PRODUCT DATA SHEET

TENCATE ADVANCED COMPOSITES

TenCate Cetex® TC1200

PEEK Resin System

PRODUCT TYPE

Polyetheretherketone (PEEK)
Thermoplastic Resin System

SERVICE TEMPERATURE

Approximately 250°F (121°C)

FEATURES

- Ambient temperature storage
- Flame retardant
- Low moisture absorption
- Good impact resistance
- 3-5 minute thermoforming cycles
- Excellent structural performance
- Outstanding solvent resistance
- Very low void content (<1%)

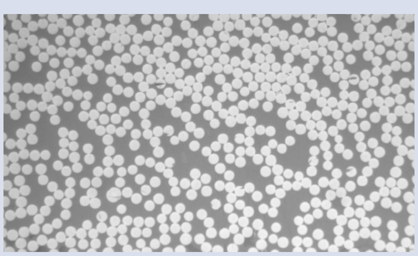
TYPICAL APPLICATIONS

- Primary Aircraft Structure
- Secondary Aircraft Structure
- Access Panels, Rib Stiffeners, Brackets, Conduit, Flooring

Tg .... 290°F (143°C)
Tm .... 649°F (343°C)

PROCESSING OPTIONS

Press,Thermoform,
in-situ ATL or Autoclave



Very low void content, 500x view of single ply Cetex UD prepreg, as produced, without further consolidation. Average void level of <0.2% with even fiber and resin distribution.

PRODUCT DESCRIPTION

TenCate Cetex® TC1200 is a semi-crystalline polyetheretherketone thermoplastic composite available in fabric and unitape form. It offers excellent resistance to chemicals and solvents, is flame retardant and combines outstanding toughness with high temperature performance. TenCate Cetex® TC1200 unitapes are offered with standard or intermediate modulus carbon fiber or S-2 glass fiber. TenCate Cetex TC1200 has a very low void content (<1%). Typical carbon unitape width offered is standard six inch (75 mm) widths with optional 12 inch (305 mm) widths offered too. Alternative narrower slit widths for ATL processing may be available through secondary slitting.

MECHANICAL PROPERTIES - CETEX TC1200 PEEK AS-4

Data generated on AS-4, 146 gsm FAW, resin content of 34% by weight, 59% fiber by volume. Prepreg areal weight 218 gsm.

Property	Condition	Test Method	Result	
Tensile Strength (0°)	RTD	ASTM D3039	330 ksi	2280 MPa
Tensile Modulus (0°)	RTD	ASTM D3039	18.9 Msi	130 GPa
Poisson's Ratio	RTD	ASTM D3039	0.33	
Tensile Strength (90°)	RTD	ASTM D3039	12.5 ksi	86 MPa
Tensile Modulus (90°)	RTD	ASTM D3039	1.4 Msi	10 GPa
Compressive Strength (0°)	RTD	ASTM D6641	188 ksi	1300 MPa
Compressive Modulus (0°)	RTD	ASTM D6641	18 Msi	124 GPa
Compressive Strength (0°)	ETW (1)	ASTM D6641	176 ksi	1210 MPa
Compressive Modulus (0°)	ETW	ASTM D6641	17.6 Msi	121 GPa
In-Plane Shear Strength (±45°)	RTD	ASTM D3518	22 ksi	152 MPa
In-Plane Shear Modulus (±45°)	RTD	ASTM D3518	0.75 Msi	5.2 GPa
Flexural Strength (90°)	RTD	ASTM D7264	22.0 ksi	152 MPa
Interlaminar Shear Strength (SBS) 0°/ 90°	RTD	ASTM D2344	13.7 ksi	94 MPa
Interlaminar Shear Strength (SBS) 0°/ 90°	ETW	ASTM D2344	11.2 ksi	77 MPa
Open Hole Tensile Strength	RTD	ASTM D5766	56.1 ksi	387 MPa
Open Hole Compressive Strength	RTD	ASTM D6484	46.4 ksi	320 MPa

(1) ETW is tested at 180°F/82°C after 14 day soaks in 160°F/71°C water.

