Toray Advanced Composites

Business Overview

From fiber to parts, composite excellence

May 30, 2024

Greg Waldrip, Account Manager
316-644-8330

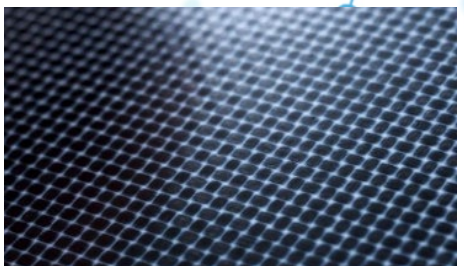
Business Snapshot

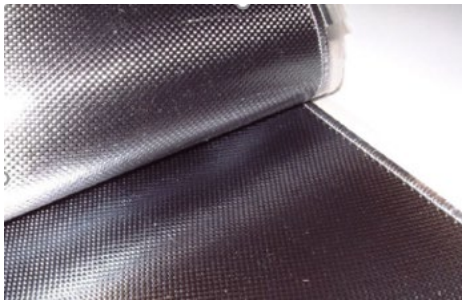
Advanced Composites

- Largest supplier of **ultra pure / low dielectric prepregs** for commercial aerospace SATCOM, military and shipboard **radome** structures.
- Key supplier of **epoxy prepregs** to the **general aviation, launch vehicles, helicopter programs and UAV industries**
- The leading supplier of **high modulus advanced composites** for satellite structures.
- Primary supplier **of thermoplastic-based composites** for commercial aerospace structural and interior applications under the Toray **Cetex**® brand.
- Key provider of **composite tooling prepregs under** Toray **AmberTool** ® brand.
- Provider of chopped fiber **compression molded parts** with internal tool design and part fabrication capabilities.
- Supplier **to high end industrial applications** including F1, niche automotive, sport footwear and recreational.

Composite Material Product Portfolio

- Thermoplastic Prepregs & Laminates
- Thermoset Prepreg
  - OOA, A/C, 250F-700 F cure
  - Ultra Toughened, low dielectric
  - AFP, ATL, Hand-lay, Press Cure
- Thermoset Ancillary Products
  - Film Adhesives
  - Surfacing Films including Lightening Strike
  - Syntactic Foams
  - Aerospace RTM Resins
- Thermoset & Thermoplastic Molding Compo
- Compression Molded Parts



Who is **TORAY**?

