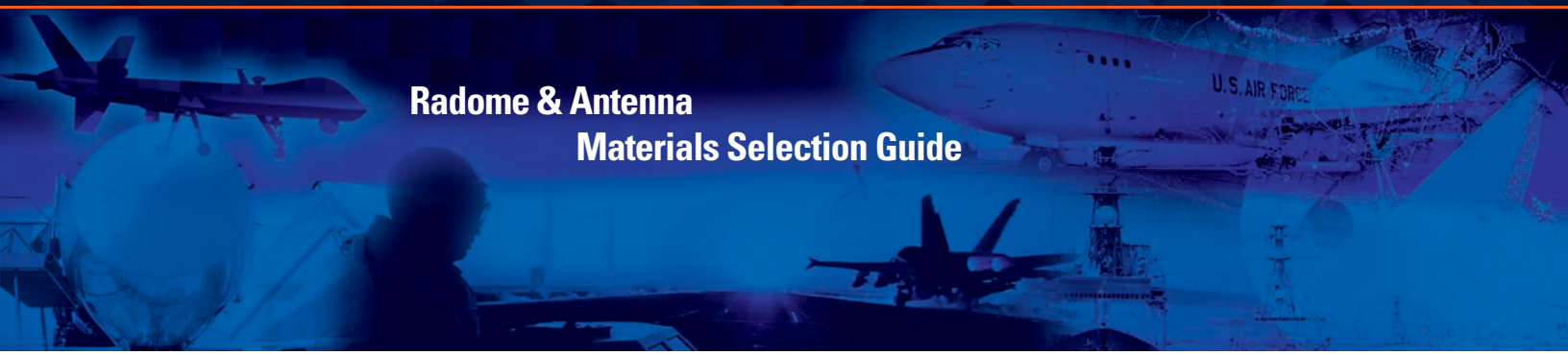
TENCATE ADVANCED COMPOSITES USA, INC.



Radome & Antenna Materials Selection Guide

Radomes & Antennas

Electronically Transparent Materials - Low Dielectric Composites

The Company

TenCate Advanced Composites is a leading supplier of advanced composites and resin systems for the radome industry. TenCate's high quality and cost-effective materials are specified for a variety of high performance aerospace, commercial, communications, and electronics applications. This success is attributed to leading edge technology, quality products and a customer driven culture that encourages responsiveness, cooperation and teamwork.

The Technology

Today's manufacturers of advanced radar and satellite communication systems look to TenCate for the latest low dielectric prepregs. TenCate's cyanate ester and epoxy-based prepregs, liquid resin systems, adhesives and syntactic foams, feature low dielectric constant, low loss tangent and low moisture absorption properties. This capability coupled with TenCate's segregated manufacturing facilities allows total isolation of conductive graphite from nonconductive (dielectric) materials, thus assuring superior quality and electrically pure products.

The Applications

Our materials are uniquely suited for manufacturing a variety of ground, shipboard, airborne and space-based products such as antennas, reflectors, radomes, sonar domes, microwave transparent and radar absorbing structures. Popular reinforcements such as fiberglass, quartz, aramid and high density polyethelene are fully compatible with TenCate's advanced resin systems and can be supplied as prepregs to satisfy the most demanding electrical and mechanical applications.

	Cyanate Ester Quartz Fabric	Low Dielectric Epoxy/ Quartz Fabric	Low Dielectric Epoxy/ Glass Fabric
Electrical Performance	**LOWEST** Dielectric Constant 3.00 to 3.20 Loss Tangent 0.001 to 0.006	**VERY LOW** Dielectric Constant 3.24 to 3.40 Loss Tangent 0.006 to 0.010	**LOW** Dielectric Constant 4.00 to 4.40 Loss Tangent 0.010 and above
Laminate Impact Strength	**VERY GOOD**	**VERY GOOD**	**MODERATE**
Temperature Performance	**HIGH** Tg 275˚- 450˚+F (135˚-204˚C)	**MODERATE - HIGH** Tg 250˚- 400˚F (121˚-204˚C)	**MODERATE - HIGH** Tg 250˚- 400˚F (121˚-204˚C)
Laminate Moisture Absorption	**LOWEST** 0.1 - 0.6%	**VERY LOW** 0.6 - 0.8%	**MODERATE** 1.2 - 1.6%

