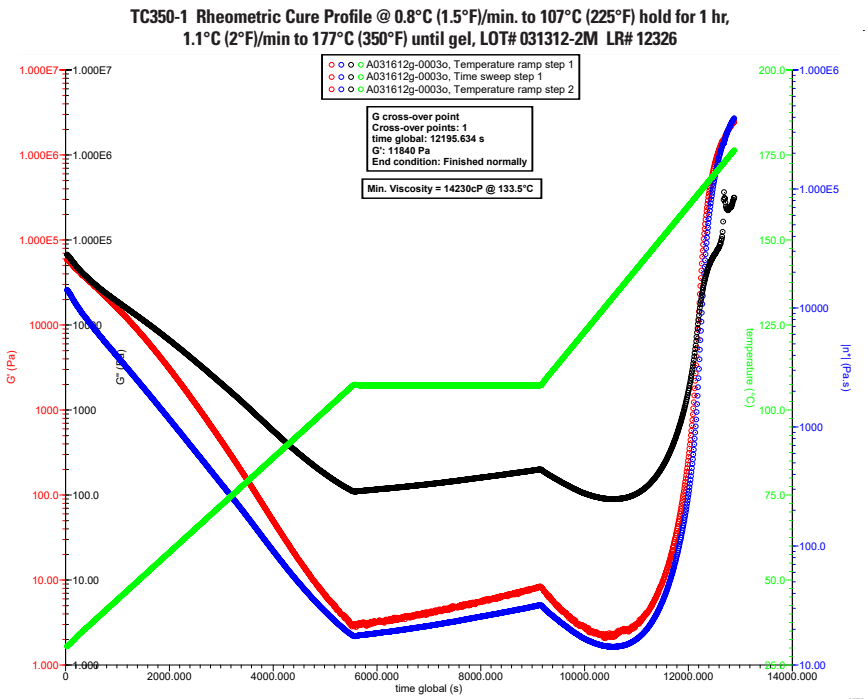


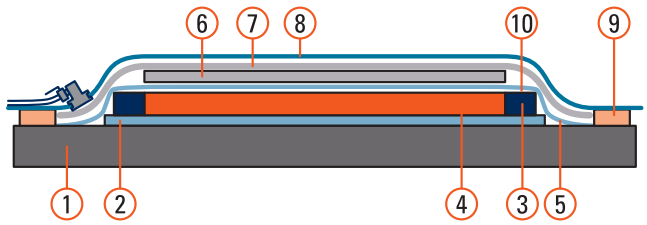
TYPICAL COMPOSITE LAMINATE STACKING SEQUENCE

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



EPOXY PREPREG, ADHESIVE, AND RESIN GUIDELINES AND HANDLING PROCEDURES

The following guidelines are provided to our customers to assure that best practices are used to attain the best results from Toray Advanced Composites epoxy products. Keep in mind that these procedures represent best practices for all composite prepreg and adhesive materials.

FREEZER STORAGE

Epoxy resin materials have good shelf life at room temperature; however, the life and performance of the material is best preserved with the following basic guidelines. Refer to the shelf life included in the product certifications. The epoxy material should be sealed in an airtight bag and kept frozen below -18°C (0°F) when not being used for longest life and most consistent performance. A good safety measure is to have a bag of desiccant (silica moisture absorber) in the core of the prepreg roll to assure the best protection from moisture ingression.

MOISTURE ABSORPTION AND SENSITIVITY

While very resistant to moisture absorption after cure, epoxies can be adversely affected by moisture uptake prior to cure. For this reason, all materials must be completely thawed to room temperature prior to opening the sealed bag to avoid condensation on the material. Also, it is good practice to keep prepreg and in-process hardware in a sealed bag or vacuum bag if it will be exposed to the atmosphere for long periods of time.

HANDLING OF MATERIALS

When handling any prepreg materials, one should always wear clean, powder-free latex gloves. This will assure that no hand oils are transferred to the prepreg and/or composite during processing. The presence of oils in the part could lead to problems in both mechanical and electrical performance of the part. This also guards against dermatitis that may occur with some users.

NONMETALLIC HONEYCOMB AND FOAM CORE USE

When using nonmetallic honeycomb and foam core materials for sandwich structures, the materials should always be dried in an oven prior to lay-up to drive off any moisture that may be in the core. The core should be cooled in the presence of a desiccant to avoid moisture uptake. Following drying, it is always best to use the material as soon as possible. Recommended core dry time/temp: 121°C (250°F) for 3–4 hours.

DEBULK LAY-UP MATERIAL SEQUENCE FROM TOOL SURFACE TO BAGGING MATERIALS

1. **Bottom Tool**
2. **Non-porous FEP**
3. **Prepreg**
4. **Porous TX1040**
5. **Non-porous FEP**
6. **Caul plate**
7. **Breather (woven or thick breather)**
8. **Vacuum bag**
9. **Repeat above procedure**

A debulking procedure was necessary to minimize entrapped air between plies as shown in Figure 1. Pulled vacuum was at least at 27 inHg. TC350-1 prepreg layers were debulked at ambient every 4 plies for 5–10 minutes. An additional ply of porous Teflon coated glass (TX1040) was used to help the removal of entrapped air and it was replaced after being used for 2–3 times of debulking.

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