FOUNDED
1926

OPERATING COUNTRIES
29

SUBSIDIARIES & AFFILIATES
275

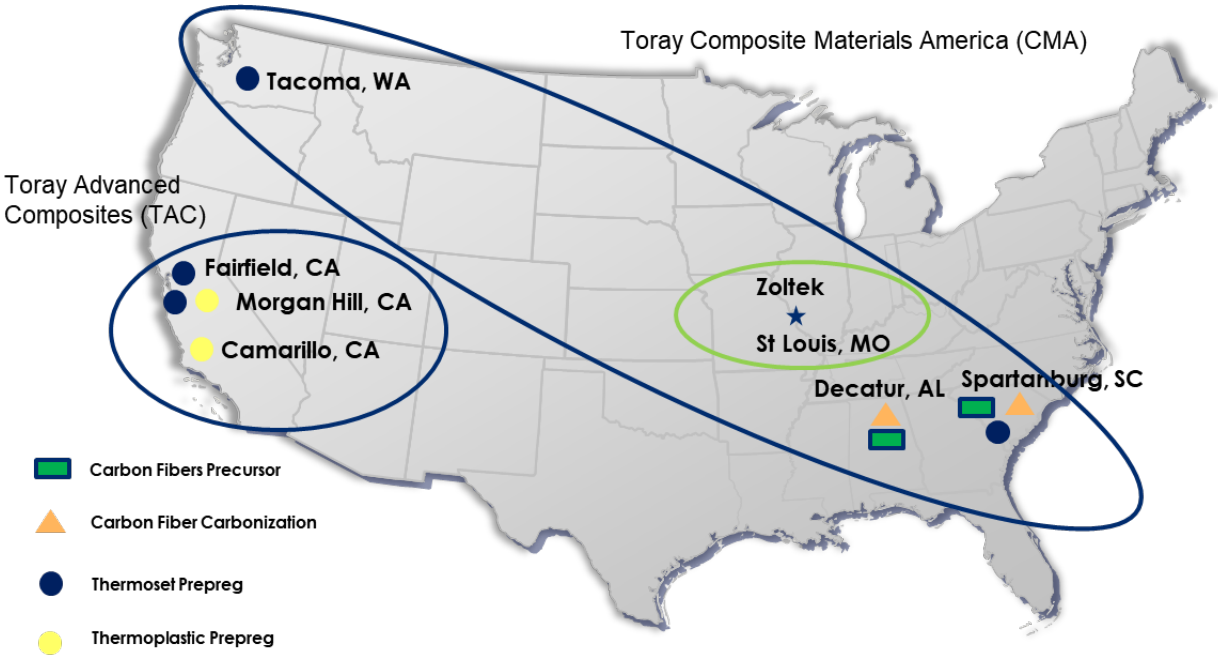
ANNUAL REVENUE
$21B

EMPLOYEES
48,320

BUSINESS DIVISIONS

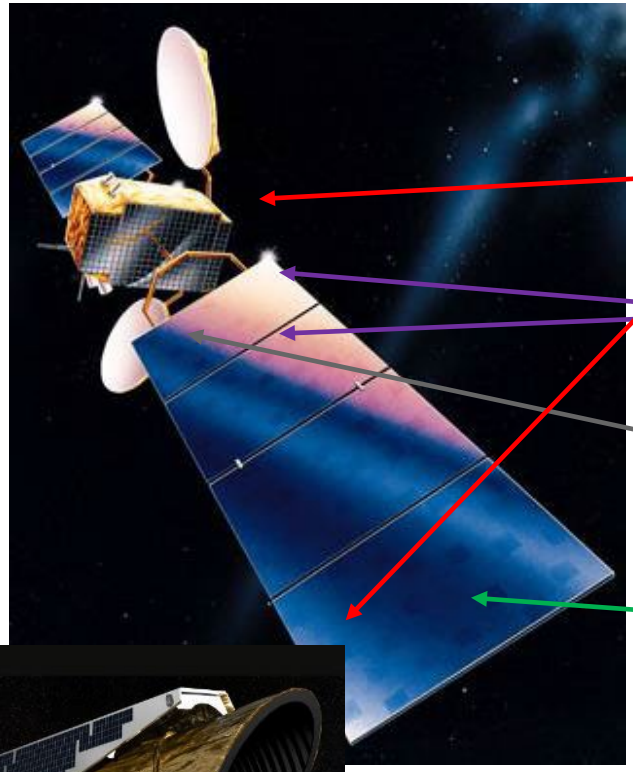
Toray Composite Materials Domestic Capabilities

- 1992 Tacoma WA
  - Prepreg
- 1997 Decatur AL
  - Carbon Fiber
- 2017 Spartanburg, SC
  - Carbon Fiber
  - Prepreg
- 2018 Acquisition of TenCate (Now TAC)
  - Prepreg Fairfield, CA
  - Prepreg Morgan Hill, CA
- Carbon Fiber Capacity
  - SM/IM/IM+ (US): >13k mt
  - HM (Worldwide): >300 mt
- Prepreg Capacity (US): >40 M Sq.Mtrs.



Toray offers diverse production capabilities ranging from specialty niche equipment to large scale production capabilities that offer market leading value and performance

Toray Material Suites for Satellite & Space Vehicle Structures



Reflectors/Optical Benches/Optics
(RS-3C, BTCy-1/-1A, EX-1515, TC410)
[IM to HM PAN, Pitch – UD & Fabrics]

Booms/Yokes/Trusses/Tubes
(RS-36, TC275-1E)
[High Modulus PAN, Pitch – UD & Fabrics]

Bus Structure/Pallets
(RS-3C, RS-36, TC275-1E)
[SM to HM PAN, Pitch – UD & Fabrics]

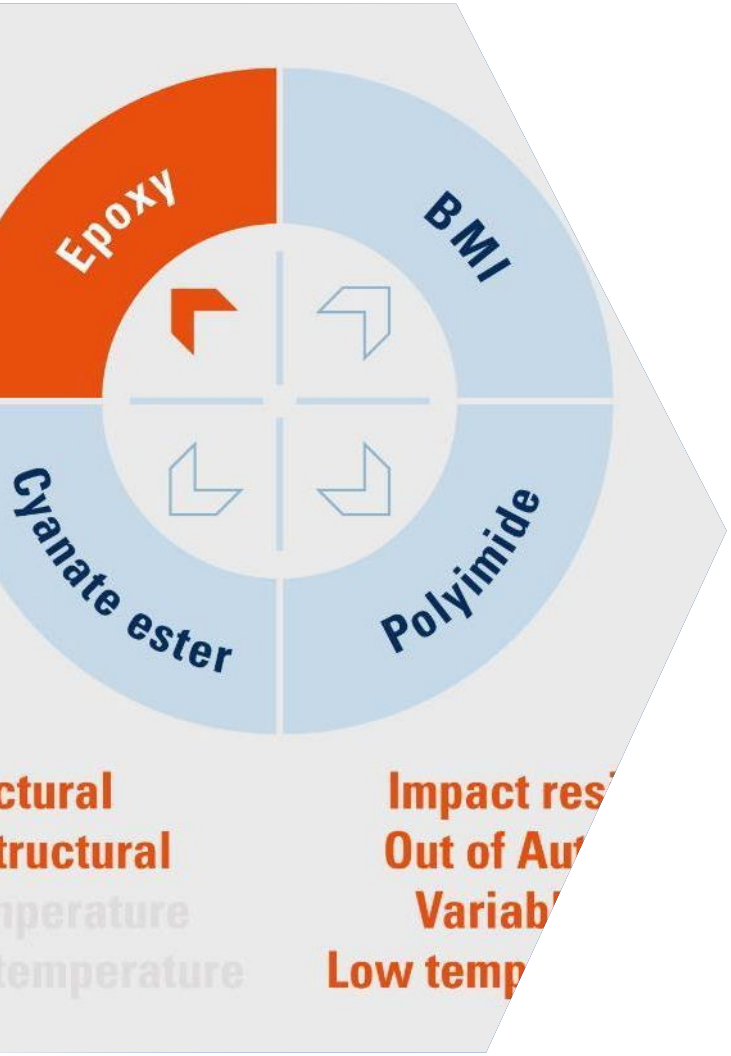
Solar & FP Arrays
(RS-3C, RS-36, EX-1515, TC250, TC275-1E, 2511, 2700, 3900-2)
[SM to HM PAN, Pitch – UD & Fabrics]

