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SPACEWOUND COMPOSITE STRUCTURES

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CONTRACT DAAJ02-77-C-0016

FINAL REPORT

JANUARY 1978

BY

DALE ABILD SKOV
SAM YAO

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Twelve 24-inch diameter cylindrical specimens were designed and fabricated by Fiber Science, Inc., and were subsequently ballistically tested at the Applied Technology Laboratory, Fort Eustis, Virginia. Three materials (Kevlar, Fiberglass, and Graphite), two fiber coverage ratios, and the use of an external fiberglass aerodynamic skin surface were assessed. Based on the results of these tests, four kevlar specimens with a fiberglass cloth skin, two with 25% and two with 50% fiber coverage ratio, were selected for final design evaluation. The final specimens were 16-inch diameter cylinders with a four-bolt ring/frame attachment fitting at each end to facilitate structural testing.

The final design specimens were subsequently structurally tested both before and after high explosive projectile ballistic tests at the Applied Technology Laboratory. A final report describing the test program and results is currently in preparation.

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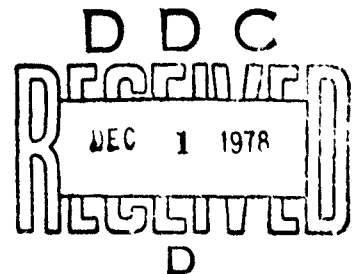
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FOREWORD

This report was prepared by Fiber Science, Inc. in accordance with Contract DAAJ02-77-C-0016, issued by the Eustis Directorate, U.S. Army Air Mobility Research and Development Laboratory, Fort Eustis, Virginia*. Mr. ^{DAS GOOD}~~Eddie Dean~~ was the U.S. Army program technical monitor.

The activities reported herein cover the period from January 1977 to November 1977. The Fiber Science project engineer was Mr. Sam Yao.

*Redesignated Applied Technology Laboratory, Research and Development Laboratories (AVRADCOM), 1 September 1977.

SUMMARY

Six configurations of Spacewind cylinders were designed to a prescribed set of strength and stiffness criteria. The variables were two levels of fiber coverage and three reinforcements; glass, Kevlar and graphite. One cylinder of each design was fabricated at Fiber Science and tested for ballistic tolerance at Fort Eustis.

Four more cylinders were fabricated for final testing. The variable was two levels of fiber coverage. Kevlar 49 was the reinforcement for all four.

TABLE OF CONTENTS

	<u>Page No.</u>
SUMMARY	1
TABLE OF CONTENTS	2
LIST OF TABLES & LIST OF FIGURES	3
INTRODUCTION	4
DESIGN	9
FABRICATION	13
TESTING	15
CONCLUSIONS	20
APPENDIX A	21
SPACEWIND ANALYSIS EQUATIONS	
APPENDIX B	31
DESIGN CALCULATIONS	
APPENDIX C	39
END FITTING ANALYSIS	
APPENDIX D	43
MATERIAL PROPERTY COMPUTER PROGRAM	
APPENDIX E	49
MATERIAL PROPERTIES, UNITS 1-6	
APPENDIX F	56
MATERIAL PROPERTIES, UNITS 7-10	
APPENDIX G	67
DRAWINGS	
APPENDIX H	69
NOMENCLATURE	

LIST OF TABLES & FIGURES

<u>Table No.</u>		<u>Page No.</u>
1	Ballistic Samples Tested	15
2	Weight Analysis	19
3	Design Data, Units 1-6	34
4	Design Data, Units 7-10	38

<u>Figure No.</u>		<u>Page No.</u>
1	Band Damage Data	17

INTRODUCTION

"Spacewind" is a descriptive term applied to the filament winding process used in this contract. Normal filament winding procedures are very specific in requiring bands to be exactly adjacent to each other. Spacewind nomenclature for a structure with adjacent bands would be "1.00 fiber coverage ratio." That is, the ratio of surface area covered by strands to the total surface area is 1.00.

Spacewind deliberately requires spaces between roving bands. The final structure, regardless of wall thickness, looks like it is made of old fashioned cane or wicker because there are holes geometrically arranged over the entire surface.

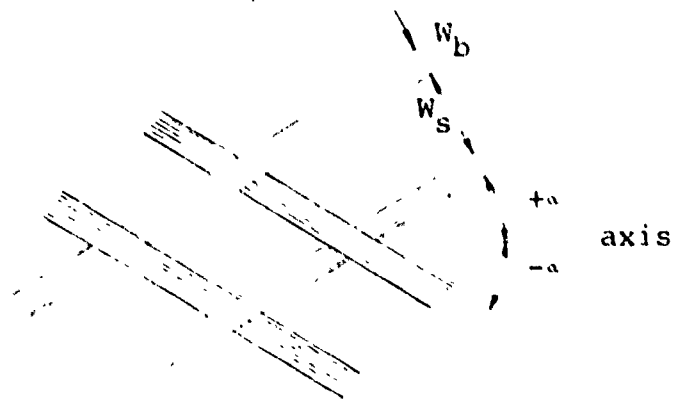
A non-standard language has developed to explain the non-standard filament winding process called Spacewind. The following definitions will help in reading this report.

- Strand A general term indicating an essentially continuous length of filamentary material, whether large or small, twisted or un-twisted.
- Band Width A single strand might be wound or several strands might be gathered and wound at one time. Band width is the width of the total number of strands wound at one time.
- Winding Angle Strands are wound onto a rotating mandrel by traversing from end to end of the mandrel. The angle between a strand and the

mandrel axis is the winding angle. It is both + and - with reference to cartesian coordinates since the band direction changes.

F.C.R.

Fiber Coverage Ratio is the ratio of mandrel surface area covered with strands going in one direction to the amount not covered, as sketched below. F.C.R. is used as an easily calculated expression for Spacewind.



$$F.C.R. = \frac{W_b}{W_b + W_s}$$

F.A.C.R

Fiber Area Coverage Ratio is the area covered by fibers divided by total surface

area, realizing that bands run both left and right.

Fiber Volume A second ratio, unrelated to F.C.R., is the ratio of fiber volume to the total volume of fiber and resin.

A prior contract, DAAJ02-76-C-0040, administered by the Applied Technology Laboratory, Research & Technology Laboratories, Fort Eustis, Virginia, had demonstrated it is possible to use analytical models in designing Spacewind composites. This contract was intended to evaluate the potential of Spacewind as a structure with built-in pressure relief valves.

Explosive projectile fire directed at modern Army aircraft is often fatal because the overpressure from the blast requires the fuselage to become a pressure vessel. Fuselages are not designed as pressure vessels because of a very large associated weight penalty. The result is structural failure from a blast which might be insignificant in terms of damage from shrapnel. Spacewind was considered a possible solution to overpressure from explosive projectiles because it has multitudes of built-in pressure relief vents.

