TECHNICAL DATASHEET

CYCOM® 5216 Modified Epoxy Resin

Description:

CYCOM® 5216 is a 200° to 250°F (93° to 121°C) curing, modified epoxy resin. Service temperature range is -67° to 180°F (-55° to 82°C). This prepreg is manufactured by the hot melt process and is virtually solvent-free.

All three fiber materials — carbon, aramid and glass — are available in unidirectional, woven and, on special order, roving forms. Typical applications include rotor blade spars and skins.

Carbon fiber is a good candidate for aircraft secondary structure, commercial aircraft, and aerospace products. Aramid currently has application in helicopter structure, rotor blades, and high impact resistant laminates. Glass fiber is used in military and commercial helicopter blades and structures and is exensively used for engine nacelles.

For more information, contact:
Cytec Engineered Materials
Technical Service
Anaheim, Calif.
714 630-9400
composites@an.cytec.com

Features and benefits:

- **Available in carbon fiber, aramid fiber, and glass fiber prepreg**
- **Excellent fatigue resistance**
- **High flow with long shop life**
- **Autoclave and press cure**
- **Maximum continuous service temperature up to 180°F (82°C)**
- **Low pressure moldable**
- **Good tack and drape characteristics**
- **Excellent translation of fiber strength**
- **Tape laying machine capability**

Cytec ENGINEERED MATERIALS
CREATING A MATERIAL ADVANTAGE

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General information

Carbon

Standard Modulus = 30 to 35 Msi (206 to 241 GPa); Intermediate modulus = 36 to 48 Msi (248 to 331 GPa).

High modulus = ³ 49 Msi (337 GPa).

Specifications

Aramid: Bell Helicopter specification BHT 299-947-158 and Hughes specification HMS 16-1112.

Glass: Meets specifications for Boeing, BMS 8-164, BMS 8-196, D393-1 0069, Bell Helicopter, BHT 299-947-134, and Hughes, HMS 16-1113.

Shelf life

Shelf life in excess of 6 months at 0°F (-18°C), 3 months at 40°F (4°C) in sealed containers. To prevent moisture pickup, a sealed package should not be opened until the prepreg reaches ambient temperature. Shop life is better than 30 days at room temperature.

Prepreg form

The prepreg is supplied as (1) unidirectional up to 48 inches (121.9 cm) wide or slit to your requirement on 10 inch (25.4 cm) diameter cardboard core; (2) woven fabric up to 60 inches (152.4 cm) wide or slit to your requirements, normally supplied on 3 inch (7.6 cm) diameter cardboard core; (3) Roving to your specification on 3 inch (7.6 cm) diameter cardboard core.

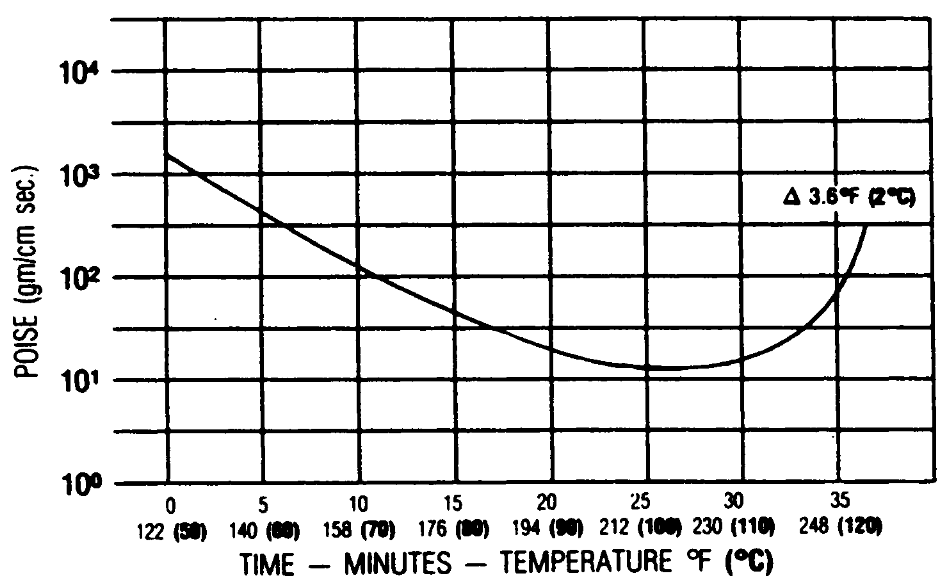
All materials are shipped in sealed poly bags.