Other Space Structures: Face Sheets, I-Beams, Tubes, Sensor Structure, Radiators, Wave Guides, Feed Horns

Thermoset Materials

Product Solutions

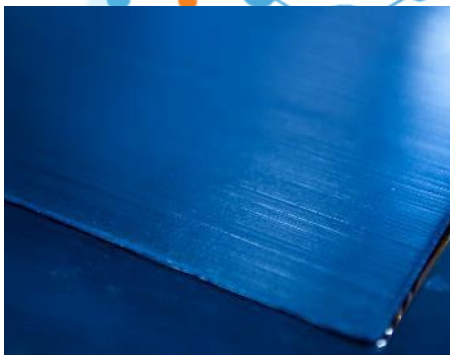
Thermoset Chemistry

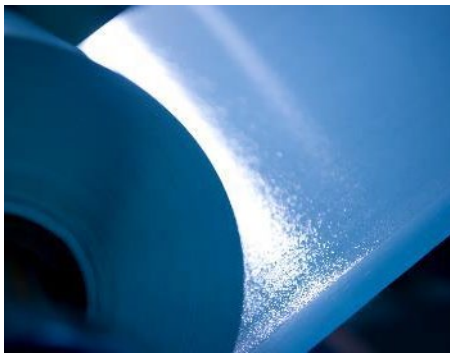


Utilizing the broadest combination of advanced fibers and resins, our materials are valued for their superior strength, high impact resistance and cost effectiveness.

Toray Advanced Composites full range of thermoset technologies includes:

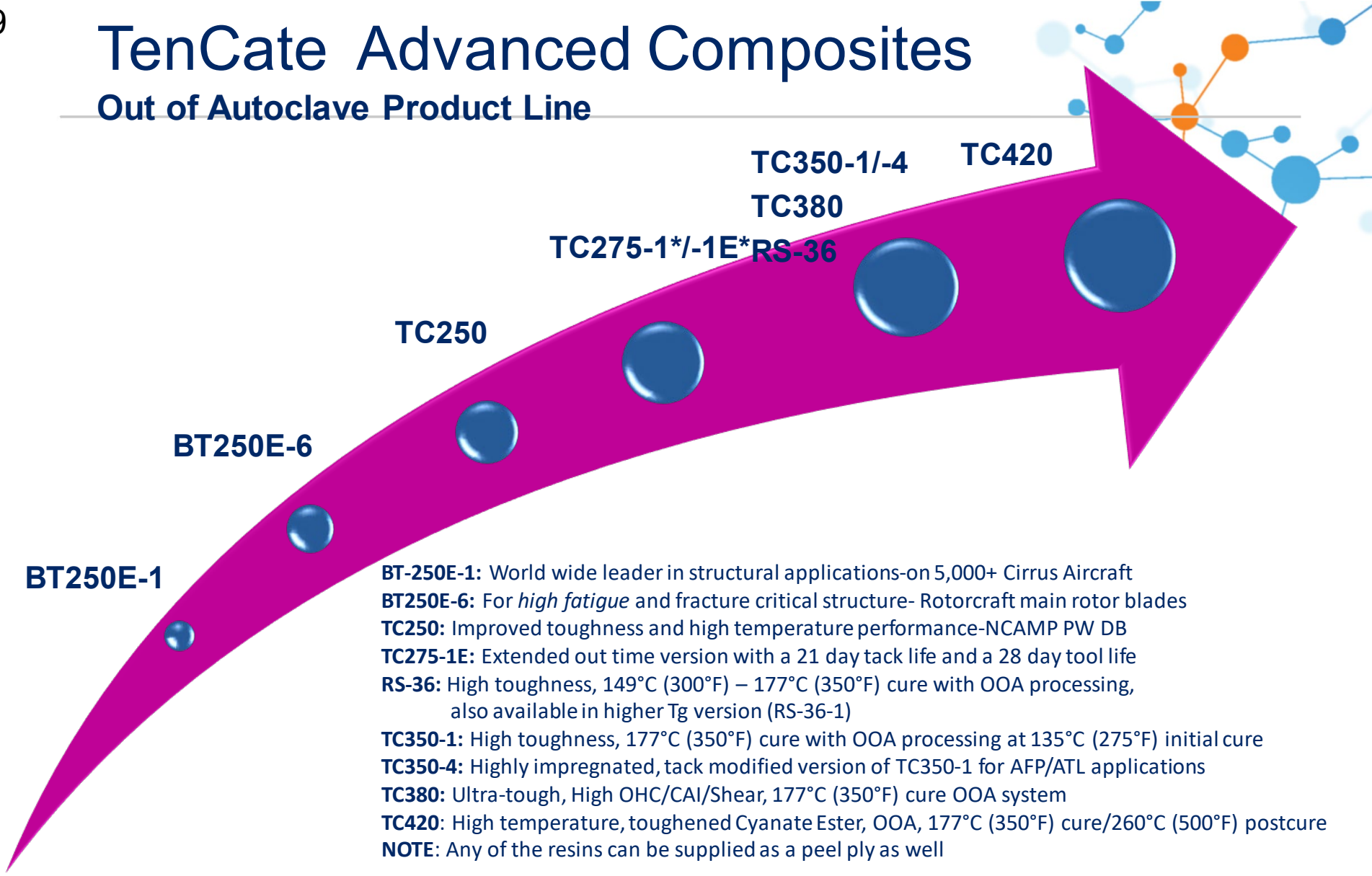
- Low temperature curing tooling prepregs
- Out-of-Autoclave (OOA) processable epoxy prepregs
- Compatible film adhesives
- Composite surfacing films
- Lightweight syntactics and foams
- RTM resins
- High temperature cyanate ester, BMI, and polyimide resins systems





