LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY

LIGO Laboratory / LIGO Scientific Collaboration

LIGO-T040032-00-D *Advanced LIGO* 2 March 2004

Polyimide Hydrocarbon Outgas Rate and Temperature Limits for the Isolation System Actuator

Dennis Coyne

Distribution of this document:
LIGO Science Collaboration

This is an internal working note
of the LIGO Project.

California Institute of Technology
LIGO Project – MS 18-34
1200 E. California Blvd.
Pasadena, CA 91125
Phone (626) 395-2129
Fax (626) 304-9834
E-mail: info@ligo.caltech.edu

Massachusetts Institute of Technology
LIGO Project – NW17-161
175 Albany St
Cambridge, MA 02139
Phone (617) 253-4824
Fax (617) 253-7014
E-mail: info@ligo.mit.edu

LIGO Hanford Observatory
P.O. Box 1970
Mail Stop S9-02
Richland WA 99352
Phone 509-372-8106
Fax 509-372-8137

LIGO Livingston Observatory
P.O. Box 940
Livingston, LA 70754
Phone 225-686-3100
Fax 225-686-7189

http://www.ligo.caltech.edu/

1 Introduction

The hydrocarbon outgas rate for polyimide materials is derived from existing mass spectrum test data. The outgas rate is then used to set a maximum temperature limit on the voice coil actuator for the advanced LIGO Seismic Isolation System (SEI).

2 Polyimide Outgas Rate

In order to set a maximum in-vacuum operating temperature for the voice coil, we would ideally have measurements of the outgas spectrum and rate, including temperature dependence, for the intended SEI voice coil actuator (or at least it's materials). The voice coil actuators used to date (BEI/Kimco LA50-62-004Z and LA18-32-006Z) have not been developed for UHV use. It is likely that the epoxies, wire insulation and potting compound outgas at too high of a rate (though this has not been confirmed by measurement). A version of the smaller actuator (LA18-32-006Z) with kapton insulated wire potted with Cycom 3001 (a high temperature polyimide adhesive[1]) has been produced. The mass spectrum of this unit, after cleaning and vacuum baking at 200C for 48 hours has been measured. The hydrocarbon (HC) outgassing rate derived from this residual gas assay (RGA) is suspect due to lack of repeatability of measurements on this chamber. The HC rate (sum of AMUs 41, 43, 53, 55 and 57) is 3.8E-10 torr-liter/sec (very likely limited by the background outgassing rate of the chamber). In addition to being suspect, this measurement was only made a room temperature. In order to establish a maximum in-vacuum operating temperature, we must know the doubling temperature (or some other measure of the outgas rate dependence with temperature). A repeat vacuum bake and mass spectrum measurement of the voice coil is planned in March, 2004 in the LHO vacuum bake oven with measurements at ~70C, ~45C and room temperature (~20 C).

In the interim we might use the outgas rate from other measurements of Polyimide materials to set approximate limits on the temperature of the voice coil. The mass spectrum of a number of polyimide materials have been measured. In particular, the Virgo measurements include the mass spectrum at multiple elevated temperatures (a practice that LIGO should adopt). Unfortunately it seems the Virgo group has not performed mass spectrum measurements of Cycom 3001 (confirmation has been requested). Five polyimide measurements were examined:

1) Coils with Polyamide-Polyimide Insulation and Polyimide Resin "varnish". The "varnish" is BASG 48816 polyimide/carbon pigment resin from Ball Aerospace.[2]

2) Coils with Polyamide-Polyimide Insulation (without the varnish)[3]

3) Cabling with Pyre-ML Insulation. Pyre-ML is a Dupont aromatic polyimide.[4]

4) Kapton ribbon cables (Kapton is a Dupont trademark polyimide). Virgo cables were provide by Axon.[5]

---

[1] A datasheet for Cycom 3002 (similar to Cycom 3001) has been included in the appendix of this memo.

[2] Virgo document VIR-TRE-PIS-3400-114, "Outgassing Test of Coils with Polyamide-polyimide Insulation and Varnishing".

[3] Virgo document VIR-TRE-PIS-3400-113, "Outgassing Test of Coils with Polyamide-polyimide Insulation".

[4] Virgo document VIR-TRE-PIS-3400-115, "Outgassing Test of Cabling with Pyre-ML Insulation".

