PRODUCT DATA SHEET

TENCATE ADVANCED COMPOSITES

EX-1515 Resin System

PRODUCT TYPE

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

TYPICAL APPLICATIONS

- High Dimensional Stability Space Structures
- Optical Benches
- Reflectors
- Radomes and Antennae
- Low Observables
- Radar Transparent Structures

SERVICE TEMPERATURE

250°F (121°C) (without post cure)
325°F (163°C) (with post cure)

SHELF LIFE

Tack Life
7 days tack life at 77°F (25°C)

Out Life
7 days out life 77°F (25°C)

Frozen Storage Life
6 months storage life at <0°F (-18°C)

Tack life is the time during which the prepreg retains enough tack, drape and handling for easy component lay-up.

Out life is the maximum time allowed at room temperature before cure.

PRODUCT DESCRIPTION

TenCate's 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 250°F (121°C) cure. This level of conversion provides optimal mechanical properties, high radiation resistance, low moisture absorption/low outgassing while retaining unparalleled toughness, a low 244°F (118°C), 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/low loss values similar to other cyanate esters which allow its use in radome and antenna applications. TenCate's EX-1515 can be post cured, free-standing, to increase its thermal performance for temperature critical structures.

PRODUCT BENEFITS/FEATURES

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

TYPICAL NEAT RESIN PROPERTIES

Moisture Absorption ..... 0.04%, P75 Laminate Saturation @ 80°F (27°C), and 85% Relative Humidity

Outgassing (TML) 0.179%
Outgassing (CVCM) 0.007%
Density ..... 1.17 g/cc
Tg (by DMA) ..... 249°F (121°C) cured at 250°F (121°C)
345°F (174°C) post cured at 350°F (177°C)

CTE ..... 34 ppm/°F (61 ppm/°C)
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

LAMINATE ELECTRICAL PROPERTIES ON 4581 AQIII QUARTZ

	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	0.0035	0.0035	0.0052	0.0065

EX-1515 Resin System

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

Properties	Condition (RTD, ETD, ETW)	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)	28.0 (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 (RTD, ETD, ETW)	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)
Interlaminar Shear Strength	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 (RTD, ETD, ETW)	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 3518	24 (ksi)	166 (MPa)

** Layup Configuration: 0°, 45°, 90°, 135° symmetrical

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

Properties	Condition (RTD, ETD, ETW)	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.l

EX-1515 Resin System

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

Properties	Condition (RTD, ETD, ETW)	Method	Results	
Tensile Strength 0°	RTD	ASTM D 3039	275 (ksi)	1896 (MPa)
Tensile Modulus 0°	RTD	ASTM D 3039	50 (Msi)	345 (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 250°F (121°C) Autoclave cure 85 psi, normalized to 60% fiber volume.

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

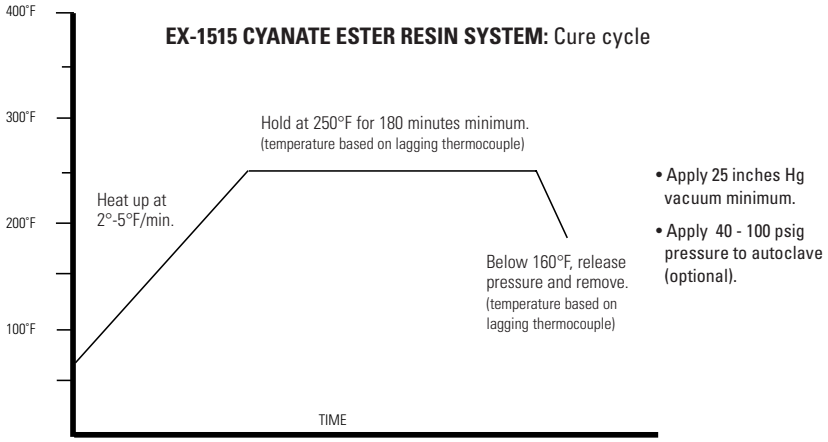
Properties	Condition (RTD, ETD, ETW)	Method	Results	
Tensile Strength 0°	RTD	ASTM D 3039	81 (ksi)	558 (MPa)
Tensile Modulus 0°	RTD	ASTM D 3039	5.3 (Msi)	36.5 (GPa)
Compressive Strength 0°	RTD	ASTM D 695	29.5 (ksi)	203 (MPa)
Compressive Modulus 0°	RTD	ASTM D 695	4.7 (Msi)	32 (GPa)
Flexural Strength 0°	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.