TenCate Advanced Composites

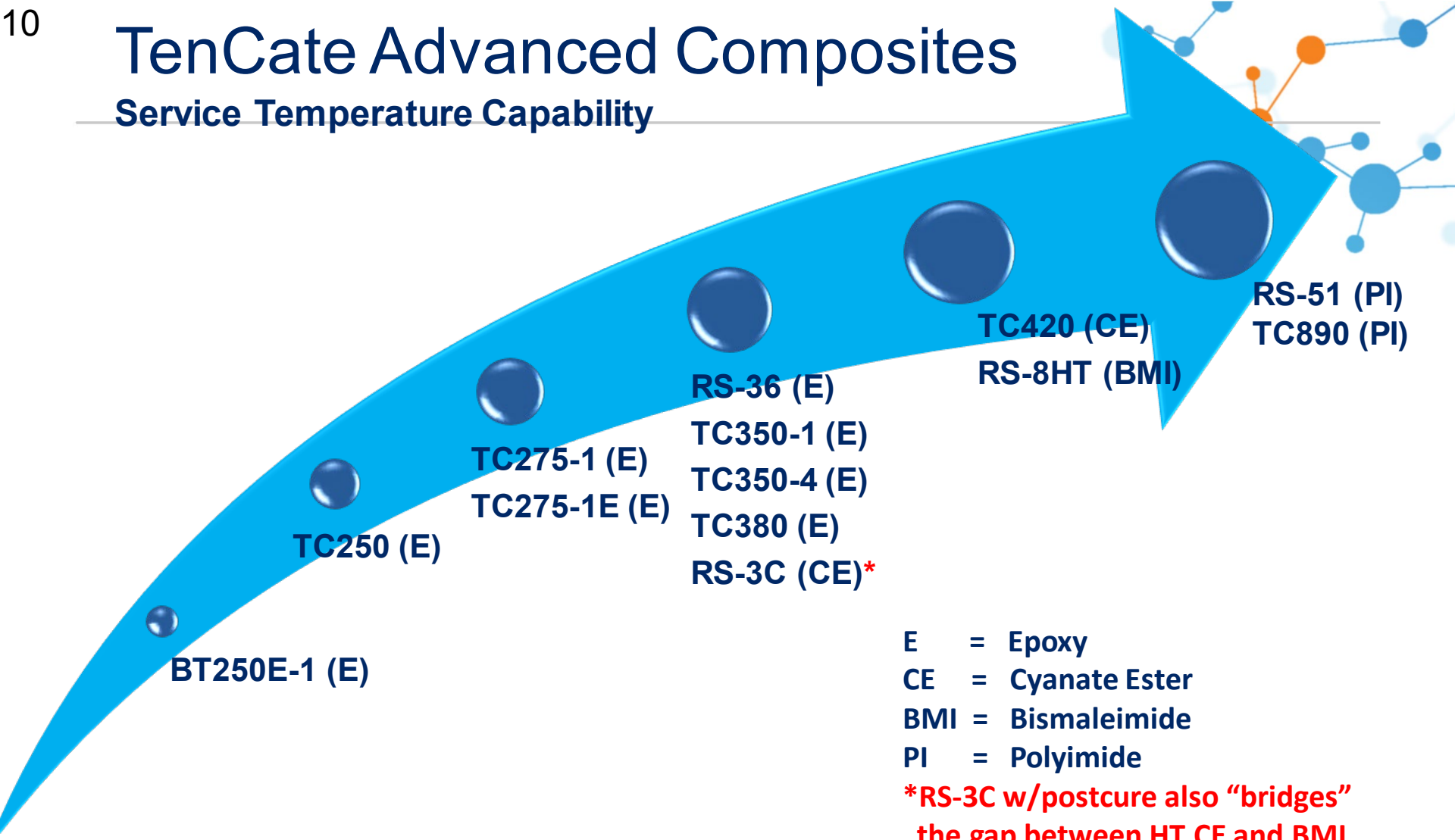
Out of Autoclave Product Line



BT-250E-1: World wide leader in structural applications-on 5,000+ Cirrus Aircraft
BT250E-6: For *high fatigue* and fracture critical structure- Rotorcraft main rotor blades
TC250: Improved toughness and high temperature performance-NCAMP PW DB
TC275-1E: Extended out time version with a 21 day tack life and a 28 day tool life
RS-36: High toughness, 149°C (300°F) – 177°C (350°F) cure with OOA processing, also available in higher Tg version (RS-36-1)
TC350-1: High toughness, 177°C (350°F) cure with OOA processing at 135°C (275°F) initial cure
TC350-4: Highly impregnated, tack modified version of TC350-1 for AFP/ATL applications
TC380: Ultra-tough, High OHC/CAI/Shear, 177°C (350°F) cure OOA system
TC420: High temperature, toughened Cyanate Ester, OOA, 177°C (350°F) cure/260°C (500°F) postcure
NOTE: Any of the resins can be supplied as a peel ply as well