5) Kapton Ribbon cables with PEEK weave and PEEK connectors from MDC Vacuum Products Inc.[6]

The Virgo report gives the total outgassing rate and the mass spectrum (in uncalibrated units) at multiple temperatures. The sequence was to dwell at each temperature and then take a mass spectrum measurement before increasing the temperature. The dwell time at temperature was not always long enough to reach a steady-state outgassing rate. The temperatures were typically 33 C, 50 C, 100 C, 150 C and then back to 40 C to 33 C. The mass spectrum plots were digitized and integrated to get a scale factor to calibrate the mass spectrum. This scale factor was then used with the HC flag AMU sum to get the HC outgassing rate.

The outgassing rate, k, is assumed to follow an Arrhenius rate equation:

$$k = Ae^{\left(-E/T\right)}$$

where in general the pre-expenential factor, A, and the activation energy, E, are temperature dependent; Here these coefficients are assumed to be temperature independent. The temperature change required to double the outgassing rate is:

$$\Delta T = \frac{-T^2 \ln(2)}{E}$$

Of course a single rate equation may not apply. In addition measurements at significantly higher temperatures than the operating temperature range may bring different kinetics into play. However the required hydrocarbon outgas rate is too low to measure at room temperature.

2.1 Polyimide Resin

For the Polyimide Resin, the outgassing rate (torr-liter/sec/cm^2) versus temperature is given in Figure 1. The same data is plotted versus 1/T in Figure 2. The outgassing rate at the two low temperatures (33 C pre-bake and 40 C post-bake) is limited by the mass spectrometer noise floor (or at least by the plot scale in the Virgo report). Also shown is a fit to an Arrhenius equation.

---

[5] Virgo document VIR-TRE-PIS-3400-137, "Outgassing Test of an Axon Kapton Ribbon".

[6] Vacuum Bake Traveler for Kapton Ribbon Cable, LIGO-E980274-00. This vacuum bake load appears to have the lowest outgassing rate measured at Caltech for initial LIGO kapton cables. Vacuum bake load travelers from LHO should be checked as well.