Physical properties

Prepreg	Resin content* % weight	Volatiles % wt. max	Flow % weight	Gel time minutes
Aramid Woven	55	0.5	25 to 30	4
Glass Unidirectional				
E-Glass	34	0.2	16	4
S-Glass	34	0.3	16	4
Test procedure**	QC-PT-37	QC-PT-16	QC-PT-17	QC-PT-3
Test temperature °F (°C)		250 (121)	250 (121)	275 (135)
Test time minutes		15	Gel + 5 minutes	
Test pressure Psi (KPa)			50 (345)	

*Resin content may be modified to your requirements.
**CEM test procedure available on request.

Neat resin data - typical viscosity profile - test procedure QA-AP-1*



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		Test per*
Cured density, lb./in.3 (gm/cc)	0.044 (1.235)	QC-PT-55
Gel time at 275°F (135°C) minute	4-6 nominal	QC-PT-3

*CEM test procedure available on request.

Mechanical properties • standard cure • aramid fiber • woven

Property **Ksi - (MPa), Msi - (GPa)**	**Test temperature** **°F (°C)**	**Kevlar** **style 285**
Tensile (ASTM D638 MOD.)	RT	76 (524)
Strength, Ksi	RT	4.3 (30)
Strain µ in./in. (%)	RT	13500 (1.4)
Compression (ASTM D695)		
Strength, Ksi	RT	37 (255)
Modulus, Msi	RT	3.8 (26)
Short beam shear (ASTM D2344)		
Strength, Ksi	RT	5.6 (39)

All testing in the warp direction.

TECHNICAL DATASHEET

Mechanical properties • standard cure • glass fiber • unidirectional

Property **Ksi - (MPa)** **Msi = (GPa)**	**Test temp** **°F (°C)**	**S-Glass (1)**	**E-Glass (2)**
Tensile (ASTM D638) 0° Strength, Ksi	 -65 (-54) RT 180 (82)	 284 (1958) 240 (1655) 206 (1420)	 170 (1172) 143 (986) 123 (848)
Modulus, Msi	-65 (-54) RT 180 (82)	6.4 (44) 6.3 (43) 6.4 (44)	5.9 (41) 5.7 (39) 5.6 (39)
0°/90° Strength, Ksi	-65 (-54) RT 180 (82)	137 (944) 137 (944) 94 (648)	89 (614) 64 (441) 66 (455)
Modulus, Msi	-65 (-54) RT 180 (82)	4.1 (28) 4.1 (28) 3.8 (26)	3.9 (27) 3.7 (26) 3.9 (27)
± 45° Strength, Ksi	-65 (-54) RT 180 (82)	25 (172) 26 (179) 21 (145)	28 (193) 26 (179) 23 (159)
Modulus, Msi	-65 (-54) RT 180 (82)	2.2 (15) 1.9 (13) 1.6 (11)	2.1 (14) 1.7 (12) 1.7 (12)
Flexure (ASTM D790) 0° Strength, Ksi	 -65 (-54) RT 180 (82)	 250 (1724) 180 (1241) 136 (938)	 192 (1324) 175 (1206) 160 (1103)
Modulus, Msi	-65 (-54) RT 180 (82)	7.0 (48) 6.5 (45) 6.4 (44)	5.4 (37) 5.9 (41) 5.8 (40)
Short beam shear **(ASTM D2344)** 0° Strength, Ksi	 -65 (-54) RT 180 (82)	 14.9 (103) 11.2 (77) 8.0 (55)	 17.3 (119) 12.4 (85) 8.6 (59)