TenCate Advanced Composites

Service Temperature Capability



E = Epoxy
CE = Cyanate Ester
BMI = Bismaleimide
PI = Polyimide

*RS-3C w/postcure also "bridges" the gap between HT CE and BMI

NOTE: Any of the resins can be supplied as a peel ply as well

TenCate Cyanate and Specialty Prepregs

EX-1515
TC410
BTCy-3A
RS-12B

250°F Cure

BTCy-1
BTCy-1A
BTCy-1C
BTCy-2

350°F Cure

EX1505
RS-3
RS-3C

350°F Cure

TC420
TC800 (BMI)

350°F Cure

RS-9D
RS-8HT (BMI)

>350°F Cure

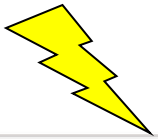
RS-51
(Polyimide)

Special Cure

- EX-1515 Cyanate, 250°F cure, Optional 350°F Postcure, Toughened
- TC410 Cyanate, 250°F cure, Optional 350°F Postcure
- BTCy-3A Cyanate, 250F Cure, Toughened
- RS-12B Cyanate, 265°F cure, Optional 310°F Postcure, Toughened
- BTCy-1 Cyanate, 350°F cure, Optional 450°F Postcure
- BTCy-1A Cyanate, 350°F cure, Optional 400°F Postcure, Toughened
- BTCy-1C Cyanate, 350°F cure, Optional 450°F Postcure, OOA
- BTCy-2 Cyanate, 350°F cure, Lowest Dielectric Properties, Low Loss
- EX-1505 Cyanate, 350°F cure, Optional 500°F Postcure, High Temp System
- RS-3 Cyanate, 350°F Cure, Optional 450°F Postcure
- RS-3C Cyanate, 350°F Cure, Opt ional 450F Postcure, Controlled Flow
- TC420 Cyanate, 350°F Cure, Optional 500°F Postcure, High Temp
- TC800 BMI, 350°F Cure, 450°F Postcure
- RS-9D Cyanate, 380°F Cure, Optional 600°F Postcure, High Temp
- RS-8HT BMI, 400°F Cure, 482°F Postcure
- RS-51 Polyimide, Call for Cure Details

EX-1515 Cyanate Ester

Property	Attributes
Neat resin data	Yes, enough for computer models at RTD Dk/Dl, Outgassing, TC, CTE, TC
Most common products	4581 AQIII, M55J unitape, K13D2U, K13C2U Pitch Fiber
Tg	274°F or 360°F w/post cure
Service Temp	220°F or 310°F w/ post cure dry
Application	Most autoclave cured, some OOA 4581 AQIII
Noteable usage	LHC, Satellite solar array panels and radomes
Forms	Unitapes, as low as 45 gsm FAW