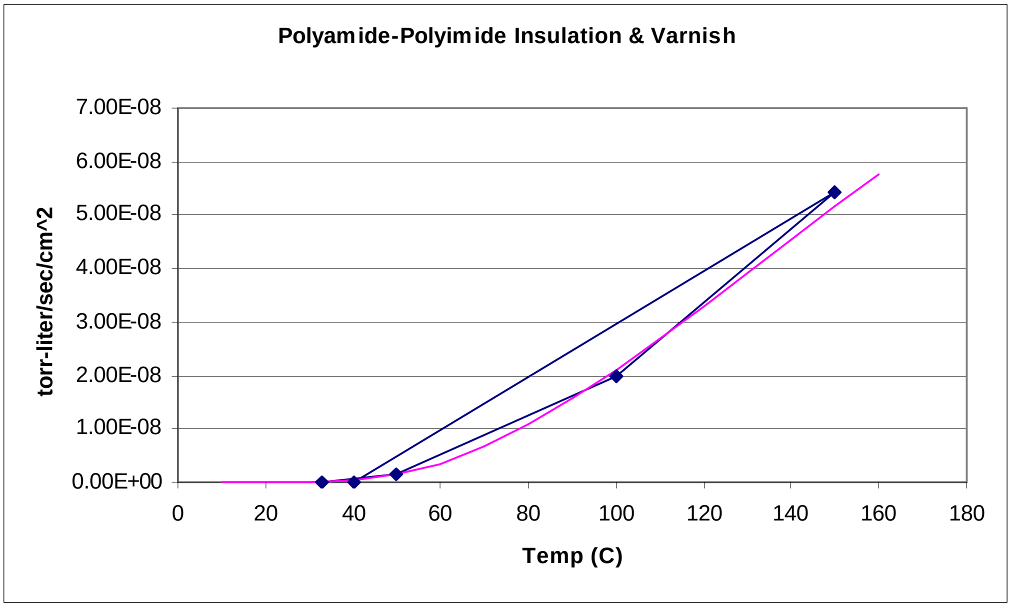


Figure 1: Polyimide Resin Outgas Rate vs Temperature

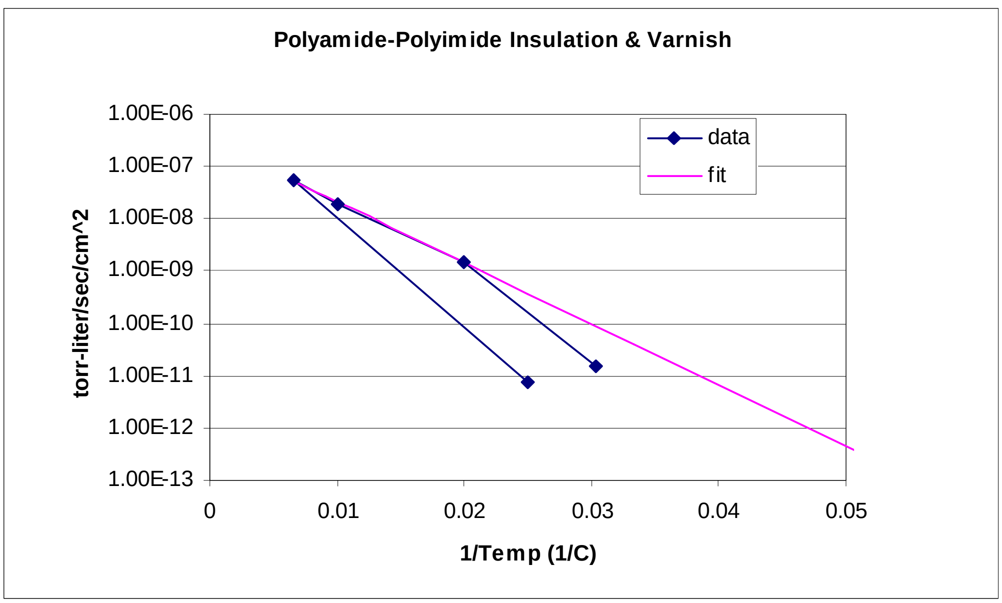


Figure 2: Polyimide Resin Outgas Rate vs Temperature

A least squares fit to the outgas rate at the three temperatures high enough to measure the outgas rate not limited by the noise floor of the spectrometer (or the lower limit of the plot in the Virgo report), yields:

A = 3.09e-7 torr-liter/sec/cm^2

E = 268 C

ΔT = 1.03 C

2.2 Polyimide Insulation

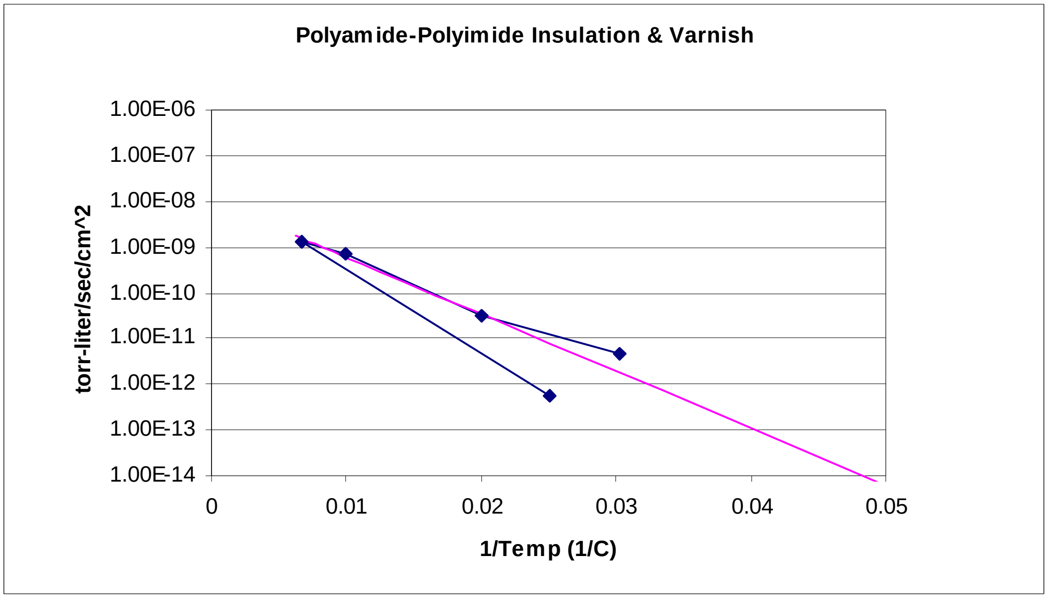


Figure 3: Polyimide Insulation Outgas Rate vs Temperature

A = 1.03e-8 torr-liter/sec/cm^2

E = 286 C

ΔT = 0.97 C

2.3 Pyre-ML Insulation

The Pyre-ML data is limited by the noise floor (limit of the plot in the Virgo report).