Six cylinders 24 inches in diameter and 72 inches long were specified as a vehicle for evaluating the ballistic tolerance of Spacewind. Three reinforcements, S-2 glass, Kevlar 49 and graphite were specified for evaluation. All six cylinders were to be designed to the following stiffness and strength requirements.

Stiffness: $EI_y = 2.6 \times 10^9 \text{ lb-in}^2$ (flexural stiffness about 'y' axis)
 $EI_z = 2.6 \times 10^9 \text{ lb-in}^2$ (flexural stiffness about 'z' axis)
 $GK = 1.2 \times 10^9 \text{ lb-in}^2$ (shear stiffness)

Limit Load: $M_x = 1.37 \times 10^5 \text{ in-lbs}$ (bending moment about 'x' axis)
 $M_z = 3.87 \times 10^5 \text{ in-lbs}$ (bending moment about 'z' axis)
 $S_z = 1.14 \times 10^3 \text{ lbs}$ (shear in the 'z' direction)

NOTE: The 'x' axis is the longitudinal axis of the cylinder.

Following testing of these sections by the Army four more cylinders 16 inches in diameter by 72 inches long were designed using Kevlar 49 as the reinforcing fiber. These specimens included four attachment fittings at each end to facilitate structural testing. The design criteria used for these four cylinders were:

Stiffness: $EI_y = 1.1 \times 10^9 \text{ lb-in}^2$
 $EI_z = 1.1 \times 10^9 \text{ lb-in}^2$
 $GK = 0.5 \times 10^9 \text{ lb-in}^2$

Limit Loads: $M_x = 1.2 \times 10^5 \text{ in-lb}$
 $M_z = 1.53 \times 10^5 \text{ in-lb}$
 $S_z = 2.84 \times 10^2 \text{ lb}$
 $S_y = 2.922 \times 10^3 \text{ lb}$

Following sections give design data and fabrication techniques for these cylinders. All testing was performed by the Army Air Mobility Research and Development

Laboratory, Fort Eustis, Virginia.

DESIGN

Design equations are given in Appendix A and design calculations based on these equations are given in Appendix B.

One primary design consideration was whether to design single wall or sandwich wall structures to meet the stability requirements. A foam core in a sandwich wall would not be acceptable because it would block off all the Spacewind holes which were being considered pressure relief valves. Honeycomb could be used, though, because of its construction. Stability calculations showed that only the fifty-percent F.C.R. graphite specimen required sandwich wall construction.

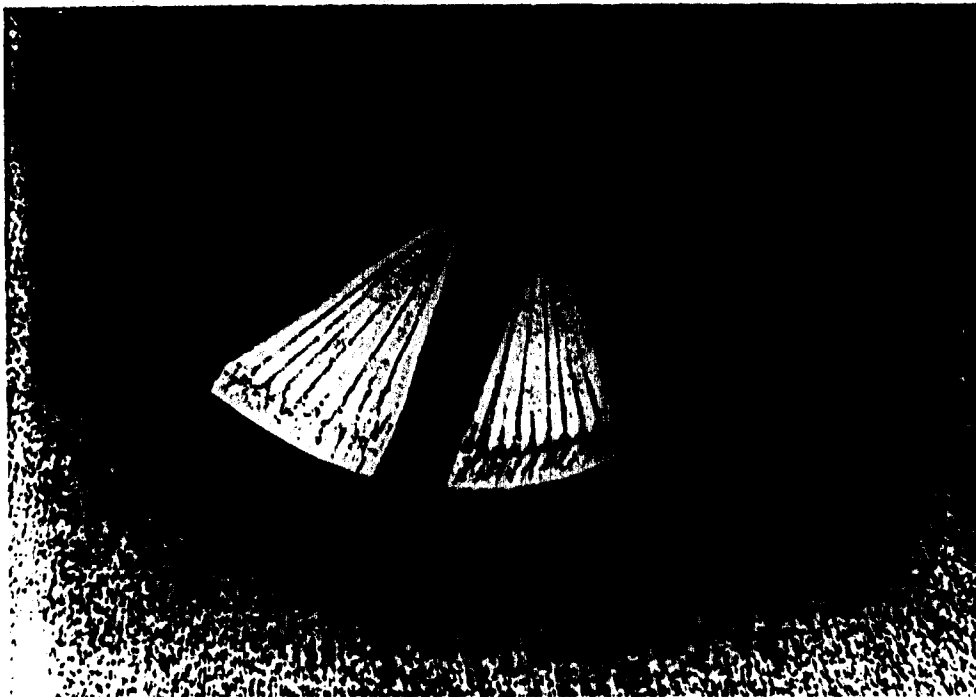
The structural requirements given earlier apply to cylinders supported at its ends with bending forces applied. These requirements are best met by strands wound at a very small angle to the cylinder axis. A hoop load was also known to be a requirement to resist overpressure loads. Its magnitude was unknown, so hoop strength could not be designated.

Past design experience led to an empirical feeling that twenty-percent of all strands should be hoop, or circumferential, strands. These strands do not contribute significantly to the strength and stiffness requirements, but do contribute to ballistic tolerance. The balance of strands were calculated to be ± 24 degrees to the cylinder axis.

The six cylinders were fabricated at Fiber Science and tested at Fort Eustis. Kevlar 49 was selected as the reinforcement for the final demonstration cylinders.

The final demonstration units were made smaller in diameter in an effort to increase the overpressure loads and to have a more severe test. They also had to have end fittings so they could be loaded in bending at the time of projectile testing.