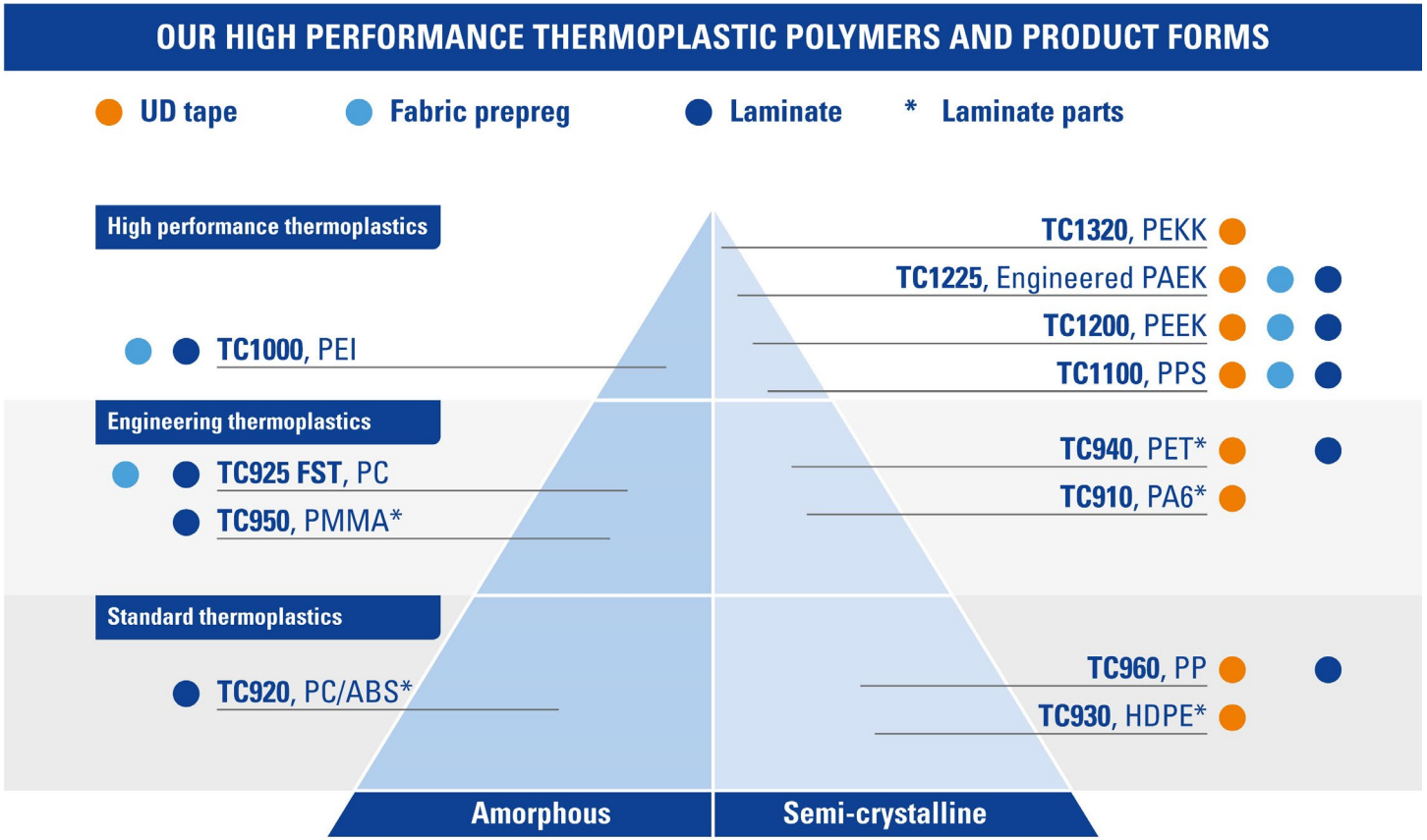
Thermoplastic Materials

Product Solutions

High Performance Thermoplastic Composites

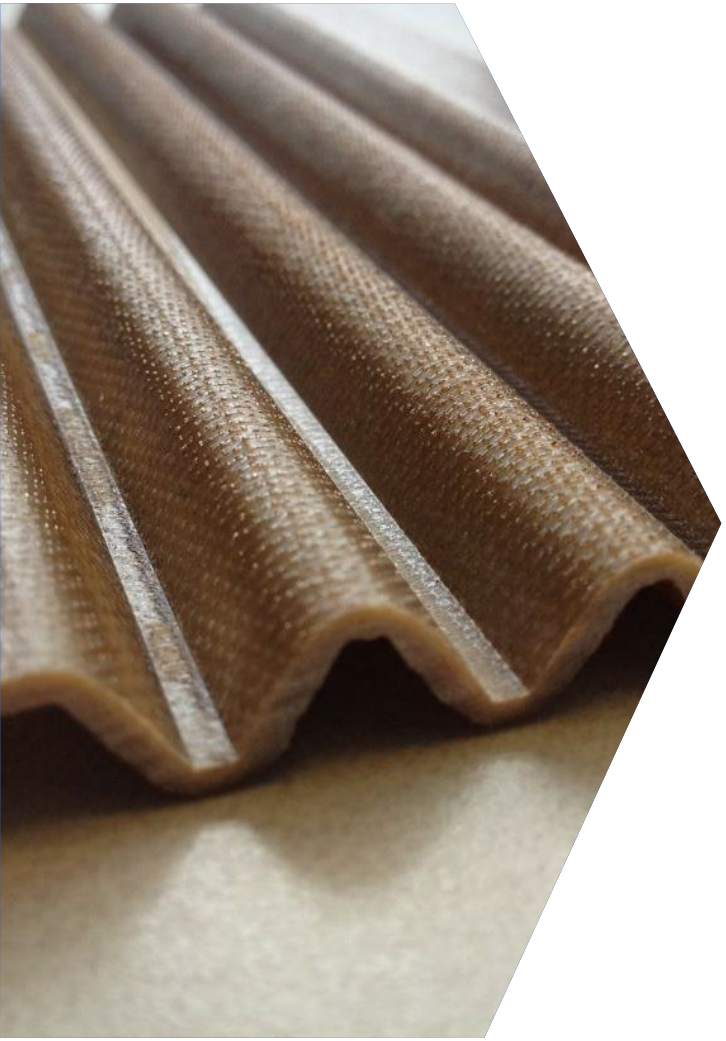
Toray product line depth along the performance pyramid

Cetex®

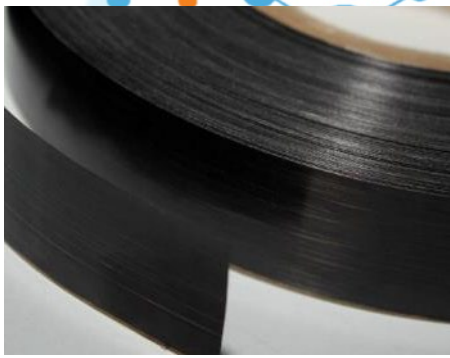


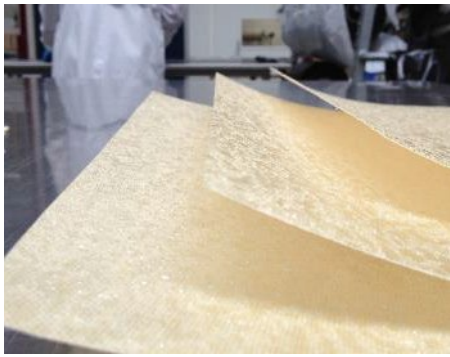
TORAY

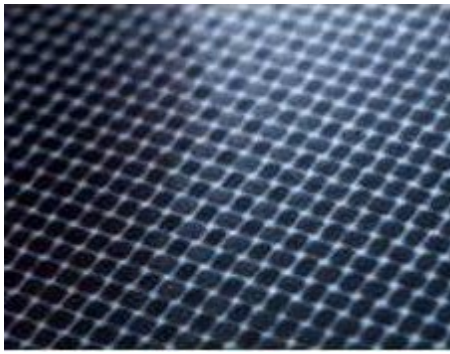
Thermoplastic Product Solutions



- Toray **Cetex**® thermoplastic advanced lightweight materials offer outstanding mechanical properties, durability, and strength.
- **Qualified** to Boeing, Airbus material specifications. Unsurpassed performance delivers proven resistance to extreme conditions and environments.
- Established choice for high volume manufacturing, Toray Cetex® family of **tape, fabric prepreg, and laminate (RTL)** thermoplastic composite materials in a wide range of fiber/resin combinations and product formats.