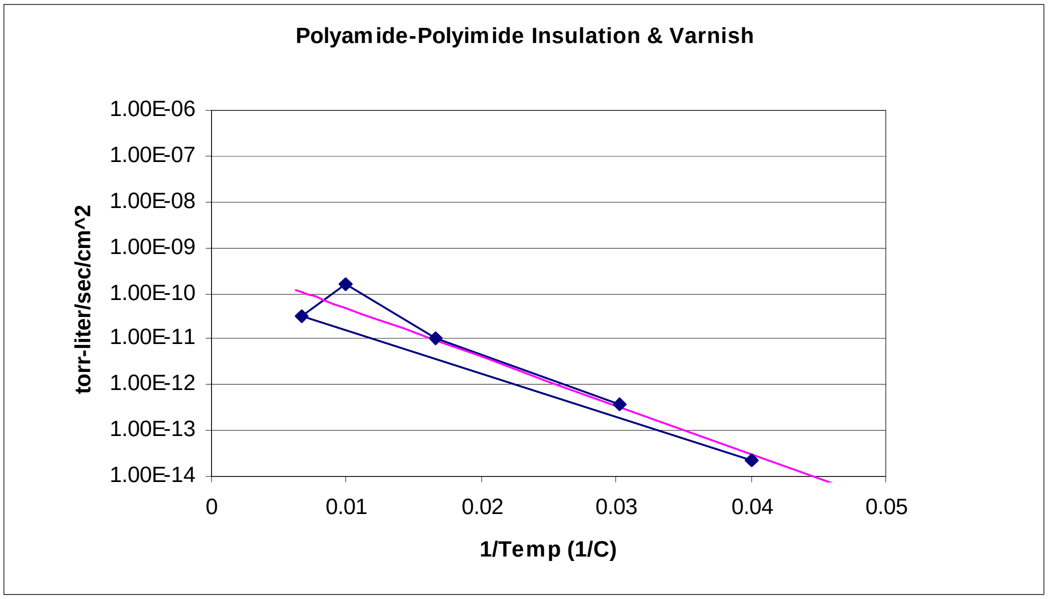


Figure 4: Pyre-ML Insulation Outgas Rate vs Temperature

A = 5.46e-10 torr-liter/sec/cm^2

E = 245 C

ΔT = 1.13 C

2.4 Axon Kapton Cabling

The Virgo report on Kapton cabling from Axon is still to be further analyzed. Using the 80 C and 150 C data (post-bake), one gets the following Arrhenius constants:

A = 1.35e-9 torr-liter/sec/cm^2

E = 753 C

ΔT = 0.37 C

With the admittedly uncertain fit, the room temperature (20 C) HC outgas rate is 6e-26 torr-liter/sec/cm^2. If the activation energy from the previous fits is used (E ~ 280 C), then the room temperature HC outgas rate is 1e-15 torr-liter/sec/cm^2, which is consistent with the measured MDC kapton cable outgas rate.

2.5 MDC Kapton Cabling

The HC outgas rate reported in E980274-00 is 2.80e-15 torr-liter/sec/cm^2 (each cable has 6080 cm^2 of area). This value does not have the oven or RGA background subtracted. Since empty chamber measurements were extremely infrequent in the Caltech vacuum bake ovens used for initial LIGO bake loads, we do not have a background to subtract. In addition, the RGA was not capable of being valved off from the chamber, so an RGA background can not be subtracted either. Looking at clean load scans (metal) in the same chamber around the same time frame as the E980274-00 load, it seems that the oven HC background is about at ½ the measured level, so a reasonable estimate of the kapton outgas rate is 1.4e-15 torr-liter/sec/cm^2.

3 Voice Coil Maximum Temperature

The exposed surface area of the larger voice coil is estimated to be 143 cm^2. With the MDC Kapton outgas level reported above, this means at room temperature (20C), the expected HC outgas rate is 2e-13 torr-liter/sec/coil.

The allowed[7] outgas rate for the SEI voice coil is 3.8e-12 torr-liter/sec/coil. Using an activation energy of 245 (the lowest reported above), the allowable temperature is only 26 C, or 6 C above ambient.

4 Appendix: Cycom 3002 Datasheet

[7] D. Coyne, Vacuum Hydrocarbon Outgassing Requirements", T040001-00.

TECHNICAL DATASHEET

CYCOM® 3002 High Service Temperature Condensation Polyimide

Description:

CYCOM® 3002 advanced composite prepreg is a condensation polyimide primarily used in applications requiring structural performance in the temperature range of 550-650°F (288-343°C). It is 350°F (177°C) curable with a free standing post cure required for elevated temperature service. CYCOM® 3002 advanced composite prepreg is methylene dianaline (MDA) free which allows ease in layup using ordinary impermeable gloves. CYCOM® 3002 advanced composite prepreg is used widely in antennae and radom applications where low dielectric properties are required.

CYCOM® 3002 advanced composite prepreg is used also in aircraft engine components such as hush kits, wiring harnesses, insulating bulkheads, thrust reversers, and inlet ducts. Parts in excess of 0.3 inches (7.62 ram) thick have been produced successfully having minimum void contents.

