Toray EX-1515

Toray Advanced Composites

PRODUCT DATA SHEET

DESCRIPTION

Toray EX-1515 cyanate ester prepreg resin system is unique in the industry in that it is able to achieve an extremely high level of cure conversion after a 121°C (250°F) cure. This level of conversion provides optimal mechanical properties, high radiation resistance, low moisture absorption, and low outgassing while retaining unparalleled toughness, a low 118°C (244°F), stress-free temperature, and long out time. The resin system excels in its ability to resist microcracking, even when subjected to thermal cycling and high levels of radiation exposure. EX-1515 also displays low dielectric and low loss values which makes it outstanding for radome and antenna applications. EX-1515 can be post cured, freestanding, to increase thermal performance for temperature-critical structures.

FEATURES

- **High radiation resistance**
- **Low microcracking even under severe thermocycling**
- **Low moisture absorption**
- **Low dielectric constant and dissipation factors**
- **Low stress-free cure temperature with high level of cure**
- **Outstanding mechanical properties**
- **Compatible adhesive is EX-1516**

PRODUCT TYPE

107–121°C (225–250°F) Cure Toughened Cyanate Ester

TYPICAL APPLICATIONS

- High dimensional stability space structures
- Optical benches
- Reflectors
- Radomes and antennas
- Low observable structures

SHELF LIFE

Out Life:	21 days at ≤ 21°C (70°F) and ≤ 60% RH
Frozen Storage Life:	12 months at -18°C (< 0°F) or below

Out life is the maximum time allowed at ≤ 21°C (70°F) and ≤ 60% RH before cure.**

** Out life tested via prepreg tack and drape, and ILSS on 24 ply 7781 fabric laminate cured at 121°C (250°F) under 85 psig pressure for 3 hours.

TYPICAL NEAT RESIN PROPERTIES

Density	1.156 g/cc
T_g (by DMA)	121°C (249°F) cured at 121°C (250°F) 174°C (345°F) post cured at 177°C (350°F)
Moisture Absorption	0.04%, P75 laminate saturation at 27°C (80°F), and 85% relative humidity
Outgassing (TML*)	0.18%
Outgassing (CVCM*)	0.01%
CTE	61 ppm/°C (34 ppm/°F)
Thermal Conductivity	0.169 W/m*K
Dielectric Constant	2.8 (at 10 GHz)
Loss Tangent	0.004 (at 10 GHz)

*TML: Total Mass Loss
*CVCM: Collected Volatile Condensable Materials

SERVICE TEMPERATURE

100°C (212°F) without post cure
154°C (310°F) with post cure

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LAMINATE ELECTRICAL PROPERTIES ON 4581 AQIII QUARTZ

Property	X Band	Ku/K Band	Ka Band	W Band
	8–12.6 GHz	18–26.5 GHz	33–50 GHz	75–100 GHz
Dielectric Constant	3.32	3.30	3.30	3.30
Loss Tangent	0.004	0.004	0.005	0.006

LAMINATE DATA - 4581 AQIII/EX-1515 8HS WOVEN FABRIC REINFORCEMENT, 300gsm FAW

Property	Condition	Method	Results	
Tensile Strength 0°	RTD	ASTM D 3039	757 MPa	109.8 ksi
Tensile Modulus 0°	RTD	ASTM D 3039	24 GPa	3.5 Msi
Compressive Strength 0°	RTD	ASTM D 6641	543 MPa	79 ksi
Compressive Modulus 0°	RTD	ASTM D 6641	28.8 GPa	4.06 Msi
Flexural Strength 0°	RTD	ASTM D 7264	738 MPa	107 ksi
Flexural Modulus 0°	RTD	ASTM D 7264	21.8 GPa	3.16 Msi
ILSS 0°	RTD	ASTM D 2344	68.0 MPa	9.9 ksi
Normalized to 55% fiber volume.				

