

TO: DISTRIBUTION
FROM: C NEUMEYER
SUBJECT: HYSOL MODULUS OF ELASTICITY

This memo serves to document the derivation of the modulus of elasticity values to be assumed for the Hysol epoxy resin composites used for the 1) torque collar wet lay-up (E=194ksi) and 2) the flag box potting (E=685ksi).

1) Wet Lay-Up Hysol EA120HP

Data from T. Kozub¹....

Shear Test:

Date of Test:	26-Sep-2003
Sample #:	G6-1
Epoxy Layers:	Two (each a combination of Hysol and Scotch-Ply)
Epoxy Thickness:	0.254 in. (for each layer)
Side Load Compression:	None
Sample Area:	5.86 in. ² (3.24 in. X 1.81 in.)
X scale:	Strain in inches.
MTS Range:	5 in.
Signal Scale:	5 in. / 10 V
Scope:	5 mV / Div. (= 0.0025 in. / Div)
Y scale:	Load in lbs.
MTS Range:	20 Kip
Signal Scale:	20000 lb / 10 V
Scope:	2 V / Div. (= 4000 lb / Div)
Test Procedure:	Cycle load from 488 lb to 20664 lb and back.
Test Results:	Figure 1
Graph Origin:	Upper Right

¹ To be published in Component Test Report

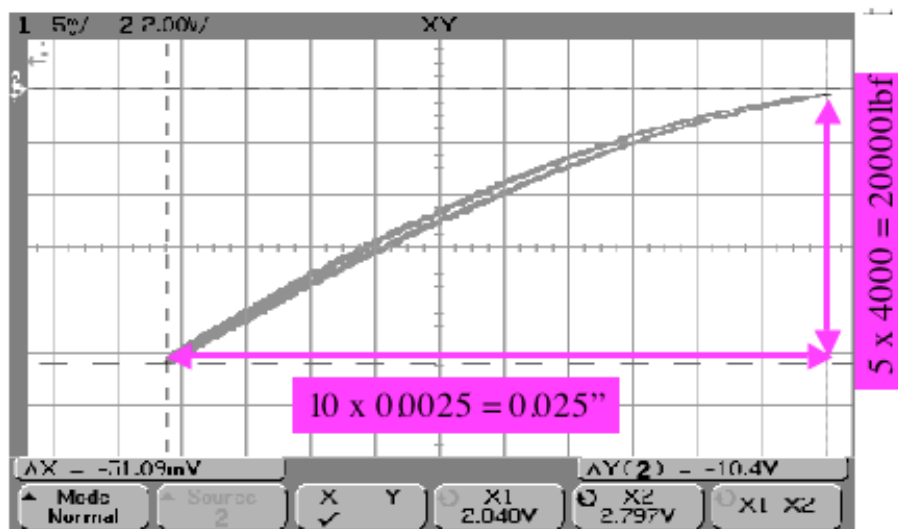


Figure 1 Epoxy Shear

Compression Test:

Date of Test: 24-Sep-2003
 Sample #: G5-5A
 Epoxy Layer: One (a combination of Hysol and Scotch-Ply)
 Epoxy Thickness: 0.245 in.
 Sample Area: 5.556 in.² (3.175 in. X 1.750 in.)
 X scale: Strain in inches.
 MTS Range: 5 in.
 Signal Scale: 5 in. / 10 V
 Scope: 10 mV / Div. (= 0.005 in. / Div) (note: corrected by CN)
 Y scale: Load in lbs.
 MTS Range: 50 Kip
 Signal Scale: 50000 lb / 10 V
 Scope: 1 V / Div. (= 5000 lb / Div)
 Test Procedure: Cycle load from 150 lb to 30685 lb and back.
 Test Results: Figure 2
 Graph Origin: Upper Right