CYCOM® 3002 advanced composite prepreg is supplied in woven broadgood and neat resin forms only. Reinforcement types are glass, quartz and carbon fiber. Widths of material are 38 inches (965 ram) standard up to 60 inches (1524 ram) maximum. It is important to follow the prescribed bagging and cure cycle as closely as possible to insure proper polymerization when oven/vacuum bag or autoclave processing.

Features and benefits:

- **High strength and dimensional stability at 600°F (316°C)**
- **MDA free: Substantial health risk elimination to manufacturer, end-user, and the environment**
- **350°F (177°C) vacuum bag/oven curable**
- **Free standing post cure**
- **Woven goods up to 60 inches (1524 ram) wide**
- **Excellent tack and drape**
- **Low dielectric**

For more information, contact:
Cytec Engineered Materials
Technical Service
Anaheim, Calif. 92806
714 630-9400

Cytec ENGINEERED MATERIALS
CREATING A MATERIAL ADVANTAGE

This information is provided for informational purposes only and without legal responsibility.
Users are expected to perform adequate verification and testing to ensure that materials meet required specifications.

Typical neat resin properties

Specific gravity	1.36
Tg, TMA rex probe, dry[1]	716°F (380°C)
Gel time @ 350°F (177°C)	6 minutes

[1]Dry = ambient temp

Typical prepreg properties

Fiber	E-Glass	E-Glass	Quartz
Reinforcement style	108	7781	581
Finish	A1100	A1100	9288
Fiber area wt., psf (gsm)	0.01 (49)	0.06 (303)	0.06 (285)
Dry resin content, % by wt., nominal	50	30	30
Flow, %:at 350°F (177ºC) with 15 psi	—	15-25	15-25
Row, %:at 450°F (232°C) with 15 psi	43-53	—	
Gel time, minutes @ 350ºF	3-6	3-6	3-6
Volatile content, % by wt. at 750ºF (399°C) for 2.5 minutes	25-35	15-25	15-25

Miscellaneous properties

Shop life	10 days at 80°F (27°C), 65% relative humidity
Shelf life	Six (6) months from date of shipment at recommended storage conditions
Recommended storage	**Store at or below 0°F (-18ºC)**

This information is provided for informational purposes only and without legal responsibility.
Users are expected to perform adequate verification and testing to ensure that materials meet required specifications.

Mechanical performance

Product description	Glass fabric	Glass fabric	Quartz fabric
Reinforcement style	7781	7781	581
Fiber description	E-Glass	E-Glass	Quartz
Orientation	Warp	Warp	Warp
Cure temperature, °F (°C)[1]	350 (177)	350 (177)	350 (177)
Cure pressure, psi (MPa)	Vacuum 13 (0.09)	Autoclave 45 (0.31)	Vacuum 13 (0.09)
Cure time	2 hours	2 hours	2 hours
Heat-up rate, degrees/min (°F/°C)	1-3 (0.6-1.7)	1-3 (0.6-1.7)	1-3 (0.6-1.7)
Physical properties			
Ply thickness, inches (ram)	0.0080 (0.203)	0.0075 (0.191)	0.0105 (0.267)
Specific gravity, g/cc	1.97	1.97	1.62
Resin content, % by wt, nominal	21.0	20.5	24.8
Mechanical properties			
Flexural strength, ksi (MPa)[3]			
RT	70 (483)	75 (517)	70 (483)
450°F (232°C)	—	65 (448)	—
550°F (288°C)	60 (414)	—	54 (372)
600°F (316°C)	—	54 (372)	—
Flexural modulus, msi (GPa)[3]			
RT	3.8 (26)	3.9 (27)	3.5 (24)
450ºF (232°C)	—	3.5 (24)	—
550°F (288°C)	3.4 (23)	—	3.5 (24)
600ºF (316°C)	—	3.5 (24)	—

[1] See "Recommended bagging/cure/procedures" section.
[2] Where testing options for either warp or fill may apply, warp conditions are assumed unless otherwise indicated.
[3] Per ASTM D790.

This information is provided for informational purposes only and without legal responsibility.
Users are expected to perform adequate verification and testing to ensure that materials meet required specifications.