Properties	Condition (RTD, ETD, ETW)	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)
Interlaminar Shear Strength	RTD	ASTM D 2344	5.6 (ksi)	38.6 (MPa)
Interlaminar Shear Strength	ETD	ASTM D 2344	5.4 (ksi)	37.2 (MPa)
Interlaminar Shear Strength	ETW	ASTM D 2344	4.7 (ksi)	32.4 (MPa)

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

EX-1515 Resin System



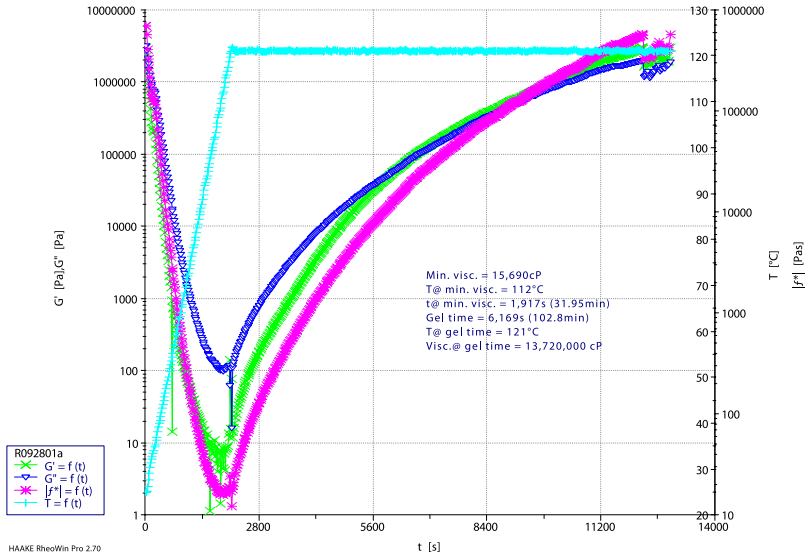
WARNING: The following statement does not apply to Spectra fabrics

Note: To improve the thermal stability of EX-1515, the material may be post cured free standing.

Post cure: Heat at 2°-5°F/min. to 350°F, dwell at 350°±10°F for two hours minimum, cool at 5°-10°F to 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.

EX-1515, Lot# 092601-2F4, 5°F/min, 77°F-250°F hold 180min



EX-1515 Resin System

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 10°F (-12°C) 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: 250°F (121°C) for 3-4 Hours

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

EX-1515 Resin System

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 60°F to 90°F (16°C to 32°C) with a relative humidity of no greater than 70% rH.

BAGGING FOR CURE

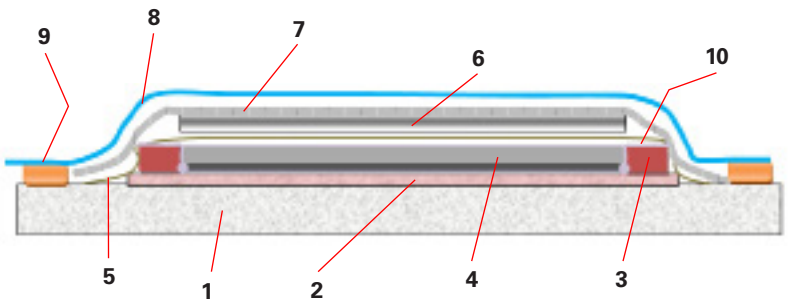
TCAC recommends that CE composite parts bagged for cure should be performed as follows.

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)
2. Release coat or film – Frekote 700NC or 770NC, FEP, TEDLAR
3. Silicone Edge Dams – 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 osy 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)



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All data given is based on representative samples of the materials in question. Since the method and circumstances under which these materials are processed and tested are key to their performance, and TenCate Advanced Composites has no assurance of how its customers will use the material, the corporation cannot guarantee these properties.

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