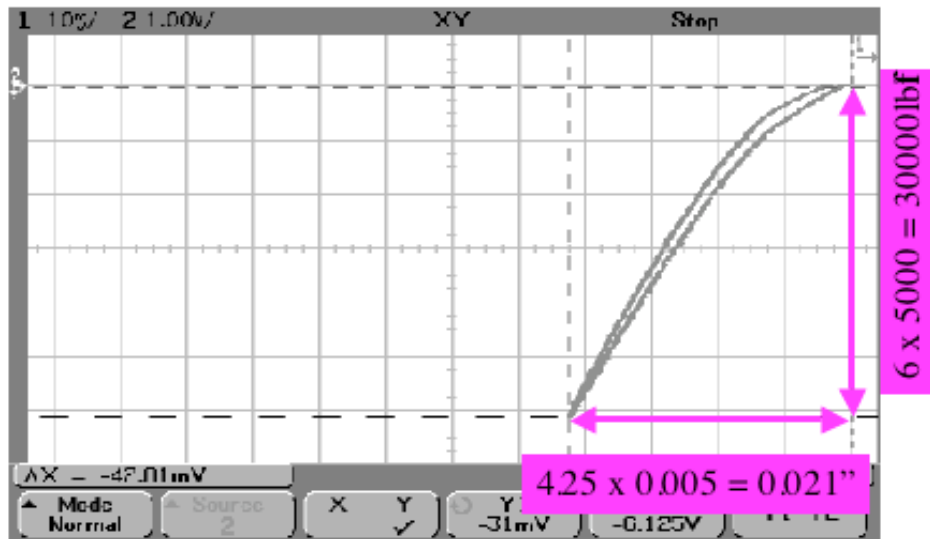
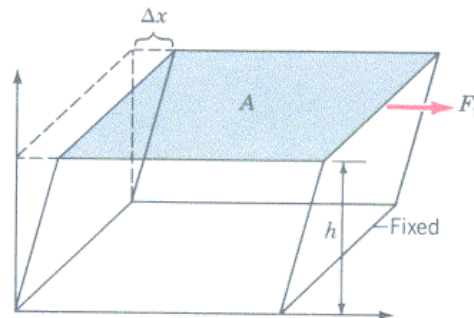


Figure 2 Epoxy Compression

Interpretation of Results on EA-120HP...

Definition of Shear Modulus (<http://local.phys.strath.ac.uk/12-142/lectures/elasticity.html>)....



Shear Stress

Shear stress = tangential force/area of the surface it acts on = F/A

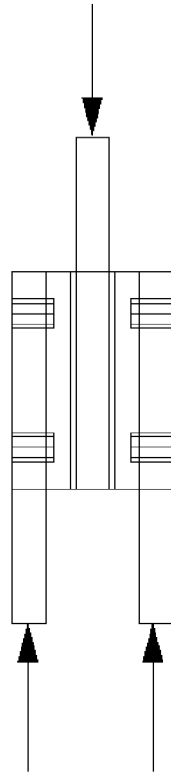
Shear Strain

$$\text{Shear strain} = \frac{\Delta x}{h}$$

Shear Modulus

Shear modulus S = Shear stress/Shear strain

Test configuration for shear consisted of two sandwiched layers as depicted below...



Therefore, for shear interpretation, use twice the area of each face, and use twice the thickness of the individual epoxy layers. Resultant calculations are given below.,.

	Hysol E120-HP		
	Shear	Compression	
Force	20000	30685	lbf
Area	11.729	5.556	sq in
Stress	1705	5523	psi
Measured Deflection	0.0250	0.0213	in
MTS Deflection	0.0093	0.0143	in
Sample Deflection	0.0157	0.0070	in
Length	0.508	0.245	in
Strain	3.09%	2.85%	
Modulus	55175	193804	psi

*Note: in the above calculation, the MTS machine deflection is taken to be equal to $d=0.0093''*F/20000\text{lbf}$.*

2) Flag Potting Hysol RE2039/HD3561

Data from T. Kozub....

Epoxy layer compression modulus test

Date of test: 2003 Oct 31

Sample #: 2-1

Initial sample size: 1.056" x 1.043" x 0.084"

MTS set-up: 50 Kip range, 0.1 Hz, 500 lb to 20000 lb cycle load

Number of Cycles: 251

Final sample size: 1.064" x 1.047" x 0.083"

Graph scale factors:

Y axis: Load, 5000 lb per 1 V (cycled from 500 to 20000), increasing load in the negative Y direction.

X axis: Displacement, 0.0025" per 5 mV, increasing displacement in negative X direction.

Graph 1: After first cycle (print 17)

Graph 2: After 251 cycles (print 18)

Other tests performed on samples of this material determined total structural failure occurred at approximately 40000 PSI compression.

Interpretation of Results on RE2039/HD3561.....

Hysol RE2039/HD3561 Compression		
Force	20000	lbf
Area	1.101	sq in
Stress	18159	psi
Measured Deflection	0.0115	in
MTS Deflection	0.0093	in
Sample Deflection	0.0022	in
Length	0.083	in
Strain	2.65%	
Modulus	685074	psi

Discussion

The above results were lower than expected. All efforts were made to ensure that the calibration and measurement technique were valid. In an attempt to provide a cross check a sample of G10 was also tested. Stacks of 10 samples were also tested. Results are shown below.

Material	Single Sample	10 Sample Stack
Hysol RE2039/3561	0.69Msi	0.61Msi
G10	0.68Msi	0.88Msi

One explanation for the lower numbers is the fact that the testing described herein is for compression normal to the planes of the glass reinforcing fabric, whereas the numbers normally discussed for G10 are for tensile loading in the plane of the glass reinforcement, either in the “warp” or “fill” direction.

If the results given here are in fact low, then this would be conservative for the flag box application and anti-conservative for the wet lay-up application.

Cc:

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