Radome & Antenna Applications & Materials Selection Guide

PREPREG RESIN SYSTEM*		Neat Resin		Quartz Laminate							
		Dielectric Constant	Loss Tangent	Dielectric Constant	Loss Tangent						
Product Name	Resin Type	Measured at 10 GHz				Cure Temp. °F/°C	Cure Time Min	Tg °F/°C	Tg after post cure °F/°C	Out of Autoclave Processible	Neat Resin Moisture Absorption
		Dk	Df	Dk	Df						
BTCy-2	Cyanate Ester	2.7	0.001	3.00	0.001	350°F/177°C	90 min	375°F/191°C	375°F/191°C	YES	0.6%
BTCy-1A	Cyanate Ester	2.7	0.003	3.10	0.005	350°F/177°C	120 min	365°F/185°C	405°F/207°C	YES	1.0%
RS-3	Cyanate Ester	2.7	0.004	3.19	0.005	350°F/177°C	120 min	390°F/199°C	490°F/254°C	YES	N/A
EX-1505	Cyanate Ester	2.7	0.008	N/A	N/A	350°F/177°C	120 min	358°F/182°C	600°F/316°C	YES	1.4%
BTCy-1	Cyanate Ester	2.7	0.003	3.20	0.004	350°F/177°C	90 min	374°F/190°C	461°F/238°C	YES	1.0%
EX-1515	Cyanate Ester	2.8	0.004	3.20	0.004	250°F/121°C	180 min	274°F/134°C	360°F/182°C	YES	0.5%
TC410	Cyanate Ester	N/A	N/A	3.26	0.006	250°F/121°C	180 min	234°F/112°C	349°F/176°C	YES	< 0.4%
EX-1522	Epoxy	2.8	0.008	3.40	0.006	350°F/177°C	120 min	396°F/202°C	396°F/202°C	YES	1.2%
BT250E-1	Epoxy	3.0	0.009	N/A	N/A	250°F/121°C	60 min	257°F/125°C	N/A	YES	2.1%
RS-8HT	BMI	N/A	N/A	3.49	0.014	400°F/177°C 482°F/250°C	120 min 480 min	N/A	590°F/310°C	NO	1.6%
PEEK[1]	Thermoplastic	3.3	0.004	N/A	N/A	N/A	N/A	290°F/143°C	379°F/193°C	**(2)**	N/A

(1) At 1MHz **(2)** Thermoformable

*See **www.tencate.com** for individual data sheets for properties and process information.

PREPREG REINFORCEMENTS			Sp. Gravity (g/cc)	Moisture Pickup (% by Wt.)	Service Temp.	Applications			
Reinforcement	Dk (10 GHz)	Df (10 GHz)				Aircraft	Ground Systems	Spacecraft	Missiles
"E" Fiberglass	6.10	0.004	2.55	nil	700°F	•	•		
"S" Fiberglass	5.21	0.006	2.49	nil	750°F	•	•		
Quartz	3.78	0.0002	2.20	nil	>1000°F	•	•	•	•
HDPE	2.00	0.0004	0.97	nil	220°F	•	•		
LMR Kevlar® 49[1]	3.85	0.008	1.47	1.9%	350°F	•	•	•	

(1) LMR Kevlar® 49 is a special TenCate proprietory product which treats the Kevlar **f**ber such that moisture absorption is greatly reduced. LMR is our Low Moisture Regain designation for this material.

Dielectric Constant is used to determine the ability of an insulator to store electrical energy. Ideal radome materials are insulators, and have low dielectric constants. Low dielectric materials are desirable for communications and electronic circuits that rely on sharp crisp transmission of low-intensity signals.

Loss Tangent is the ratio of the power loss in a dielectric material to the total power transmitted through the dielectric. Most plastics have a low dissipation factor, a desirable property because it minimizes the waste of electrical energy as heat. Communications and electronics rely on low intensity signals so any signal loss can be critical. Therefore, materials with the lowest dissipation factors are desirable.

TenCate's electronically transparent materials are used extensively in commercial and military applications including radar systems and satellite communications.