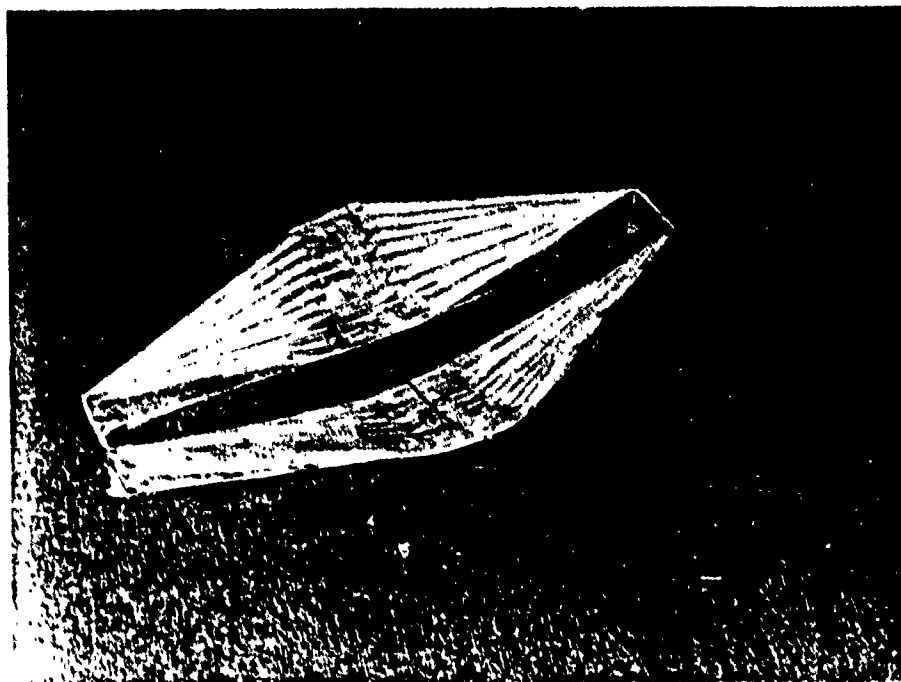
Design calculations for the fittings are in Appendix C. The concept employed is one used previously at Fiber Science and referred to as a broom. A broom fitting is shown below.



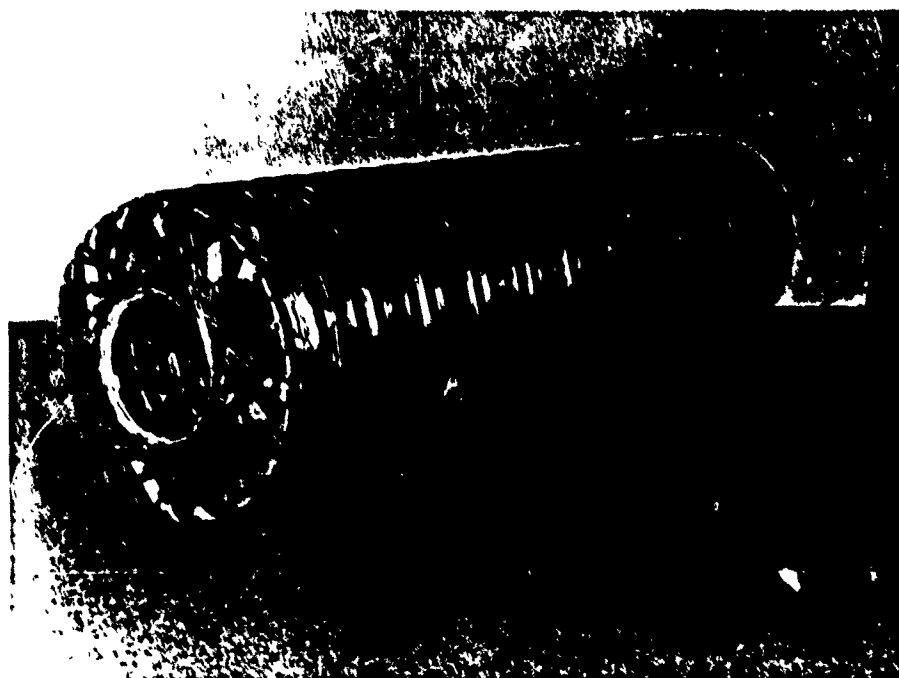
Glass rovings were wound into a circular, unidirectional package and then transferred to a mold. The circular rovings were deformed in the mold to make two fittings,

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end to end, as shown below.



A closure flange for the cylinder was designed to back up the fittings and rovings were wound over it as shown below.



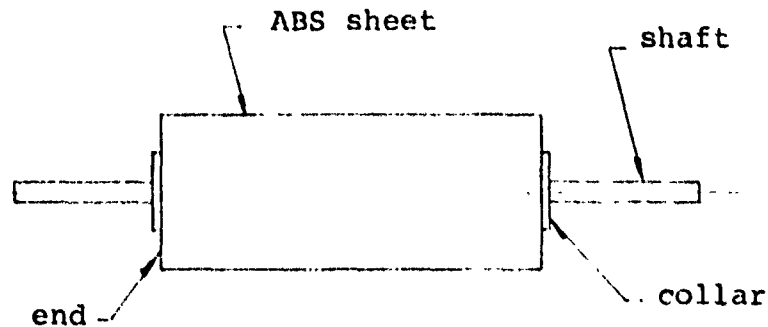
The attach fittings were then bonded inside the cylinder at four places on each end. A force applied to one or more fittings is transferred to the mounting ring and thereby to the rovings as well as to the rovings by adhesive bond shear.

These four cylinders were fabricated and delivered to Fort Eustis for testing.

FABRICATION

Cylinders were wound on standard helical filament winding machines. The machines were programmed to give the pattern desired and that program was used for all three reinforcements.

Tooling was composed of a steel shaft, steel collars, glass composite ends and an ABS sheet cylinder as sketched below.



Ends were bolted to the collars, which in turn were bolted to the shaft. The ABS sheet was bonded to the ends and then was pressurized at 1 PSI with air to stabilize it. The outer surface was coated with mold release so it could be removed after winding and curing the cylinders.

The last four demonstration cylinders had flanged end plates built in. These plates were made from ten plies of Style 1581 glass fabric impregnated with epoxy resin. They fit over the fiberglass tooling ends and were wound

over with rovings, which prevented the tooling from being removed in one piece.

Glass composite tool ends for these cylinders were cut in half and sealed together again before the ABS sheet was bonded on. After the cylinder was cured, ends were unbolted from collars and pushed into the cylinder. They then were removed in half pieces, ready to be used again.

Fittings were made from glass fibers and epoxy resin by filament winding around two spools. The windings, before being cured, were moved to a fiberglass mold and deformed to the correct shape and then cured. The resulting structure was two fittings, formed end-to-end. It was cut in the middle to yield two fittings.

Properly located holes were drilled in the wound and cured cylinders. Fittings were mated to the holes on the inside of the tank and adhesive bonded into place.

There were no fabrication problems in winding or assembly.

TESTING

The first cylinders made were 24 inches in diameter and 92 inches long. These were cut in half (46 inches long) at Fort Eustis and one-half had a single ply of 181 glass fabric laminated on to simulate the skin on an aircraft. Twelve variations were tested as shown below.

Reinforcement	FCR	Skin
Glass	.25 & .50	with and without
Kevlar	.25 & .50	with and without
Graphite	.25 & .50	with and without

Table 1. Ballistic Samples Tested

Samples were held in a fixture and fired upon. Results were evaluated by Fort Eustis personnel as follows.