TENCATE

TenCate Cetex® TC1200 PEEK Resin System

MECHANICAL PROPERTIES - TENCATE CETEX TC1200 PEEK 5HS LAMINATE

Data generated on 5HS fabric, 280 gsm FAW, resin content of 42% by weight, 50% fiber by volume. (Fiber used T300 JB 3K)

Property	Condition	Test Method	Result	
Tensile Strength (0°)	RTD	ISO 527-4	776 MPa	113 ksi
Tensile Modulus (0°)	RTD	ISO 527-4	56.1 GPa	8.1 Msi
Tensile Strength (90°)	RTD	ISO 527-4	827 MPa	120 ksi
Tensile Modulus (90°)	RTD	ISO 527-4	55.6 GPa	8.1 Msi
Compression Strength (0°)	RTD	AITM 1-0008	585 MPa	84.8 ksi
Compression Modulus (0°)	RTD	AITM 1-0008	51.6 GPa	7.5 Msi
Compression Strength (90°)	RTD	AITM 1-0008	595 MPa	86.3 ksi
Compression Modulus (90°)	RTD	AITM 1-0008	49.7 GPa	7.2 Msi
Flexural Strength (90°)	RTD	EN 2562	859 MPa	125 ksi
Flexural Modulus (90°)	RTD	EN 2562	46.3 GPa	6.7 Msi
In Plane Shear Strength	RTD	AITM 1-0002	155 MPa	22.5 ksi
In Plane Shear Modulus	RTD	AITM 1-0002	4.5 GPa	0.65 Msi
Compression After Impact Strength	RTD @ 40J	AITM 1-0002	265 MPa	38.4 ksi

Tg = 289°F/143°C   Tm = 649°F/343°C

MECHANICAL PROPERTIES - TENCATE CETEX TC1200 PEEK IM-7

Data generated on IM-7, 146 gsm FAW, resin content of 34% by weight, 59% fiber by volume. Prepreg areal weight 218 gsm.

Property	Condition	Test Method	Result	
Tensile Strength (0°)	RTD	ASTM D3039	400 ksi	2760 MPa
Tensile Modulus (0°)	RTD	ASTM D3039	25.0 Msi	172 GPa
Tensile Strength (90°)	RTD	ASTM D3039	12.5 ksi	86 MPa
Tensile Modulus (90°)	RTD	ASTM D3039	1.5 Msi	10 GPa
Compressive Strength (0°)	RTD	ASTM D6641	175 ksi	1210 MPa
Compressive Modulus (0°)	RTD	ASTM D6641	17.9 ksi	123 GPa
Interlaminar Shear Strength (SBS)	RTD	ASTM D2344	13.9 ksi	96 MPa
Flexural Strength (90°)	RTD	ASTM D7264	23.5 ksi	162 MPa
Open Hole Compression Strength	RTD	ASTM D 6484	44 ksi	303 MPa
Open Hole Tensile Strength	RTD	ASTM D 5766	73.5 ksi	506 MPa

TenCate Cetex® TC1200
PEEK Resin System

MECHANICAL PROPERTIES - TENCATE CETEX TC1200 S2 GLASS UNITAPE

Data generated on S-2 205 gsm FAW, resin content of 29%, 56% fiber by volume. Prepreg areal weight of 289 gsm.

Property	Condition	Test Method	Result
Tensile Strength 0°	RTD	ASTM D3039	220 ksi (1520 MPa)
Tensile Modulus 0°	RTD	ASTM D3039	7.5 Msi (52 GPa)
Poisson's Ratio	RTD	0.29	
Compression Strength 0°/90°	RTD	ASTM D6641	232 ksi (1600 MPa)
Compression Modulus 0°/90°	RTD	ASTM D6641	7.7 Msi (53 GPa)
In-Plane Shear Tension Strength ±45°	RTD	ASTM D3518	11.2 ksi (77 MPa)
In-Plane Shear Tension Modulus ±45°	RTD	ASTM D3518	0.48 Msi (3.3 GPa)
0° Flexural Strength	RTD	ASTM D790	232 ksi (1600 MPa)
0 °Flexural Modulus	RTD	ASTM D790	7.7 Msi (53 GPa)
0° Short Beam Shear ILSS	RTD	ASTM D2344	12.5 ksi (86 MPa)

Processing Guidelines for TenCate Cetex® TC1200 (Polyetheretherketone) Thermoplastic Composite Materials