Markets Served

General Aviation

Unmanned Systems

Space/Satellites and Launch Vehicles

Commercial Aircraft T/P for p*rimary and secondary structure*

Radomes & Antennas

Aircraft Interiors

Military Aircraft *incl High Temp Materials*

High End Industrial, F1, Niche Automotive and Recreational Footwear

Awards and Quality

- **AASC Supplier Excellence Award** - 2014-2015, 2016
- **General Atomics Supplier Excellence Awards** - 2010-2016
- **Boeing Silver Supplier Award** – 2011, 2012, 2014, 2017
- **JEC Innovation Awards**
  - 2010 Gulfstream G650 induction welded thermoplastic elevator/rudder
  - 2011 Cutting Dynamics/A&P thermoplastic commercial aircraft seat
  - 2013 Agusta Westlands horizontal thermoplastic helicopter tail
  - 2014 Expliseat lightweight thermoplastic/titanium aircraft seat
  - 2015 Recycled thermoplastic composites for aerospace structures. TPRC and Fokker collaborative co-recipients.
- **Lockheed Martin Aeronautics** – 2014 100% OTD/Zero Defects Award
- **Lockheed Martin Fleet Ballistic Program** – 2016 Appreciation Award
- **Erickson Air Crane** - 2012-2013 Silver Supplier Award, 2014 Gold Award
- **Quality Systems** - Compliant with AS9100D:2016 and ISO 9001:2015

Appendix

Liquid Resins (RTM) & MicroPly Syntactic Paste Products

Product	Application	Summary	Benefits
RS-50	RTM Resin	One Part Toughened Epoxy	• 177°C (350°F) Cure • High temp toughened RTM resin.
EX-1510	RTM Resin	Two Part Cyanate	• 177°C (350°F) Cure • High Temp Properties with Postcure • Low Viscosity
EX-1545	RTM Resin	Two Part Cyanate	• 177°C (350°F) Cure • Low Viscosity • One Part
RS-16	RTM Resin	Two Part Toughened Cyanate	• 135°C (275°F) Cure • High >204°C (400°F) Tg • Space Qualified
EX-1541	Potting/Filling	Cyanate Ester Syntactic Paste	• 177°C (350°F) curing cyanate • Available in different densities • 11 to 20 pcf
TCF4001	Missile/Heat Shield	Cyanate Ester Syntactic Paste	• 177°C (350°F) Cure, 232° (450°F) Postcure • High temp syntactic for use with TC420 • 22 to 26 pcf

MicroPly Syntactics, Core Splice & Surfacing Film

Product	Product Form	Summary	Benefits
TCF4045	Syntactic Film	Epoxy Hybrid Syntactic Film (EX-1522 compatible)	• 177°C (350°F) cure, higher Tg than TCF4035. • Very low dielectric & loss for radomes • Density 38 pcf*
TCF4035	Syntactic Film	Epoxy Syntactic Film (TC250 compatible)	• 121°C (250°F) cure, higher Tg than TCF4025 • Low dielectric & loss for radomes • Density 40 pcf*
SF-5	Syntactic Film	Cyanate Syntactic Film (RS-3 compatible)	• 177°C (350°F) Cure • Density 38 pcf*
SF-4	Syntactic Film	BMI Syntactic Film (RS-8HT compatible)	• 200°C (392°F)/2 hr. cure, 250°C (482°F)/6hr. postcure • Density 40 pcf*
SF-3	Syntactic Film	Epoxy Syntactic Film (RS-1 compatible)	• Cure 6 hrs at 90°C (200°F) • Density 40 pcf*
TC235SF-1	Surfacing Film	Epoxy Surfacing Film	• 121°C (250°F) Cure • OOA surfacing film • Lightning strike version available
EM-3	Core Splice (Expanding Syntactic)	Epoxy Core Splice Honeycomb fill/splice/stabilization	• 121°C (250°F) cure • Density ~40 pcf* / Expansion factor 3x to 6x
EM-5A	Core Splice (Expanding Syntactic)	Cyanate Core Splice Honeycomb fill/splice/stabilization	• 177°C (350°F) cure • Density ~50 pcf* / Expansion factor 3x to 6x • Low moisture absorption, high Tg
EM-6	Core Splice (Expanding Syntactic)	Epoxy Core Splice Honeycomb fill/splice/stabilization	• 80°C (176°F) to 100°C (212°F) cure • Density ~38 pcf* / Expansion factor 3x to 5x
TCF4050	Core Splice (Expanding Syntactic)	Cyanate High Temperature Core Splice Honeycomb fill/splice/stabilization	• 177°C (350°F) cure / 232°C (450°F) post cure • Density ~69 pcf* / Expansion factor 2x to 4x • Low moisture absorption, very high Tg