Damage Assessment

1. To assess the relative damage to the specimens as a result of the 23mm HEI-T ballistic impact tests, an inspection of the specimens was conducted in which the number of partially or fully severed fiber bands was tabulated.
 - a. The number of severed fiber bands was counted on the top, bottom, and exit side of the specimens as shown in Figure 1. The damage on the entrance side was not considered for the following reasons.
 - (1) The damage is relatively small compared to the top, bottom, and exit side damage.

(2) The damage on the entrance side is a function of whether the projectile passed through one or more bands or through the function plate.

- b. The number of hoop bands and $\pm 24^\circ$ bands was counted separately.
- c. The degree of damage (i.e., percent of band severance) was estimated as being 25, 50, 75 or 100 percent.
- d. The band damage data are shown in Figure 1. The damage levels were then weighted to arrive at a "Damage Coefficient". The weights are as follows:

<u>Percent of Band Severed</u>	<u>Weighting Factor</u>
25	1
50	2
75	3
100	4

The weighted points were then summed for each damage location and band direction. Then the points were summed over all damage locations to arrive at a damage coefficient for both the 24° and hoop bands.

- 2. It should be noted, however, that the loss of a given band in the 25% FCR specimens is more damaging than the loss of a band in the 50% FCR specimens in that the band thickness in the 25% FCR specimens is twice that of the 50% FCR specimens.

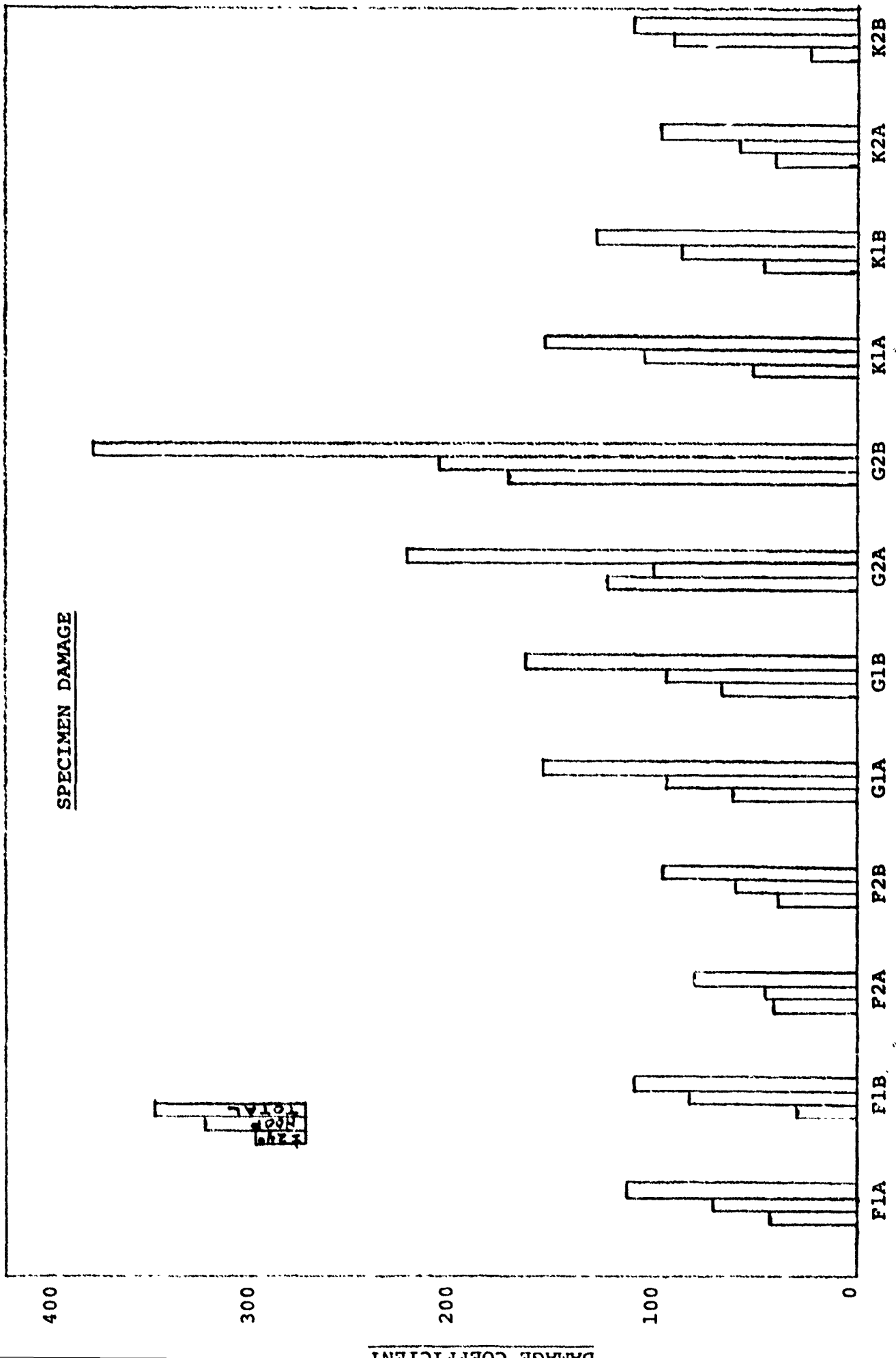


Figure 1. Band Damage Data

Samples were given the following code.

First Character

F = Fiberglass

K = Kevlar

G = Graphite

Second Character

1 = 25% FCR

2 = 50% FCR

Third Character

A = with #181 glass clothskin

B = no skin

Test results are graphed in Figure 1.

The effect of a skin is very small and perhaps none at all. Glass and Kevlar reinforced specimens tested quite similarly, while graphite was a clear third choice.

Weights of the various samples are given in Table 2.

Spacewind Composite Structures
Weight Analysis

Material	FCR	Weight		
		Calculated	Actual	
		No Skin	No Skin	With Skin
S-Glass	25%	29.58	33	35.75
S-Glass	50%	29.04	32	35.5
Kevlar	25%	14.66	17.63	20.27
Kevlar	50%	14.63	15.38	18.25
Graphite	25%	9.4	11.75	15.5
Graphite	50%	10.93	12.63	15.25

Table 2 . Weight Analysis

Kevlar 49 samples are 40-50% lighter in weight than glass. The final demonstration samples were made from Kevlar reinforcement because of weight.

CONCLUSIONS

Test results indicate a single ply 181 glass covering over Spacewind cylinders has little, if any, effect on their ballistic resistance to 23mm HEI-T projectiles. Graphite reinforced cylinders suffer more damage, and perhaps less predictable damage, than glass or Kevlar reinforced cylinders. Spacewind appears to offer a solution to ballistic projectile over-pressure damage to aircraft fuselage structures.