LAMINATE DATA - 7781 FIBERGLASS/EX-1515 8HS LAMINATE, 300gsm FAW

Property	Condition	Method	Results	
Tensile Strength 0°	RTD	ASTM D 3039	424 MPa	62 ksi
Tensile Modulus 0°	RTD	ASTM D 3039	25.2 GPa	3.65 Msi
Compressive Strength 0°	RTD	ASTM D 6641	393 MPa	57 ksi
Compressive Modulus 0°	RTD	ASTM D 6641	25.5 GPa	3.7 Msi
Flexural Strength 0°	RTD	ASTM D 7264	490 MPa	71 ksi
Flexural Modulus 0°	RTD	ASTM D 7264	21.7 GPa	3.15 Msi
ILSS 0°	RTD	ASTM D 2344	46.2 MPa	6.7 ksi
Normalized to 55% fiber volume.				

LAMINATE DATA - TORAY M55J (78 Msi/538 GPa) PAN GRAPHITE/EX-1515

Property	Condition	Method	Results	
Tensile Strength**	RTD	ASTM D 3039	607 MPa	88 ksi
Tensile Modulus**	RTD	ASTM D 3039	100.7 GPa	14.6 Msi
Compressive Strength**	RTD	ASTM D 6641	317 MPa	46 ksi
Compressive Modulus**	RTD	ASTM D 6641	91.7 GPa	13.3 Msi
In-Plane Shear Strength**	RTD	ASTM D 7264	166 MPa	24 ksi
**Normalized to 60% fiber volume. Lay-up Configuration: 0°, 45°, 90°, 135° symmetrical				

Continued on page 3

LAMINATE DATA - 4503 AQIII/EX-1515 38" WOVEN FABRIC REINFORCEMENT

Continued from page 2

Property	Condition	Method	Results	
Tensile Strength 0°	RTD	ASTM D 3039	703 MPa	102 ksi
Tensile Modulus 0°	RTD	ASTM D 3039	26.2 GPa	3.8 Msi
Compressive Strength 0°	RTD	ASTM D 6641	537.8 MPa	78 ksi
Compressive Modulus 0°	RTD	ASTM D 6641	28.3 GPa	4.1 Msi
Flexural Strength 0°	RTD	ASTM D 7264	681.4 MPa	98.8 ksi
Flexural Modulus 0°	RTD	ASTM D 7264	23.8 GPa	3.45 Msi
Short Beam Shear Strength	RTD	ASTM D 2344	74.5 MPa	10.81 ksi
Normalized to 55% fiber volume.				

LAMINATE DATA - TORAY M55J (78 Msi/538 GPa) PAN GRAPHITE/EX-1515

Property	Condition	Method	Results	
Tensile Strength 0°	RTD	ASTM D 3039	1896 MPa	275 ksi
Tensile Modulus 0°	RTD	ASTM D 3039	354 GPa	50 Msi
Compressive Strength 0°	RTD	ASTM D 6641	731 MPa	106 ksi
Compressive Modulus 0°	RTD	ASTM D 6641	310 GPa	45 Msi
Flexural Strength 0°	RTD	ASTM D 7264	1089 MPa	158 ksi
Flexural Modulus 0°	RTD	ASTM D 7264	317 GPa	46 Msi
Interlaminar Shear Strength	RTD	ASTM D 2344	62 MPa	9 ksi
Standard 121°C (250°F) Autoclave cure 85 psi, normalized to 60% fiber volume.				

LAMINATE DATA - LMR 120 KEVLAR 49 PW PT/EX-1515 LAMINATE

Property	Condition	Method	Results	
Tensile Strength 0°	RTD	ASTM D 3039	558 MPa	81 ksi
Tensile Modulus 0°	RTD	ASTM D 3039	36.5 GPa	5.3 Msi
Compressive Strength 0°	RTD	ASTM D 695	203 MPa	29.5 ksi
Compressive Modulus 0°	RTD	ASTM D 695	32 GPa	4.7 Msi
Flexural Strength 0°	RTD	ASTM D 7264	517 MPa	75 ksi
Flexural Modulus 0°	RTD	ASTM D 7264	20 GPa	2.9 Msi
Interlaminar Shear Strength	RTD	ASTM D 2344	42 MPa	6.1 ksi

