

DESCRIPTION

TenCate EX-1515 cyanate ester 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. TenCate 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 out life ≤ 21°C (70°F) and ≤ 60% RH
Frozen Storage Life:	12 months storage life 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 three hours.

NEAT RESIN PROPERTIES

Resin Density	1.17 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 @ 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

Properties	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, 300 gsm FAW.

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

Normalized to 55% fiber volume.

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

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

Normalized to 55% fiber volume.

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

Properties	Condition	Method	Results	
Tensile Strength**	RTD	ASTM D 3039	88 ksi	607 MPa
Tensile Modulus**	RTD	ASTM D 3039	14.6 Msi	100.7 GPa
Compressive Strength**	RTD	ASTM D 6641	46 ksi	317 MPa
Compressive Modulus**	RTD	ASTM D 6641	13.3 Msi	91.7 GPa
In Plane Shear Strength**	RTD	ASTM D 7264	24 ksi	166 MPa

**Normalized to 60% fiber volume. Lay-up Configuration: 0°, 45°, 90°, 135° symmetrical

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

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

Normalized to 55% fiber volume.

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

Properties	Condition	Method	Results	
Tensile Strength 0°	RTD	ASTM D 3039	275 ksi	1896 MPa
Tensile Modulus 0°	RTD	ASTM D 3039	50 Msi	354 GPa
Compressive Strength 0°	RTD	ASTM D 6641	106 ksi	731 MPa
Compressive Modulus 0°	RTD	ASTM D 6641	45 Msi	310 GPa
Flexural Strength 0°	RTD	ASTM D 7264	158 ksi	1089 MPa
Flexural Modulus 0°	RTD	ASTM D 7264	46 Msi	317 GPa
Interlaminar Shear Strength	RTD	ASTM D 2344	9 ksi	62 MPa

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.

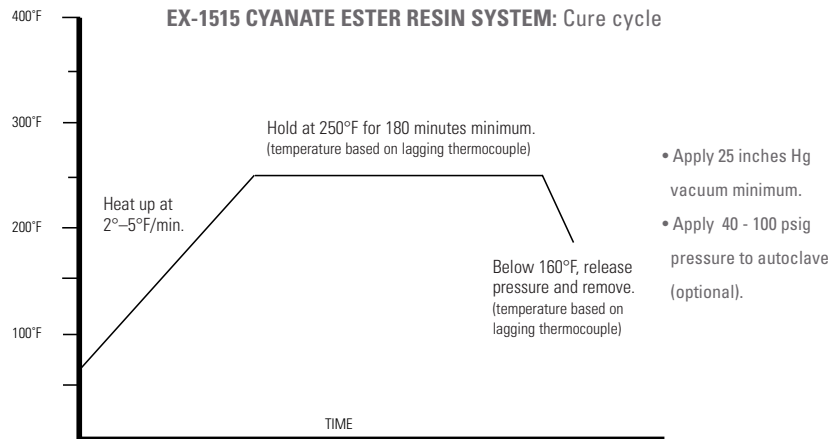
Properties	Condition	Method	Results	
Tensile Strength 0°	RTD	ASTM D 3039	81 ksi	558 MPa
Tensile Modulus 0°	RTD	ASTM D 3039	5.3 Msi	36.5 GPa
Compressive Strength 0°	RTD	ASTM D 695	29.5 ksi	203 MPa
Compressive Modulus 0°	RTD	ASTM D 695	4.7 Msi	32 GPa
Flexural Strength 0°	RTD	ASTM D 7264	75 ksi	517 MPa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

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

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

- 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.

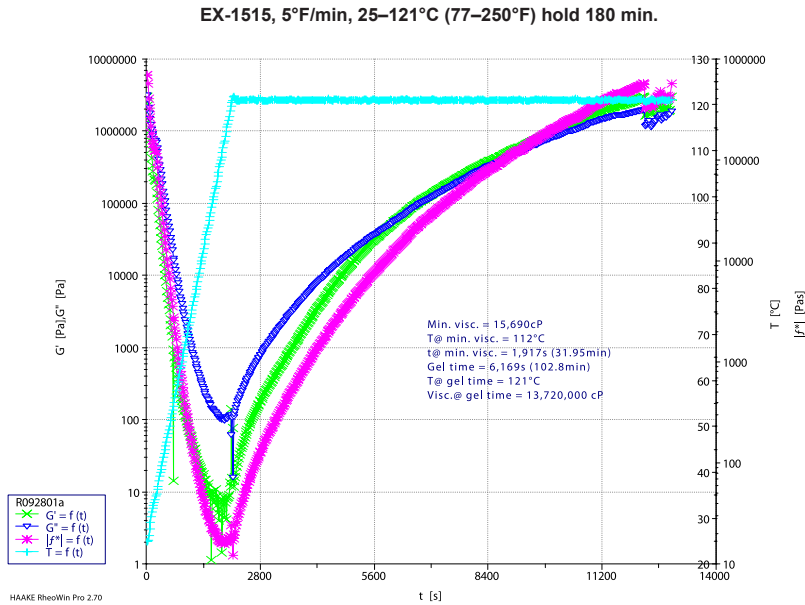


WARNING: The following statement does not apply to Spectra fabrics

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 two 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 TenCate Advanced Composites (TCAC) 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 (CE's) 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 pin-hole in the bag or other problem occurs.

MOISTURE ABSORPTION AND SENSITIVITY

While very resistant to moisture absorption after cure, CE's 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 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.

NON-METALLIC HONEYCOMB AND FOAM CORE USE

When using Non-Metallic honeycomb and foam core materials for sandwich structures, the materials should always be dried in an oven prior to layup 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 re-hydration.

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

TCAC 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 TCAC for customers who are looking for the best electrical properties available by not using a film adhesive. TCAC 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

TCAC 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

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

- 1. Release the tool surface**
- 2. Layup 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 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 TCAC cure cycle for the particular resin system**

COMPOSITE LAMINATE STACKING SEQUENCE

List of Materials

1. Tool – aluminum, steel, Invar, composite (tool plates must be release coated or film covered). See below.
2. Release coat or film – Frekote 700NC or 770NC, FEP, TEDLAR
3. Silicone edge dams – 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/yd² 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)

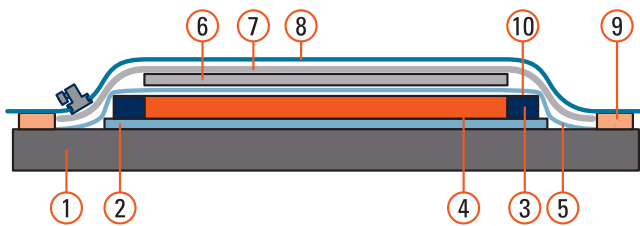


Figure 1

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