APPENDIX A
SPACEWIND ANALYSIS EQUATIONS

SPACEWIND ANALYSIS EQUATIONS

The equations used in the design of the specimens follows:

Relation Between Modulus & Shear Modulus

$$\begin{aligned} I &= \pi \bar{R}^3 t \\ K &= 2\pi \bar{R}^3 t \\ \frac{E}{G} &= \frac{(EI)K}{(KG)I} = \frac{2(EI)}{KG} \end{aligned}$$

The above equations were used to establish the helical winding angle. This was accomplished by first assuming 20% of the winds would be in the hoop direction and 80% would be in the helical direction. The properties of spacewind composites were calculated using the computer with various helical winding angles and the helical angle which satisfied the above equation ($\frac{E}{G}$) selected.

Calculation of Outside Shell Radius

$$\begin{aligned} EI &= \frac{\pi E}{4} (R_o^4 - R_i^4) \\ R_o &= \left(\frac{4 EI}{\pi E} + R_i^4 \right)^{1/4} \end{aligned}$$

Calculation of Maximum Bending & Shear Stresses

$$\begin{aligned} \sigma_{\max} &= \frac{M_z}{\pi \bar{R}^2 t} \\ \tau_{\max} &= \frac{M_x}{2\pi \bar{R}^2 t} + \frac{S_y}{\pi \bar{R} t} \end{aligned}$$

Calculation of Critical Axial (Bending) Buckling Stress

Solid Wall Construction

$$\sigma_{cr} = C_c \left(\frac{E_e t}{\bar{R}} \right)$$

$$\bar{R} = \frac{R_o + R_i}{2}$$

$$C_c = 0.606 - .546 (1 - e^n)$$

$$n = - \frac{1}{16} \sqrt{\frac{\bar{R}}{t}}$$

$$E_e = \frac{2 E_x E_y}{E_x + E_y}$$

Sandwich Wall Construction

$$\sigma_{cr} = \frac{G_e (t_c + t_f)}{2 t_c t_f}$$

$$G_e = G_c (\text{FACR})$$

Note: FACR - Fiber Area Coverage Ratio

Calculation of Critical Distance Between Cross-over Points

The critical length between cross-over points of the helical windings is calculated by equating the buckling stress to the compressive strength of the helical windings.

Solid Wall Construction

$$P_{cr} = \frac{\pi^2 E_e I}{L_{cr}^2} \quad (\text{pin ended column})$$

$$\sigma_{cr} = \frac{P_{cr}}{t} = \frac{\pi^2 E_e t^2}{12 L_{cr}^2}$$

$$L_{cr} = \sqrt{\frac{\pi^2 E_e t^2}{12 F_{cu}}}$$

$$E_e = \frac{E_{11}}{2}$$

$$F_{cu} = \frac{F_{cu_{11}}}{2}$$

Sandwich Wall Construction

$$P_{cr} = \frac{\pi^2 E_e I}{L_{cr}^2} \quad (\text{pin ended column})$$

$$I = \frac{(t_c + 2 t_f)^3}{12}$$

$$t_f = \frac{t}{2}$$

$$E_e = \frac{E_{11}}{2}$$

$$F_{cu} = \frac{F_{cu_{11}}}{2}$$

$$\sigma_{cr} = \frac{P_{cr}}{t} = \frac{\pi^2 E_e (t_c + t)^3}{12 L_{cr}^2 t}$$

$$L_{cr} = \sqrt{\frac{\pi^2 E_e (t_c + t)^3}{12 F_{cu} t}}$$

When the core is weak in shear

$$\sigma_{cr} = \frac{G_e (t_c + t_f)}{2 t_c t_f}$$

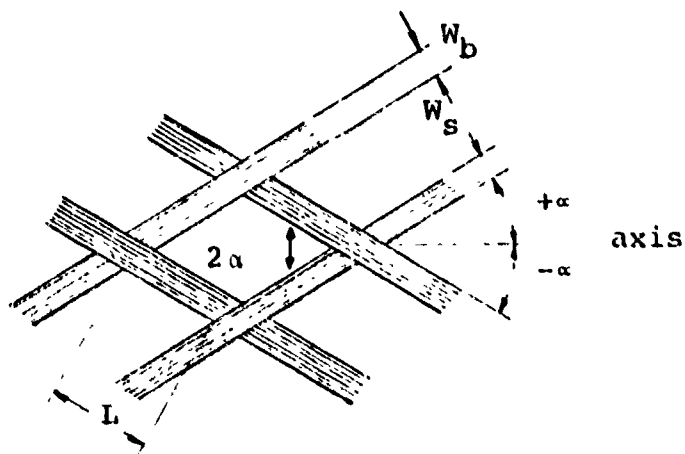
$$G_e = G_c (\text{FACR})$$

Note: FACR = Fiber Area Coverage Ratio

Fiber Coverage Analysis

Fiber Coverage Ratio "FCR"

$$\text{FCR} = \frac{W_b}{W_b + W_s} \quad (\text{by definition})$$



$$W_b = \frac{W_s (\text{FCR})}{1 - \text{FCR}}$$

$$\sin 2\alpha = \frac{W_s}{L}$$

$$W_s = L 2 \sin \alpha \cos \alpha$$

The open area between helical bands is

$$\text{Open area} = W_s L = \frac{(W_s)^2}{2 \sin \alpha \cos \alpha}$$

The total area including fiber coverage to mid point of helical bands is

$$\text{Total area} = \frac{(W_s + W_b)^2}{2 \sin \alpha \cos \alpha}$$

The fiber area coverage ratio (FACR) is

$$\text{FACR} = 1 - \frac{\text{Open Area}}{\text{Total Area}} \quad (\text{by definition})$$

$$\text{FACR} = 1 - \frac{(W_s)^2}{(W_s + W_b)^2}$$

Note: $W_b = \frac{W_s (\text{FCR})}{1 - \text{FCR}}$

$$\text{FACR} = 2 \text{FCR} - (\text{FCR})^2$$

<u>FCR</u>	<u>FACR</u>
.250	.4375
.375	.6094
.500	.7500
.625	.8594
.875	.9844

The fiber area coverage ratio for both circumferential and helical windings is

$$FACR = (FACR)_h + [1 - (FACR)_h] (FACR)_c$$

Note:

$$(FACR)_h = 2(FCR)_h - (FCR)_h^2$$

$$(FACR)_c = (FCR)_c$$

¹⁰ (FCR) _{helical} 324°	¹⁵ (FACR) _{helical} 324°	²⁰ (FCR) _{circumferential}	²¹ (FACR) _{circumferential}	⁶ (FACR)
.250	.4375	.250	.250	.5781
.375	.6094	.375	.375	.7559
.500	.7500	.500	.500	.8750
.625	.8594	.625	.625	.9173
.875	.9844	.875	.875	.9981