Cytec ENGINEERED MATERIALS
CREATING A MATERIAL ADVANTAGE

TECHNICAL DATA SHEET

Mechanical performance

Product description	Glass fabric	Glass fabric	Quartz fabric
Reinforcement style	7781	7781	581
Fiber description	E-Glass	E-Glass	Quartz
Orientation	Warp	Warp	Warp
Cure temperature, ºF (ºC)[1]	350 (177)	350 (177)	350 (177)
Cure pressure, psi (MPa)	Vacuum 13 (0.09)	Autoclave 45 (0.31)	Vacuum 13 (0.09)
Cure time[1]	2 hours	2 hours	2 hours
Heat-up rate, degrees/min (ºF/ºC)	1-3 (0.6-1.7)	1-3 (0.6-1.7)	1-3 (0.6-1.7)
Physical properties			
Ply thickness, inches (ram)	0.0080 (0.203)	0.0075 (0.191)	0.0105 (0.267)
Specific gravity, g/cc	1.97	1.97	1.62
Resin content, % by wt., nominal	21.0	20.5	24.8
Mechanical properties[2]			
Tensile strength, ksi (MPa)[3]			
RT	54 (372)	59 (407)	44 (303)
550ºF (288ºC)	53 (366)	57 (393)	—
Tensile modulus, msi (GPa)[3]			
RT	3.7 (26)	3.8 (26)	3.3 (23)
550°F (268°C)		—	
Tensile fill strength, ksi (MPa)[3]			
RT	49 (338)	—	42 (290)
Tensile fill modulus, msi (GPa)[3]			
RT	3.5 (24)	—	3.2 (22)

[1] See “Recommended bagging/cure/postcure procedures” section.
[2] Where testing options for either warp or fill may apply, warp conditions are assumed unless otherwise indicated.
[3] Glass fabric tested per ASTM D638. Quartz fabric tested per ASTM D3039.

This information is provided for informational purposes only and without legal responsibility.
Users are expected to perform adequate verification and testing to ensure that materials meet required specifications.

Cytec ENGINEERED MATERIALS
CREATING A MATERIAL ADVANTAGE

Mechanical performance

Product description	Glass fabric	Glass fabric	Quartz fabric
Reinforcement style	7781	7781	581
Fiber description	E-Glass	E-Glass	Quartz
Orientation	Warp	Warp	Ward
Cure temperature, ºF (ºC)[1]	350 (177)	350 (177)	350 (177)
Cure pressure, psi (MPa)	Vacuum 13 (0.09)	Autoclave 45 (0.31)	Vacuum 13 (0.09)
Cure time[1]	2 hours	2 hours	2 hours
Heat-up rate, degrees/min (ºF/ºC)	1-3 (0.6-1.7)	1-3 (0.6-1.7)	1-3 (0.6-1.7)
Physical properties			
Ply thickness, inches (ram)	0.0080 (0.203)	0.0075 (0.191)	0.0105 (0.267)
Specific gravity, g/cc	1.97	1.97	1.62
Resin content, % by wt., nominal	21.0	20.5	24.8
Mechanical properties[2]			
Compressive strength, ksi (MPa)[3]			
RT	70 (483)	—	58 (400)
450ºF (232ºC)	49 (338)	—	—
550ºF (288ºC)	42 (290)	—	44 (303)
Compressive modulus, msi (GPa)[3]			
RT	—	—	3.5 (24)
550ºF (288ºC)	—	—	3.4 (23)

[1] See "Recommended bagging/cure/postcure procedures" section.
[2] Where testing options for either warp or fill may apply, warp conditions are assumed unless otherwise indicated.
[3] Per ASTM D695.

This information is provided for informational purposes only and without legal responsibility.
Users are expected to perform adequate verification and testing to ensure that materials meet required specifications.

Cytec ENGINEERED MATERIALS
CREATING A MATERIAL ADVANTAGE

TECHNICAL DATA SHEET

Mechanical performance

Product description	Glass fabric	Glass fabric	Quartz fabric
Reinforcement style	7781	7781	581
Fiber description	E-Glass	E-Glass	Quartz
Orientation	Warp	Warp	Warp
Cure temperature, °F (°C)[1]	350 (177)	350 (177)	350 (1 77)
Cure pressure, psi (MPa)	Vacuum 13 (0.09)	Autoclave 45 (0.31)	Vacuum 13 (0.09)
Cure time[1]	2 hours	2 hours	2 hours
Heat-up rate, degrees/rain (°F/°C)	1-3 (0.6-1 3)	1-3 (0.6-1 3)	1-3 (0.6-1 3)
Physical properties			
Ply thickness, inches (mm)	0.0080 (0.203)	0.0075 (0.191)	0.0105 (0.267)
Specific gravity, g/cc	1.97	1.97	1.62
Resin content, % by wt, nominal	21.0	20.5	24.8
Mechanical properties[2]			
Compressive interlamlnar shear strength, ksi (MPa)[3]			
RT	9.0 (62)	—	—
550°F (288°C)	6.0 (41)	—	—
Tensile interlaminar shear strength, ksi (MPa)[4]			
RT	4.0 (26)	—	—
550°F (288°C)	3.0 (21)	—	—
Short beam shear strength, ksi (MPa)[5]			
RT	—	7.0 (48)	6.0 (41)
450°F (232°C)	—	5.0 (34)	—
550°F (288°C)	—	—	4.3 (30)
600°F (316°C)	—	3.4 (23)	—

[1] See “Recommended bagging/cure/postcure procedures” section.
[2] Where testing options for either warp or fill may apply, warp conditions are assumed unless otherwise indicated.
[3] Per ASTM D3846
[4] Per FED-STD-406 method1042.
[5] Per ASTM D2344.