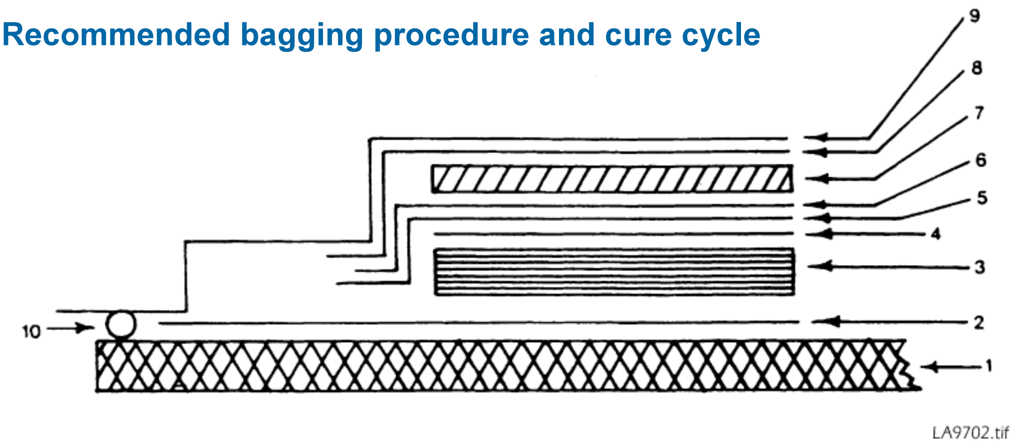
(1) F.V. is 52.7%
(2) F.V. is 60.4%

Mechanical properties • standard cure • glass fiber • unidirectional • environmental conditioning

Property Ksi = (MPa) Msi = (GPa)	Test temp °F (°C)	Dry [1]	Oil soak [2]	Water boil [3]	Temp Exposure [4]
S-Glass					
Flexure (ASTM D790) 0°Strength, Ksi	-65 RT 180 (82)	250 (1724) 180 (1241) 136 (938)	261 (1800) 180 (1241) 144 (993)	235 (1620) 165 (1138) 152 (1048)	221 (1524) 199 (1372) 175 (1206)
Modulus, Msi	-65 RT 180 (82)	7.0 (48) 6.5 (45) 6.4 (44)	6.3 (43) 7.1 (49) 6.3 (43)	6.4 (44) 6.1 (42) 6.9 (48)	7.7 (53) 7.4 (51) 7.8 (54)
Short beam shear (ASTM D2344) 0°Strength, Ksi	-65 RT 180 (82)	14.9 (103) 11.2 (77) 8.0 (55)	13.7 (94) 11.1 (76) 7.5 (52)	15.7 (108) 10.4 (72) 7.6 (52)	15.6 (107) 12.4 (85) 10.7 (74)
E-Glass					
Flexure (ASTM D790) 0°Strength, Ksi	-65 RT 180 (82)	192 (1324) 175 (1206) 160 (1103)	209 (1441) 162 (1117) 149 (1027)	199 (1372) 148 (1020) 145 (1000)	222 (1531) 198 (1365) 174 (1200)
Modulus, Msi	-65 RT 180 (82)	5.4 (37) 5.9 (41) 5.8 (40)	5.7 (39) 5.6 (39) 5.3 (36)	6.0 (41) 5.5 (38) 5.8 (40)	7.2 (50) 7.3 (50) 6.5 (45)
Short beam shear (ASTM D2344) 0°Strength, Ksi	-65 RT 180 (82)	17.3 (119) 12.4 (85) 8.6 (59)	17.7 (122) 13.0 (90) 9.0 (62)	17.1 (118) 11.6 (80) 8.2 (56)	20.0 (128) 14.4 (99) 12.9 (89)

[1] Not conditioned
[2] Oil soak = seven days at 160°F (66°C) in MIL-H-83282
[3] Water boil = boiled two hours in distilled water
[4] Temperature exposure = 1000 hours at 180°F (82°C)

Recommended bagging procedure and cure cycle



1. Aluminum caul plate with smooth upper surface.
2. Solid FEP Teflon film, 2 mils thick, covering caul except for bag seal area.
3. Laminate.
4. TX-1040 or equivalent (permeable Teflon coated glass fabric) over laminate, snugly fitting to edges, extend approximately 6 inches (15.2 cm) beyond edges and in contact with breather material.
5. Bleeder Material. Recommended bleeder ratio: 1 ply Style 120 glass fabric per 6 plies unidirectional. For thick laminates, 1 ply of Style 3733 or 1581 glass fabric may be substituted for 2 plies of 120 glass. 120 glass should always be used on the surface of the laminate to prevent mark-off from heavier bleeder fabrics.
6. Solid FEP Teflon film, extending approximately 1 to 2 inches (2.54 to 5 cm) beyond edge of laminate.
7. Aluminum pressure plate (flat) the size of laminate, 0.063 inches (1.600 mm) thick minimum. Use of pressure plate is optional, but is recommended for small laminates. A dam also may be used to prevent crowning in small laminates.
8. Two plies glass breather covering entire layup and aluminum caul, out to bag sealant, connected to vacuum source.
9. Vacuum bag.
10. Vacuum bag sealant.