Relationship Between Fiber Coverage Ratio and Helical Area Coverage
 The fiber cross-over area (FCOA) for helical windings is

$$FCOA = \frac{w_b^2}{2 \sin \alpha \cos \alpha}$$

The fiber area (FA) is

$$FA = \text{Total area} - \text{open area}$$

$$FA = \frac{(W_s + W_b)^2 - (W_s)^2}{2 \sin \alpha \cos \alpha}$$

The fiber cross-over coverage ratio is

$$\frac{FCOA}{FA} = \frac{(W_b)^2}{(W_s + W_b)^2 - (W_s)^2} = \frac{W_b}{W_b + 2W_s}$$

$$\text{Noting FCR} = \frac{W_b}{W_b + W_s}$$

$$W_s = \frac{W_b (1 - \text{FCR})}{\text{FCR}}$$

$$\frac{FCOA}{FA} = \frac{W_b}{W_b + \frac{2W_b (1 - \text{FCR})}{\text{FCR}}} = \frac{1}{1 + \frac{2(1 - \text{FCR})}{\text{FCR}}}$$

FCR	$\frac{FCOA}{FA}$
.250	.1429
.375	.2308
.500	.3333
.675	.4545
.750	.6000
.875	.7778

Fiber Volume Ratio Analysis

In order for the thickness of Spacewind helical windings

to be the same at cross-over points and in between the cross-over areas, the fiber volume ratio " V_f " (ratio of fiber volume to total of fiber plus resin volume) at the cross-over points will differ from the fiber volume ratio in between cross-over points.

The fiber volume ratio at and between cross-over points is,

$$t_{co} = \frac{2}{V_{fco}} \quad (\text{two plies of windings})$$

$$t_{bco} = \frac{1}{V_{fbco}} \quad (\text{one ply of windings})$$

Assuming there are no voids,

$$t_{co} = t_{bco} \text{ and } V_{fbco} = \frac{V_{fco}}{2}$$

As an example, assume the fiber volume ratio at the cross-over points $V_{fco} = .65$,

then between cross-over points the fiber volume ratio would be,

$$V_{fbco} = \frac{.65}{2} = .325$$

The desired fiber volume ratio assuming no resin bleed out for fiber coverage areas of 25 and 50% are,

$$\underline{FCR = .25}$$

$$\frac{\text{FCOA}}{\text{FA}} = .1429$$

$$V_f = .1429 \times .65 + (1 - .1429) \cdot .325 = .3714$$

$$\underline{\text{FCR} = .50}$$

$$\frac{\text{FCOA}}{\text{FA}} = .3333$$

$$V_f = .3333 \times .65 + (1 - .3333) \cdot .325 = .4333$$

APPENDIX B
DESIGN CALCULATIONS

DESIGN CALCULATIONS

Units one through six

Design Criteria

$$ID = 24.0 \text{ in.}$$

$$L = 72.0 \text{ in.}$$

Stiffness:

$$EI_y = 2.6 \times 10^9 \text{ lb-in}^2$$

$$EI_z = 2.6 \times 10^9 \text{ lb-in}^2$$

$$GK = 1.2 \times 10^9 \text{ lb-in}^2$$

Limit Loads:

$$M_x = 1.37 \times 10^5 \text{ in-lb}$$

$$M_z = 3.87 \times 10^5 \text{ in-lb}$$

$$S_z = 1.14 \times 10^3 \text{ lb}$$

Ultimate loads = 1.5 x limit loads

Construction -- 20% @ 90° (hoops) and 80% @ ± 24°

Fiber volume ratio = .50

Fiber coverage ratio (FCR) -- arbitrarily selected at .25 and .50.

Analysis

The material properties are based on computer analysis inputting the fiber and resin properties, fiber volume ratio, fiber orientation and fiber coverage ratio. Appendix E shows the composite material properties for the various materials. Note the helical winding angle was arrived at by an iterative process where the relation between the E and G of the composite satisfied the criteria stiffness.

Table 3 summarizes the calculation for units one through six. The equations used are shown in Appendix A and all stresses are for ultimate loads.

Property	S2-Glass/Epoxy	Kevlar 49/Epoxy	Thornel 300/Epoxy
$V_f, \%$	.50	.50	.50
$E_{11}, 10^6 \text{ psi}$	6.535	9.375	17.230
$FCR, \%$	25	25	25
$FACR \text{ (hel. only), } \%$	43.75	43.75	43.75
$FACR, \%$	57.81	57.81	57.81
$E_x, 10^6 \text{ psi}$	.8536	1.243	2.203
$E_y, 10^6 \text{ psi}$	.3957	.5205	.9103
$E_e, 10^6 \text{ psi}$	.5407	.7337	1.2883
$R_o, \text{ in.}$	12.5255	12.3680	12.2117
$t, \text{ in.}$	.5255	.3680	.2117
$\bar{R}, \text{ in.}$	12.2628	12.1840	12.1059
$\sigma_{max}, \text{ psi}$	2338	3381	5955
$\tau_{max}, \text{ psi}$	498	720	1266
$\sigma_{cr}, \text{ psi}$	10,745	9774	9019
$F_{cu}, \text{ psi}$	13,760	4445	13,691
$F_{cu \text{ II}}$	53,750	17,500	53,750
$F_{su}, \text{ psi}$	3735	1513	3612
$L_{cr}, \text{ in}$	5.1258	9.0040	5.2827
$W_s, \text{ in.}$	3.8092	6.6913	3.9258
$W_b, \text{ in.}$	1.2697	2.2304	1.3086

* $\sigma_{max} > \sigma_{cr}$, therefore, use sandwich wall construction, see page 35.

Table 3. Design Data, Units 1-6

CALCULATIONS FOR SANDWICH WALL CONSTRUCTION

$$t_c = .25 \text{ in.}$$

$$t_f = \frac{t}{2} = .0527 \text{ in.}$$

$$G_e = .750 \times 3000 = 2250 \text{ psi}$$

$$\sigma_{cr} = \frac{2250 (.25 + .0527)}{2 \times .25 \times .0527} = 25,847 \text{ psi}$$

Units seven through ten

Design Criteria

ID = 16.0 in.

L = 72.0 in.