This information is provided for informational purposes only and without legal responsibility.
Users are expected to perform adequate verification and testing to ensure that materials meet required specifications.

Cytec ENGINEERED MATERIALS
CREATING A MATERIAL ADVANTAGE

Dielectric performance

Product description	Glass fabric	Quartz fabric
Reinforcement style	7781	581
Fiber description	E-Glass	Quartz
Orientation	Warp	(0º/45°)
Cure temperature, °F (°C)[1]	350 (177)	350 (177}
Cure pressure, psi (MPa)	Vacuum 13 (0.09)	Autoclave 45 (0.31)
Cure time[1]	2 hours	2 hours
Heat-up rate, degrees/rain (°F/°C)	1-3 (0.6-1.7)	1-3 (0.6-1.7)
Physical properties		
Thickness, inches (rnm)	0.105 (2.67)	0.105 (2.67)
Resin content, % by wt., nominal	21.6	21.6
Dielectric data[2]		
Dielectric constant @ 10 GHz	4.8052	3.4000
Dielectric loss tangent @ 10 GHz	0.0006	0.0004

[1] See “Recommended bagging/cure/postcure procedures” section.
[2] Per “X” band frequency waveguide method.

This information is provided for informational purposes only and without legal responsibility.
Users are expected to perform adequate verification and testing to ensure that materials meet required specifications.

Cytec ENGINEERED MATERIALS
CREATING A MATERIAL ADVANTAGE

TECHNICAL DATA SHEET

Recommended bagging/cure/postcure procedures

Layup procedure-vacuum bag/autoclave

1. Cover tool plate with non-porous armalon, or release treat.
2. Laminate.
3. One ply nylon bleeder or porous armalon.
4. 7781 edge bleed touching laminate plies - see "note".
5. 7500 glass bleeder (bleeder plies shall extend 2" beyond edge of laminate) - see "note".
6. Bag and seal.

Note: Use only ply of 7781 and 7500 glass bleeder for every two piles of prepreg. Based on style 7781 prepreg or equivalent.

Cure cycle-vacuum bag/autoclave

1. Apply vacuum of 27" Hg minimum at room temperature. Vacuum lines should be 3/8" minimum diameter and equipped with cold caps for collecting low boiling volatiles.
2. Heat 1°F per minute maximum to 160°F - hold 1 hour.
3. Heat 1°F per minute maximum to 230°F - hold 2 hours.

Cure cycle-vacuum bag only

4. Heat 1°F per minute maximum to 270ºF - hold 1 hour.
5. Heat 3°F per minute to 350ºF -hold 1 hour.
6. Cool to 150°F or below under vacuum at 3-5°F per minute before removing part.

Cure cycle-autoclave only

4. Heat 1°F per minute maximum to 270°F. Once part temperature reaches 270°F, apply 45 psi and hold 2 hours.
5. Heat 3°F per minute to 350°F hold 1 hour.
6. Cool to 150°F or below under pressure and vacuum at 3-5°F per minute before removing part.

Preform procedure-press

1. Prepare laminate to required ply count.
2. Preform over tool. Preform tool should be heavy wire mesh or screen for allowing maximum breating.
3. Cover preform layup with porous armalon.
4. Restrain the preform to designed shape with suitable porous/breathable webbed material.
5. Place restrained preform in oven at room temperature and heat at 3°F maximum per minute to 230°F plus zero (0) minus five (5) °F. Hold at 230°F for 2 hours minimum.

Molding procedure-press

1. Remove preform from oven.
2. Remove restraining material and porous armalon.
3. Place laid up preform in release coated press preheated to 230°F. Close press and hold at 230°F for 1 hour.
4. Heat 1°F per minute to 270°F. Apply 200 psi minimum and hold for 1 hour.
5. Heat 3°F per minute to 350°F. Hold for 1 hour.
6. Cool under pressure to 150ºF or below at 3-5°F per minute before removing part.