TenCate Cetex® TC1200 thermoplastic composite materials from TenCate are processed by heating the material above the PEEK melting point, molding it and cooling it under pressure to the desired shape. Because no chemical change occurs to the PEEK matrix, processing is very rapid. The quick easy processing of TenCate Cetex materials is also made possible because of the rapid crystallization rate of the PEEK matrix. The key thermal processing parameters are:

Melt Temperature .... 649°F (343°C)
Typical Processing Temperature .... 700-750°F (370-400°C)

TenCate can also produce TenCate Cetex slit tape & simple profiles (round rods, ovals, rectangles, etc.). TenCate also has the capability to chop the slit tape & simple profiles into discrete length long fiber thermoplastic type materials for injection or compression molding type processes.

AUTOMATED PROCESSES

Below are several examples of automated processes that are utilized and available in the market today. The three processes utilize similar premises in that they eliminate the need for autoclave consolidation of thermoplastic composite parts, thereby dramatically reducing the cost and time of producing continuous fiber composite structures.

1. **Fiber Placement with In Situ Consolidation**
   This process utilizes narrow width tapes typically 0.25 – 1 inches (6 – 25 mm) as its composite material medium and lays down, heats via hot gas, laser, or other heating methods and consolidates the composite material onto the tool, in situ, without the need for further consolidation processes.

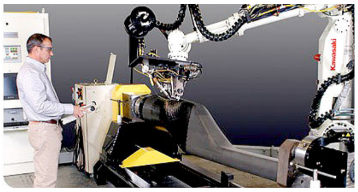


Photo courtesy of Automated Dynamics
www.automateddynamics.com

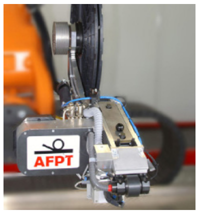


Photo courtesy of AFPT
www.afpt.biz/

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PEEK Resin System

2. Rapid Lamination / Forming

This process uses wider UD tapes typically ≥ 2 inches (50 mm) width automated tape laying equipment to rapidly lay down and consolidate the thermoplastic composite material into an engineered laminate structure that can then be transformed into parts via a secondary compression thermoforming process.

Automated tape laying of tailored blank followed by consolidation.

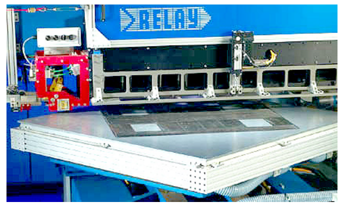

Photo Courtesy of FiberForge
www.fiberforge.com

The consolidated flat laminate is first consolidated, then thermoformed to a 3-D final shape.

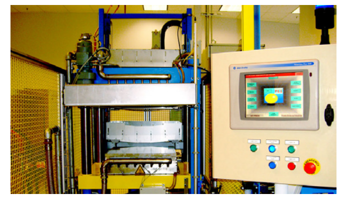

Photo courtesy of TenCate

3. Continuous Compression Molding

In this multi-step process, multiple plies of thermoplastic unitape are fed into a continuous process through a heated mold and pressed into a laminate. This laminate is then pressed into a mold and thermoformed to the desired profile. A final step then molds with heat and pressure into the curved profile through a process called continuous compression molding. Items such as clips, rails, beams and profiles are manufactured in this type of process.

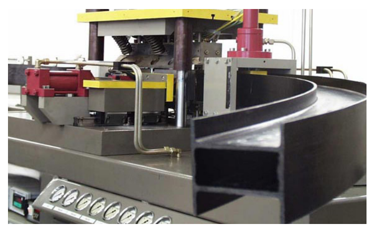

Photo Courtesy of ACM/Xperion Aerospace
www.acm-fn.de

Press Lamination: A laminate can be fabricated from any TenCate Cetex prepreg by stacking two or more plies in the desired orientation into a picture frame mold, transferring the assembly to a heated platen press where it is brought to approximately 700-750°F (370-400°C) at contact pressure until the material reaches temperature. The pressure should then be increased to 100-300 psi (7-21 bar) and held for approximately 15-30 minutes. The part should then be cooled to room temperature at a 5-20°C cool down rate to maintain the crystalline nature of PEEK for solvent resistance.