Recommended standard autoclave cure cycle for CYCOM® 5216 composites, up to 0.5 inches (12.7 mm) in thickness is as follows:

Initial pressure	22 to 24 inches Hg **vacuum minimum** (74 to 81 KPa)
Initial heat rise	RT to 175 ± 5°F (79 ± 3°C) at 4° to 6°F (2° to 3°C)/minute
Dwell	25 to 30 minutes beginning at 170°F (77°C) part temperature
Pressurize	Apply 85 to 100 Psi (586 to 689 KPa) clave pressure vent at 25 Psi (122 KPa)
Final heat rise	175° ± 5° F (79° ± 3° C) to 260° ± 10° F (127° ± 6° C) at 4° to 6° F (2° to 3° C)/minute
Hold	95 ± 5 minutes at 260° ± 10°F (127° ± 6°C)
Cool down	Cool to 140°F (60°C) or below under pressure (do not open vacuum bag until below 140°C)

For recommendations on other cure cycles, contact the Technical Service Department.

Test specimen fabrication

Unidirectional s-glass composites fabricated from CYCOM® 5216 materials are currently generating tensile strengths up to 280 Ksi (1930 MPa), and modulus values in the 6 to 6.5 Msi (41 to 45 GPa) range, depending on the fiber chosen.

Precautions

As might be expected, a much greater level of care must be exercised in several areas of specimen fabrication and mechanical testing in order to achieve the available properties of the test material. Due to the high stresses associated with tests involving this material, we have identified some of the more critical areas requiring additional precision to obtain ultimate properties.

1. Very precise 0° fiber alignment in layup.
2. Extremely accurate alignment in cutting test specimens relative to 0° fiber orientation.
3. Careful matching of tab material thickness on opposite sides of test specimens (especially compression). Avoid taper in tab bondline thickness.
4. Carefully avoid any minute imperfections (stress concentration points), especially in the edges of the tensile specimens. Cytec recommends wet grinding all tension and compression specimens to final width and length dimensions.
5. Parallelism of bonded tab ends (in both planes) is critical in specimens, and the ground ends should be perpendicular within 0.001 inch (0.025 mm) across both width and thickness dimensions of the specimen.
6. Tab bonding adhesives — it is necessary to use very high shear strength adhesives for tab bonding. Suitable recommnended adhesives are shown below.

Test condition	Adhesive
-67°F (-55°C)	Metlbond 1113 or equivalent
RT	Metlbond 1113 or equivalent
200°F (93°C)	Metlbond 1515 or equivalent
Wet 200°F	Metlbond 1515 or equivalent
270°F (132°C)	Metlbond 329-7 or equivalent
Wet 270°F	Metlbond 329-7 or equivalent
325°F (163°C)	Metlbond 329-7 or equivalent
350°F (177°C)	Metlbond 329-7 or equivalent

Precautions, con't.

7. Tab materials - for tensile tab materials, users have found it convenient to purchase an electrical grade epoxy glass laminate. This material is designated MIL-P-18177, GEE/G10, 0.060 inches (1.524 mm) thick. The material may be purchased in 3 inch (7.6 cm) wide x 26 inch (66.0 cm) long strips. However, some recent work strongly indicates that a ± 45° fiber orientation to the tab loading axis is quite beneficial in more uniformly loading the tab bond area, thereby precluding premature tab bond failure. Cytec grinds the taper on tensile tab material to 15 ± 2°, leaving 0.005 to 0.010 inches (0.127 to 0.254 mm) edge thickness, rather than a "feather" edge. NOTE: For elevated temperature testing at 270°F (132°C) and above, a higher temperature tab material is required, such as Cytec's 506.

   Testing tensile specimens - a very important requirement is that the test machine grips be of sufficient length to grip the entire tab length up to or beyond the beginning of the taper. This is to avoid a "pinch-off" effect which almost always causes premature failure. The test specimen must be precisely aligned in the grips in the direction of the load.

   Compression tabs - Cytec recommends the use of CYCOM® 5216 material, all 0° orientation in the longitudinal direction of the specimen. Use sufficient plies to produce a nominal thickness of 0.070 inches (1.778 mm).