Photos Courtesy of Boeing & U.S. Military

Carbon-Free Manufacturing for Low-Dielectric Materials

- **Separate environmentally controlled carbon-free area with positive ventilation for glass, quartz and electronic products.**
- **Full computer controlled process parameters.**
- **Precision filming and precision prepregging capability.**

ADHESIVES & SYNTACTIC		Neat Resin		Quartz Laminate				
Product Name	**Resin Type**	**Dielectric Constant**	**Loss Tangent**	**Dielectric Constant**	**Loss Tangent**	**Cure Temp. °F/°C**	**Cure Time Min**	**Tg °F/°C**
RTM Resins		Dk	Df	Dk	Df			
EX-1545	Cyanate Ester	2.8	0.008	3.4	0.006	350°F/177°C	90 min	345°F/173°C
EX-1510	Cyanate Ester	2.9	0.005	3.4	0.004	350°F/177°C	120 min	380°F/193°C
Paste Adhesives								
EX-1537	Cyanate Ester	2.7	0.003	N/A	N/A	350°F/177°C	120 min	405°F/207°C
EX-1537-1	Cyanate Ester	2.7	0.003	N/A	N/A	350°F/177°C	120 min	405°F/207°C
EX-1502-1	Cyanate Ester	2.8	0.004	N/A	N/A	250°F/121°C	300 min	260°F/127°C
Film Adhesives								
EX-1516	Cyanate Ester	2.8	0.008	N/A	N/A	250°F/121°C	300 min	250°F/121°C
EX-1543	Cyanate Ester	2.8	0.008	N/A	N/A	350°F/177°C	60-90 min	405°F/207°C
RS-4A	Cyanate Ester	N/A	N/A	N/A	N/A	350°F/177°C	120 min	397°F/203°C
BF522	Epoxy	2.8	0.008	N/A	N/A	350°F/177°C	120 min	365°F/185°C
BF548	Epoxy	3.0	0.017	N/A	N/A	235°F/113°C	30 min	262°F/128°C
BT250E-1	Epoxy	3.1	0.018	N/A	N/A	250°F/121°C	60 min	257°F/125°C
Syntactic Film or Paste								
EX-1541 (11 pcf)	Cyanate Ester	1.24	0.003	N/A	N/A	350°F/177°C	90-120 min	350°F/177°C
EX-1541 (13 pcf)	Cyanate Ester	1.24	0.003	N/A	N/A	350°F/177°C	90-120 min	350°F/177°C
EX-1541 (17.5 pcf)	Cyanate Ester	1.27	0.004	N/A	N/A	350°F/177°C	90-120 min	350°F/177°C
SF-4 (39 pcf)	BMI Film	N/A	N/A	N/A	N/A	482°F/250°C	480 min	563°F/295°C
SF-5 (38 pcf)	Cyanate Ester Film	1.7	0.004	N/A	N/A	350°F/177°C	120 min	349°F/176°C

TENCATE
materials that make a difference

TENCATE

materials that make a difference

Morgan Hill CA, USA.

Benicia CA, USA.

Nijverdal, Netherlands.

Photos courtesy of Airbus, Boeing, General Atomics, U.S. Military and NASA. Printed in USA.

TENCATE ADVANCED COMPOSITES

TENCATE ADVANCED COMPOSITES USA, INC.

18410 Butterfield Blvd.
Morgan Hill, CA 95037 USA
Tel: +1 408 776 0700

TENCATE ADVANCED COMPOSITES, NL

Campbellweg 30
7443 PV Nijverdal NL
Tel: +31 548 633 700

TENCATE ADVANCED COMPOSITES (YLA)

2970 Bay Vista Court, Suite C
Benicia, CA 94510 USA
Tel: +1 707 747 2750

TENCATE ADVANCED COMPOSITES (Phoenixx TPC)

250 Cape Hwy, Rte 44
Taunton, MA 02718 USA
Tel: +1 508 977 9501

CCS COMPOSITES, LLC
www.ccscomposites.com

3070 Bay Vista Court, Suite A
Benicia, CA 94510 USA
Tel: +1 707 747 4945

www.tencate.com

E-mail: tcac-us@tencate.com (USA)

E-mail: info_tcac@tencate.com (Europe)

ISO 9001
AS 9100
Registered