Continued on page 4

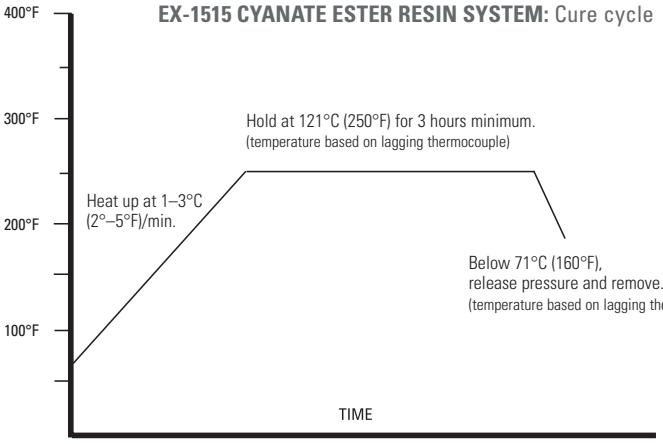
LAMINATE DATA - LMR 285 KEVLAR 49 PT/EX-1515 LAMINATE

Continued from page 3

Property	Condition	Method	Results	
Compressive Strength 0°	RTD	ASTM D 6641	193 MPa	28 ksi
Compressive Modulus 0°	RTD	ASTM D 6641	33.1 GPa	4.8 Msi
Compressive Strength 0°	ETD	ASTM D 6641	179 MPa	26 ksi
Compressive Modulus 0°	ETD	ASTM D 6641	31.0 GPa	4.5 Msi
Compressive Strength 0°	ETW	ASTM D 6641	124 MPa	18 ksi
Compressive Modulus 0°	ETW	ASTM D 6641	31.0 GPa	4.5 Msi
Flexural Strength 0°	RTD	ASTM D 7264	414 MPa	60 ksi
Flexural Modulus 0°	RTD	ASTM D 7264	20.7 GPa	3 Msi
Flexural Strength 0°	ETD	ASTM D 7264	393 MPa	57 ksi
Flexural Modulus 0°	ETD	ASTM D 7264	19.3 GPa	2.8 Msi
Flexural Strength 0°	ETW	ASTM D 7264	338 MPa	49 ksi
Flexural Modulus 0°	ETW	ASTM D 7264	15.9 GPa	2.3 Msi
In-Plane Shear Strength	RTD	ASTM D 2344	38.6 MPa	5.6 ksi
In-Plane Shear Strength	ETD	ASTM D 2344	37.2 MPa	5.4 ksi
In-Plane Shear Strength	ETW	ASTM D 2344	32.4 MPa	4.7 ksi

- ETD is 70°C (158°F)
- ETW is 70°C (158°F) after 2 hr boil.
- Standard cure: 121°C (250°F), 85 psi.
- Normalized to 50% fiber volume.

EX-1515 CYANATE ESTER RESIN SYSTEM: Cure cycle



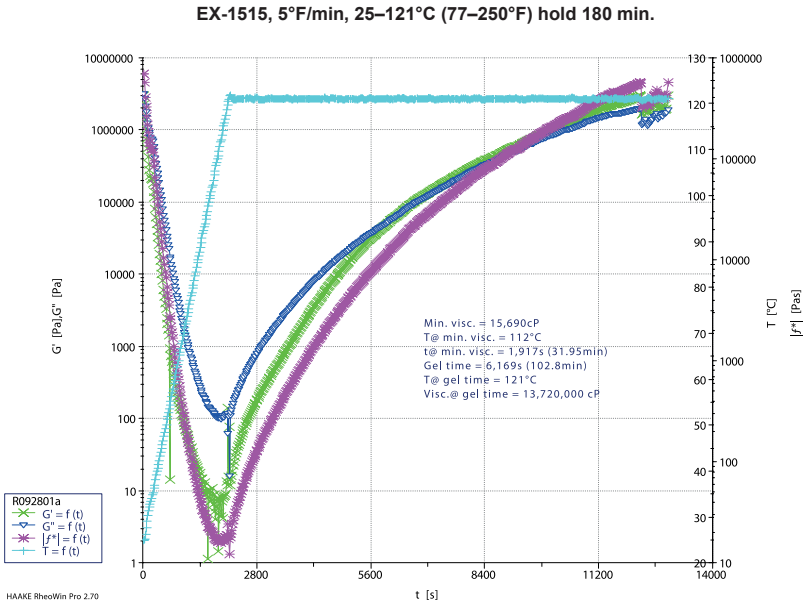
- Apply 25 inHg vacuum minimum.
- Apply 40–100 psig pressure to autoclave (optional).

WARNING: The following statement does not apply to Spectra fabrics

Note: To improve the thermal capability of EX-1515, the material may be post cured freestanding.