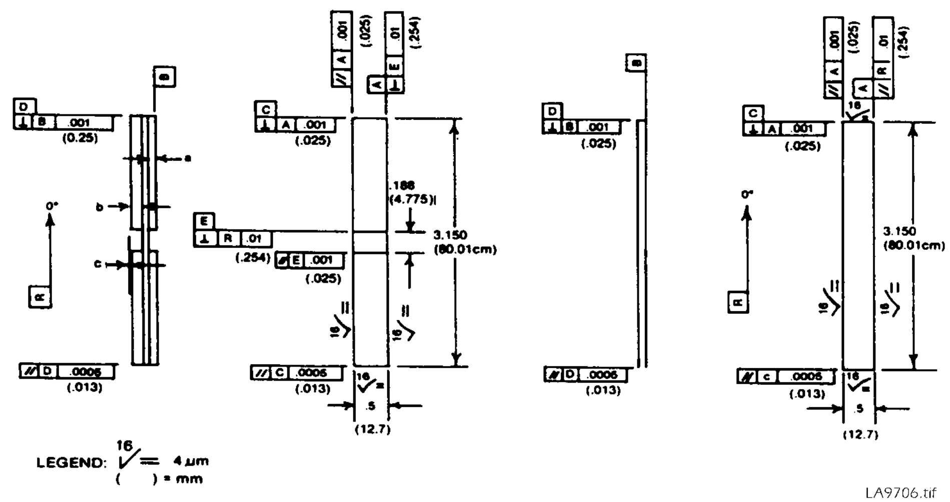
   Tab bondng - all tab bonding should be done at relatively low pressure, i.e., 10 to 15 Psi (69 to 103 KPa), in order to maintain suitable glue in line thickness. In compression specimens, it is important to keep the 0.188 inch (4.775 mm) unsupported section as free as possible from adhesive flash. A properly sized strip of cured composite or aluminum, covered with Teflon film, can be used effectively for this purpose. It is also desirable to fabricate a simple bonding fixture to accurately position the tabs on the test laminate, drill positioning holes outside of the bond area, and use sub-surface pins to prevent tab slippage during bonding. Although this is not mandatory, it will greatly assist in maintaining accurate tab spacing and alignment.

Tensile test specimen • ASTM D3039 • tensile unidirectional

Notes:

1. Use sufficient plies of CYCOM® 5216 unidirectional S-Glass to produce a cured laminate thickness of 0.035 inches (0.889 mm) nominal.
2. Prepare the specimen prior to bonding the tabs by uniformly hand-sanding the bonding area of the test laminate and the tabs with 240-280 grit sandpaper. Clean thoroughly with MEK or Acetone.

Compression test specimen • ASTM D695 modified
Compression strength and compression modulus



Notes:

1. Use sufficient plies of CYCOM® 5216 unidirectional S-Glass for compression and modulus laminates to produce a cured laminate thickness of 0.035 inches (0.889 mm) nominal.
2. Prepare the specimen prior to bonding the tabs by uniformly hand-sanding the bond area of the test laminate and the tab material with 240-280 grit sandpaper and cleaning thoroughly with MEK or Acetone.
3. “a” must be equal to “b” within 0.010 inches (0.254 mm) and “c” must be less than 0.0025 inches (0.064 mm). Rework of the faces of the tabbed specimen may be necessary.

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Health and safety information

Refer to Material Safety Data Sheet numbers 8790 and 8789.

Important notice

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contact us

Cytec Engineered Materials Inc. North American Facilities

Anaheim, California
714 630-9400 • Fax 714 666-4345

Havre de Grace, Maryland
410 939-1910 • Fax 410 939-8100

Greenville, Texas
903 457-8500 • Fax 903 457-8598

Winona, Minnesota
507 454-3611 • Fax 507 452-8195

Orange, California
714 639-2050 • Fax 714 639-2033

D Aircraft Products, Inc.
Anaheim, California
714 632-8444 • Fax 714 632-7164

Cytec Carbon Fibers LLC
Piedmont, South Carolina
800 222-2448 • Fax 864 299-9333

GLOBAL HEADQUARTERS
Tempe, Arizona
480 730-2000 • Fax 480 730-2390

**Cytec Engineered Materials, Ltd.
United Kingdom**

Wrexham, UK
+44 1978 665200
Fax +44 1978 665222

**Cytec Engineered Materials (GmbH)
Germany**

Ostringen, Germany
+49 7523 912800
Fax +49 7523 912899

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