Stiffness:

$EI_y = 1.1 \times 10^9 \text{ lb-in}^2$

$EI_z = 1.1 \times 10^9 \text{ lb-in}^2$

$GK = 0.5 \times 10^9 \text{ lb-in}^2$

Limit Loads:

$M_x = 1.2 \times 10^5 \text{ in-lb}$

$M_z = 1.53 \times 10^5 \text{ in-lb}$

$S_y = 2.922 \times 10^3 \text{ lb}$

$S_z = 2.84 \times 10^2 \text{ lb}$

Ultimate loads = 1.5 x limit loads

Construction -- 20% @ 90° (hoops) and 80% @ ± 24°

Fiber Volume Ratio -- .65 at cross-over areas and .325 between cross-over areas.

Average fiber volume ratio for .25 and .50 FCR are .3714 and .4333 respectively.

Fiber coverage ratio -- .25 and .50.

Analysis

The material properties are shown in Appendix F. Table 4 summarizes the calculations for units seven through ten.

Property	Kevlar 49/Epoxy	
V_f , %	32.5	32.5
E_{11} , 10^6 psi	6.492	6.492
F.C.R., %	25	50
FACR (hel. only), %	43.75	75.00
FACR, %	57.81	87.50
E_x , 10^6 psi	1.553	3.156
E_y , 10^6 psi	.5232	1.119
E_e , 10^6 psi	.7827	1.6522
R_o , in.	8.4081	8.2084
t , in.	.4081	.2084
R , in.	8.2041	8.1042
σ_{max} , psi	2659	5337
τ_{max} , psi	1459	2919
σ_{cr} , psi	18,399	18,259
F_{cu} , psi	5558	11,241
F_{su} , psi	1837	3958
$F_{cu ll}$	11,375	11,375
L_{cr} , in.	6.2521	3.1927
W_s , in.	4.6462	2.3726
W_b , in.	1.5487	2.3726
ρ_c , lb/in ³	.0114	.0231

Table 4. Design Data, Units 7-10

APPENDIX C
END FITTING ANALYSIS

Frame

Internal member loads were solved by a computer program with the following assumptions:

EI = Constant

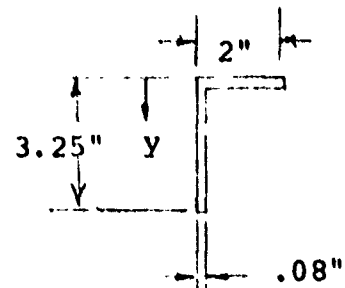
Loads reacted in a $\frac{VQ}{I}$ or $\frac{Mx}{2A}$ distribution

The critical loads are summarized below.

<u>B</u>	<u>V</u>	<u>P</u>	<u>M</u>
55°	-20 lb	-2281 lb	-1038 in-lb
210°	26	1608	1137
225°	-1265	-3319	740
315°	-1265	-4094	739

Section properties of the frame (E-glass)

<u>A</u>	<u>Y</u>	<u>Ay</u>	<u>Ay²</u>	<u>I_o</u>
.16	.04	.0064	.0003	--
.26	1.625	.4225	.6866	.2289
<u>Σ .42</u>		<u>.4289</u>	<u>.6869</u>	<u>.2289</u>



$$\bar{y} = \frac{.4289}{.42} = 1.02 \text{ in}$$

$$I = .2289 + .6869 - .42 (1.02)^2 = .4788 \text{ in}^4$$

Maximum stresses are:

$$\sigma = \frac{4094}{.42} + \frac{739 \times 2.23}{.4788} = 13,189 \text{ psi}$$

$$\tau_{\max} = \frac{3}{2} \times \frac{1265}{.42} = 4,518 \text{ psi}$$

Attachment

End Frame Limit Loads:

$$M_x = 1.2 \times 10^5 \text{ in-lb}$$

$$M_z = 1.53 \times 10^5 \text{ in-lb}$$

$$S_y = 2922 \text{ lbs}$$

Ultimate load = limit load x 1.5

Bolt loads -- 4 bolts

$$P_x = \frac{153,000 \times 1.5}{2 \times 14 \cos 45^\circ} = 11,591 \text{ lb}$$

$$V_y = \frac{2922 \times 1.5}{4} = 1095 \text{ lb}$$

$$V_t = \frac{120,000 \times 1.5}{4 \times 7} = 6428 \text{ lb}$$

Resolving V_y to the tangential and radial force components

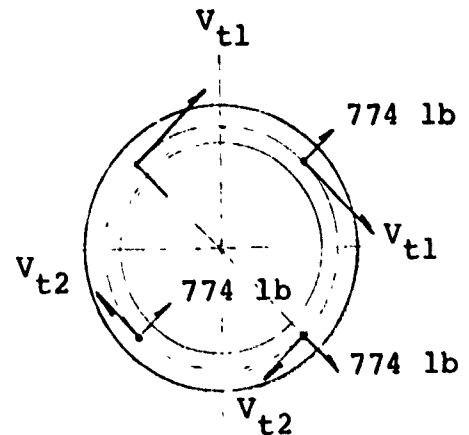
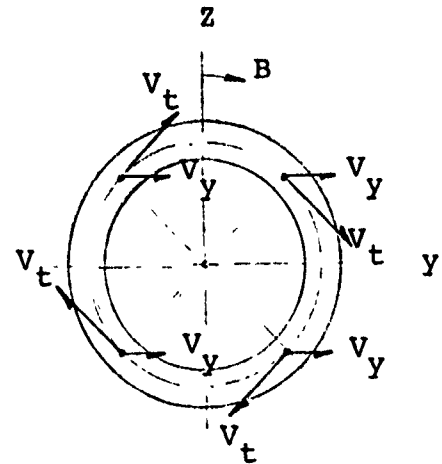
$$V_s = 1095 \cos 45^\circ = 774 \text{ lb}$$

$$V_t = 1095 \sin 45^\circ = 774 \text{ lb}$$

The combined tangential and radial forces are

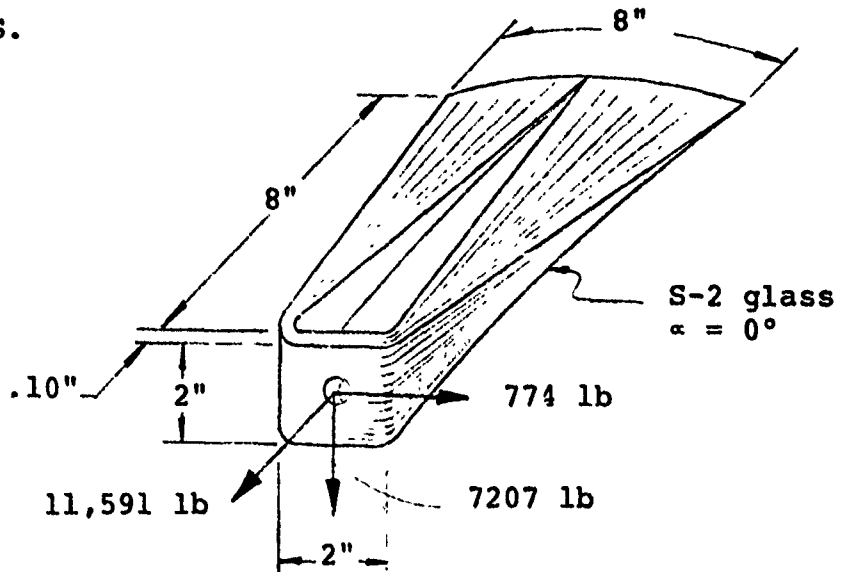
$$V_{T1} = 6428 + 774 = 7202 \text{ lb}$$