MicroPly Standard Cyanate and Epoxy Aerospace Adhesive Films

Product	Application	Summary	Benefits
RS-15H (Epoxy)	Aerospace & Industrial	82°C (177°F) to 93°C (200°F) Cure Epoxy	• Compatible w/RS-1 Prepregs, SF-3
TC263 (Epoxy)	General purpose composite bonding	121°C (250°F) Cure Adhesive compatible with TC250, TC275, TC275-1, TC-275-1E	• Out of autoclave capable • Toughened epoxy adhesive
TC310 (Epoxy)	General purpose composite bonding	110°C (230°F) to 177°C (350°F) Cure Toughened adhesive for composites	• Out of autoclave capable. • Evaluated for dual cure scenarios at temperatures from 110°C (230°F) to 177°C (350°F)
EX-1516 (Cyanate)	Honeycomb bonding	121°C (250°F) Cure Compatible with EX-1515	• Cyanate Ester Resin Film • Similar resin profile to EX-1515 • 121°C (250°F) Cure
RS-4A (Cyanate)	Honeycomb bonding	177°C (350°F) Cure Compatible with RS-3/-3C Reticulatable adhesive	• Cyanate Ester • 177°C (350°F) Cure • Can postcure to higher Tg
EX-1543 (Cyanate)	Honeycomb bonding	177°C (350°F) Cure Compatible with BTCy-1 series of cyanate ester prepregs	• Cyanate Ester Resin Film • Similar resin profile to BTCy-1 • 177°C (350°F) Cure
TC4015 (Cyanate)	Missile/Heat Shield	177°C (350°F) Cure, 232°C (450°F) Postcure Compatible with TC420	• 177°C (350°F) Cure, 232°C (450°F) Postcure

TORAY

Key Cyanate Ester Systems

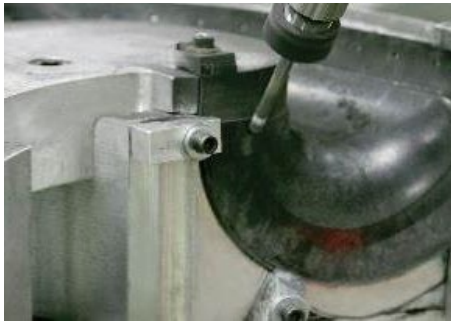
THERMOSET PREPREGS CYANATE ESTER

	RESIN MATRIX	DRY T_g ONSET	CURE TIME AND TEMPERATURE	KEY PRODUCT CHARACTERISTICS	OUTGASSING, CTE/ CME OR HOT/WET DATA	OOA/VBO	TOUGHENED	LOW MOISTURE ABSORPTION	SPACE/ SATELLITE	LAUNCH
EX-1515	Cyanate Ester	121°C (249°F) or 174°C (345°F) with post cure	3 hours at 121°C (250°F) Optional post cure of 2 hours at 177°C (350°F)	▸ Low density ▸ Resistant to microcracking ▸ Low residual stress with 121°C (250°F) cure	TML 0.18 % CVCM 0.01 % CTE 61 ppm/°C		○	○	○	
TC410	Cyanate Ester	112°C (234°F) or 181°C (358°F) with post cure	3 hours at 121°C (250°F) Optional post cure at 177°C (350°F)	▸ Low CTE 58.4 µm/m/°C ▸ Extremely low CME 1205 µm/m/% ▸ Ideal system for stable structures	TML 0.29 % CVCM < 0.01 % WVR 0.17 % TML-WVR 0.12 %		○	○	○	
BTCy-1A	Cyanate Ester	185°C (365°F) or 207°C (405°F) with post cure	2 hours at 177°C (350°F) Optional post cure of 60 minutes at 204°C (400°F)	▸ Tough ▸ High T_g	CTE 77 ppm/°C		○	○	○	
RS-3/ RS-3C	Cyanate Ester	191°C (375°F) or 254°C (490°F) with post cure	2 hours at 177°C (350°F) Optional post cure of 60 minutes at 232°C(450°F)	▸ Extensive qualification portfolio ▸ Low CTE, CME ▸ High stability ▸ RS-3C is controlled-flow version	TML 0.22 % CVCM 0.01 %	○	○	○	○	
TC420	Cyanate Ester	176°C (349°F) or 348°C (658°F) with post cure	3 hours at 177°C (350°F) Optional post cure at 260°C (500°F)	▸ Good resistance to microcracking ▸ Capable of high-temperature service ▸ Ideal for heat shield and ablative applications	TML 0.41 % CVCM < 0.01% WVR 0.28% CTE 55 ppm/°C	○	○	○	○	○

TORAY

Compression Molded Parts

- The CCS division of Toray Advanced Composites is focused on molding high tolerance, low to mid-volume parts out of chopped thermoset and thermoplastic prepregs.
- In-house tool design and fabrication capability.
- Core competencies;
  - Highly complex, high tolerance parts for **military, satellite and aircraft** applications
  - Tool design and fabrication
  - Analysis and design for manufacturability
  - Ability to readily process difficult to manufacture high performance resin and fiber BMC combinations
- Key technology for **cost and weight reduction and part fabrication efficiency** on current aircraft platforms
- Lower cost alternative to cast/machined metals and continuous composites



Toray Advanced Composites

www.toraytac.com