Autoclave Lamination: Autoclave consolidation maybe used for fabricating laminates from any TenCate Cetex prepreg tape. Individual layers are stacked in the desired orientation and vacuum bagged (vacuum should be maintained throughout the entire process). A high temperature bagging material, such as Kapton or polyimide should be used. The assembly should then be placed in the autoclave and brought to approximately 700-750°F (370-400°C), at which time the pressure is increased from ambient to 100-300 psi (7-21 bar) and maintained for around 5-30 minutes. The part should then be cooled to room temperature at a 5-20°C cool down rate to maintain the crystalline nature of PEEK for solvent resistance.

Thermoforming Laminates into Shapes: Thermoforming is used to convert a flat consolidated continuous fiber reinforced laminate into a complex shape with no change in starting laminate thickness. The laminate should be heated to around 700-750°F (370-400°C) in an infrared or similar oven, and then quickly transferred to a matched core/cavity mold where it can be formed at 150-600 psi (10-40 bar). For optimum properties and formability, heating of the composite laminate should take no longer than 8 minutes. Overall part production cycle times are between 2-10 minutes, depending on material thickness and part geometry. Production tooling consists of machined aluminum halves, one that has a compliant layer of cast silicone, and an associated laminate tensioning system to prevent wrinkling within the part being thermoformed.

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PEEK Resin System

Cutting and Machining: Thermoplastic composite laminates and thermoformed parts can be machined with feed rates and tip speeds similar to those used when machining brass.

The following are some general guidelines:

Circular Saw:	Diamond-grit-edge blade of 220 grit. Blade speed: 6000 fpm (1830 mpm) with water or soap solution as coolant. Feed rates depend on thickness.
Turning Operations:	Cutting Speed: 350-400 fpm (105-120 mpm) for high speed tools, 1500-2500 fpm (180-455 mpm) for Stellite or carbide tools, and 2000-4000 fpm (600-1200 mpm) for diamond tools
Milling Operations:	Tip speed: 250-450 fpm (75-135 mpm) for carbide and diamond tools Plunge feed rate: 0.5-1 fpm (0.15-0.30 mpm)
Drilling Operations:	Feed Rate: 0.008-0.016 in/rev (0.2-0.4 mm/rev) Drill speed: 150-300 fpm (45-90 mpm) Drill point angles: 60° for thin parts, 90° for thick parts Clearance angle: 15°
Tapping:	Tool rake of 0° to 5° negative
Shearing:	Thicknesses up to 0.125 inch (3.2 mm)

Joining: Thermoplastic composites can be joined via mechanical fasteners, adhesive bonding, or fusion welding. Fusion welding via resistance or inductive welding is common preferred method of joining thermoplastics.

Strong adhesive bonds are possible with epoxy adhesives when PEEK surfaces are cleaned with a suitable degreasing solvent (i.e. MEK), abrasive treatment (i.e., abrasion wheels, sand paper, or grit blasted with #100 or #200 Aluminum Oxide). The surface energy may also be enhanced by flame/corona treatment, chromic acid etching, laser treatment, or plasma techniques. Epoxy
films or pastes with cure temperatures up to 350°F (177°C), anaerobics, silicone sealers, and cyanoacrylates are effective adhesives depending on specific requirements.

TenCate Cetex® TC1200 based composites may also be bonded using conventional thermoplastic welding techniques. PEEK based materials have very high melt temperatures and considerable amounts of energy must be put into the interface to achieve a good bond. Satisfactory results have also been obtained using induction or resistance welding.

Painting: TenCate Cetex® TC1200 composite surfaces can be painted with a variety of products. It is recommended that a paintable (non-silicone) mold release be used, if possible, during the molding of all surfaces to be painted. If a silicone or Teflon mold release is used during molding, laminate and part surfaces may require abrasion prior to painting. In all cases, surfaces must be wiped with a suitable solvent to remove oils, release agents, or other impurities.

Health & Safety: Health and safety information on handling and processing TenCate composite materials is described in a Material Safety Data Sheet available from TenCate Advanced Composites USA, Inc. To obtain this or any other information about TenCate PEEK thermoplastic composite materials, contact: TenCate Advanced Composites USA, Inc. at the addresses and telephone numbers below, or our website at www.tencateadvancedcomposites.com.

Revised 01/2017

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