Post cure: Heat at 1°C–3°C (2°F–5°F)/min. to 177°C (350°F), dwell at 177°C ± 6°C (350°F ± 10°F) for 2 hours minimum, cool at 3°C–6°C (5°F–10°F) to 71°C (160°F), then remove.

This cure cycle is to be used as a guideline by users because the part that they will produce may have different properties requirements than those laminates for which this cure cycle was determined.



CYANATE ESTER PREPREG, ADHESIVE, AND RESIN GUIDELINES AND HANDLING PROCEDURES

The following guidelines are provided to our customers for one specific purpose: to assure that all customers are aware of the manner by which to attain the best possible results from Toray Advanced Composites cyanate ester products. These resin systems will provide sound composite hardware and structures if some simple procedures are followed. Keep in mind that these procedures are good practice for all composite prepreg and adhesive materials and should be used whenever possible.

FREEZER STORAGE

Cyanate Esters (CEs) should always be sealed in an airtight bag and kept frozen below -12°C (10°F) when not being used. A good safety measure is to have a bag of desiccant (silica moisture absorber) in the core of the prepreg roll just in case a pinhole in the bag or other problem occurs.

MOISTURE ABSORPTION AND SENSITIVITY

While very resistant to moisture absorption after cure, CEs can be adversely affected by moisture uptake prior to cure. For this reason, all materials must be “thoroughly 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 to be exposed to the atmosphere for long periods of time.

HANDLING OF MATERIALS

When handling any prepreg materials, one should always be wearing 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 any dermatitis that could occur with certain 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 material should then be cooled in the presence of a desiccant, to avoid any moisture uptake. Following this procedure, it is always a good idea to use the material as soon as possible to avoid rehydration.

Recommended Core Dry Time/Temp: 121°C (250°F) for 3–4 hours (minimum), core must be kept dry until it is used.

SELF ADHESIVE PROPERTIES AND FILM ADHESIVE USE

Toray Advanced Composites cyanate ester resins have been formulated to have good self-adhesive properties to core materials. However, this should not be taken as a green light to eliminate a film adhesive from a cored, structural piece of hardware. This option has been given by Toray for customers who are looking for the best electrical properties available by not using a film adhesive. Toray recommends that the structural integrity be verified per customer specification prior to end item usage and takes no responsibility otherwise.

If this option is exercised, the following modified cure cycle has been found to work well.

1. Ramp the part to 66–71°C (150–160°F) (Keep Pressure < 15 Psi)
2. Dwell for approximately 1 hour
3. Ramp the part to the recommended cure temperature for the resin and cure per the provided standard cure cycle.

LAY-UP AREA ENVIRONMENTAL CONTROLS

Toray recommends that any composite or adhesive lay-up be performed in a clean area visibly free from dust. Any work surfaces should likewise be free of residue, dust, or debris. No eating or smoking shall be allowed in the shop area. For radome materials, conductive materials shall not be allowed in the process area. The processing shop area should be maintained between 16–25°C (60–77°F) with a relative humidity of no greater than 70%.

BAGGING FOR CURE

Toray recommends that CE composite parts bagged for cure should be performed as follows.

1. Release the tool surface
2. Lay-up part using standard debulking procedures
3. Dam the edges of the part for cure
4. Place 1 ply of porous Teflon® or perforated Teflon® onto the bag surface of the part
5. Place bleeder layers over 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 facilitate vacuum draw
8. Install vacuum bag on the tool for cure
9. Follow the provided Toray cure cycle for the particular resin system

TYPICAL COMPOSITE LAMINATE STACKING SEQUENCE

List of Materials

1. Tool – aluminum, steel, Invar, composite (tool plates must be release coated or film covered).
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.

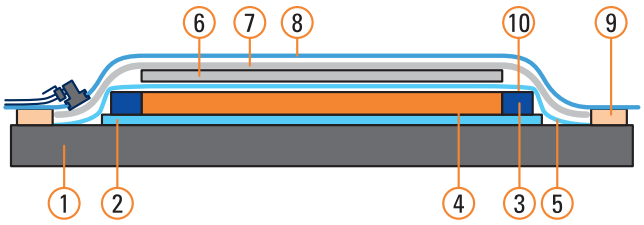


Figure 1

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