Note: Bump press once temperature reaches 350ºF *SEVERAL INTERVALS CRUCIAL 230-250-300-350*

Postcure-vacuum bag/autoclave press

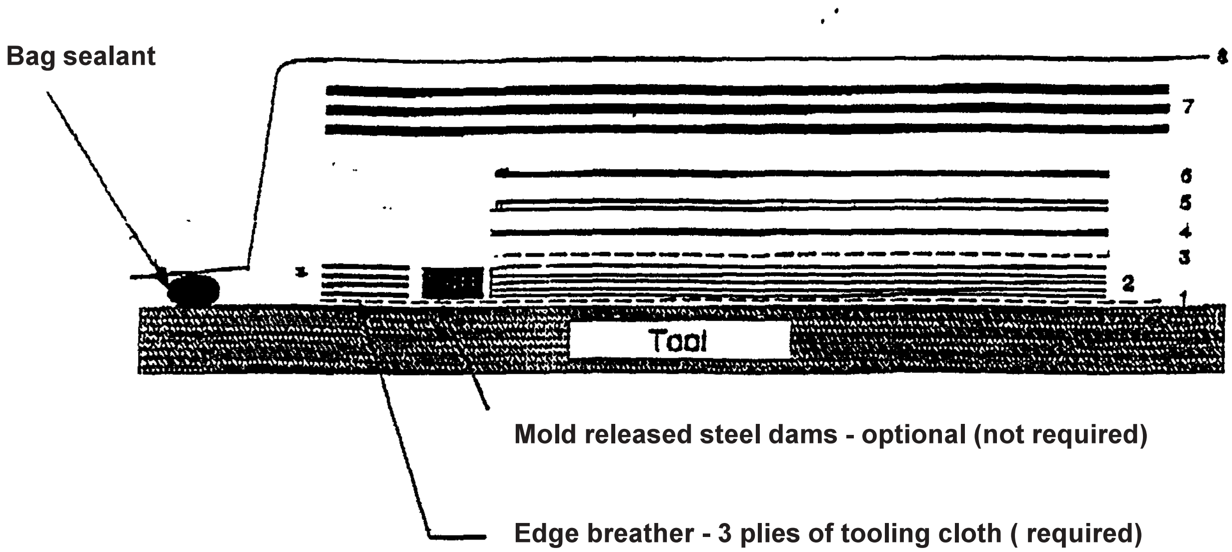
1. 1 hour @ 350°F
2. 2 hours @ 400°F
3. 2 hours @ 450°F
4. 2 hours @ 500ºF
5. 2 hours @ 550°F
6. 2 hours @ 600°F

This information is provided for informational purposes only and without legal responsibility.
Users are expected to perform adequate verification and testing to ensure that materials meet required specifications.

Cytec ENGINEERED MATERIALS
CREATING A MATERIAL ADVANTAGE

Bagging scheme for CYCOM® 3002 e-glass/polyimide

Bagging scheme for CYCOM® 3002
E-Glass/polyimide



Number	Material description
1	**Porous teflon glass =** ***1” larger than part***
2	**Giass/po!ymide**
3	**Porous teflon glass** ***net part area***
4	**Separator perforated 3” centers** ***net***
5	**Glass bleeder/ breather** ***net 7500 PREFERRED***
6	**Separator perforatad 3" centers** ***net***
7	**Tooling cloth (3 plies) breather for vacuum distribution**
8	**Vacuum bag**

This information is provided for informational purposes only and without legal responsibility.
Users are expected to perform adequate verification and testing to ensure that materials meet required specifications.

Cytec ENGINEERED MATERIALS
CREATING A MATERIAL ADVANTAGE

Health and safety information

Warning: CYCOM® 3002 advanced composite prepreg contains polyimide resin. This resin may cause eye and skin irritation. Avoid prolonged or re-peated contact with skin or eyes and overexposure to vapor.

First aid: In case of skin contact, wash affected areas with soap and water. In case of eye contact, immediately irrigate with plenty of water for 15 minutes. Ventilation required: Use mechanical exhaust ventilation when heat-curing resin system.

Detailed handling instructions: Refer to material safety data sheets and product labels.

Important notice

The information and statements herein are believed to be reliable but are not to be construed as a warranty or representation for which Cytec Engineered Materials assumes legal responsibility or as an assumption of a duty on our part. Users should undertake sufficient verification and testing to determine the suitability, for their own particular purpose, of any information or products referred to herein. NO WARRANTY OF FITNESS FOR A PARTICULAR PURPOSE IS MADE. Nothing herein is to be taken as permission, inducement or recommendation to practice any patented invention without a license.

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

Cytec ENGINEERED MATERIALS
CREATING A MATERIAL ADVANTAGE