$$V_{T2} = 6428 - 774 = 5654 \text{ lb}$$



Fitting

Use 1/2-20 UNF bolt
with 180,000 psi U.T.S.
socket head cap screw



Fiber stress

$$\sigma = \frac{11591}{2 \times 2 \times .1} = 28,977 \text{ psi}$$

Bond stress of broom

$$\tau = \frac{11591 \times 2}{8 \times 8 \times .4325} = 827 \text{ psi}$$

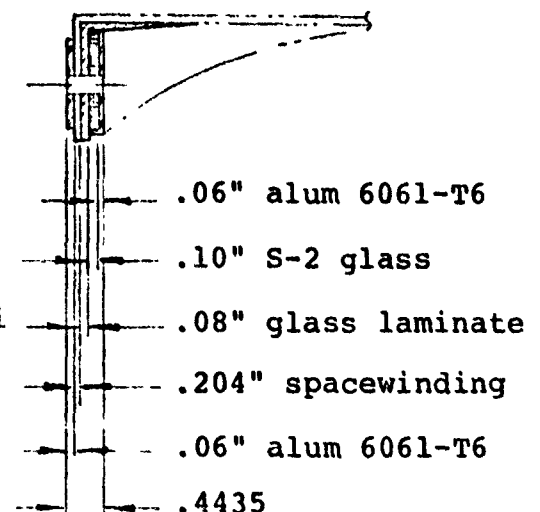
$$\text{Shear strength} = 180,000 \times .6 \times \pi (.25)^2 = 21,205 \text{ lb}$$

Bond stress of fitting end 2" x 2"

$$\tau = \frac{(774^2 + 7207^2)^{1/2}}{(2 \times 2) - (\pi \times .25^2)} = 1905 \text{ psi}$$

Bearing stress on metal insert

$$\sigma_{br} = \frac{(774^2 + 7207^2)^{1/2}}{(.5) (.4435)} = 16,343 \text{ psi}$$



APPENDIX D
MATERIAL PROPERTY COMPUTER PROGRAM

MATERIAL PROPERTY COMPUTER OUTPUT

NOMENCLATURE

AF	Fiber thermal expansion coefficient, in/in/F°
AFT	Fiber transverse thermal expansion coefficient, in/in/F°
AR	Resin thermal expansion coefficient, in/in/F°
AX	Composite thermal expansion coefficient in x-direction, in/in/F°
AY	Composite thermal expansion coefficient in y-direction, in/in/F°
EF	Fiber modulus, psi
EFT	Fiber transverse modulus, psi
ER	Resin modulus, psi
EX	Composite modulus in x-direction, psi
EY	Composite modulus in y-direction, psi
FCU	Fiber compressive strength, psi
FTU	Fiber tensile strength, psi
FXCU	Composite compressive strength in x-direction, psi
FXTU	Composite tensile strength in x-direction, psi
FXY	Composite shear strength, psi
FYCU	Composite compressive strength in y-direction, psi
FYTU	Composite tensile strength in y-direction, psi
GF	Fiber shear modulus, psi
GXY	Composite shear modulus, psi
RHO	Resin density, lb/in ³
TF	Fiber thickness, in
UF	Fiber Poisson's ratio
UXY	Composite Poisson's ratio
UYX	Composite Poisson's ratio

```

PROGRAM SWPRGR(INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT)
DIMENSION B21(10),B22(10),B33(10),B12(10),B13(10),B23(10),Q11L(10)
000003 1,Q22M(10),Q11N(10),Q12N(10),Q22N(10),Q66N(10),FTU(10),FCU(10),
000015 2,Q12L(10),Q12M(10), T(10),EF(10),EFT(10),GF(10),RHOF(10),UF(10)
000020 3,VF(10),HEAD(16),A(10),Q11S(10),Q12S(10),Q22S(10),Q66S(10),
000036 4AF(10),AFT(10),BT1(10),BT2(10),A1B(10),A2B(10),CK(10)
000044 1 READ(5,2)(HEAD(I),I=1,16)
000044 2 FORMAT(16A5)
000050 3 IF(EOF,5)110,4
000065 4 READ(5,5)RHOR,UR,ER,AR,K
000071 5 FORMAT(2F10.4,2E10.3,1I5)
000071 6 WRITE(6,7)HEAD
000071 7 FORMAT(1H1,16A5//)
000071 8 GR=ER/(2.+(1.+UR))
000071 9 WRITE(6,9)RHOR,UR,ER,GR,AR
000071 10 FORMAT(5X,16HRESIN PROPERTIES//6X,4HRHO=F6.4,5X,3HUR=F6.4,5X,3HER=
000071 1E10.3,5X,3HGR=E10.3,5X,3HAR=E10.3//)
000071 11 WRITE(6,10)
000071 12 FORMAT(5X,16HFIBER PROPERTIES//5X,127HNO. ALPHA TF VF
000071 13 EF EFT GF AF AFT UF
000071 14 RHOF FTU FCU CK/)
000071 15 2CU/)
000071 16 RQ11=J.
000072 17 RQ12=C.
000072 18 RQ22=J.
000073 19 RQ66=J.
000074 20 RS11=C.
000075 21 RS12=C.
000076 22 RS22=C.
000077 23 RS66=J.
000100 24 TT=J.
000101 25 RHO=C.
000103 26 DO 20 I=1,K
000104 27 READ(5,12)A(I),T(I),RHOF(I),UF(I),VF(I),EF(I),EFT(I),GF(I),AF(I),A
000141 28 1FT(I),FTU(I),FCU(I),CK(I)
000141 29 12 FORMAT(5F10.4/5E10.3,2F10.4/1F10.4)
000201 30 WRITE(6,14)I,A(I),T(I),VF(I),EF(I),EFT(I),GF(I),AF(I),AFT(I),UF(I)
000201 31 1,RHOF(I),FTU(I),FCU(I),CK(I)
000203 32 14 FORMAT(17,F8.2,2F8.4,5E12.3,2F8.4,2F10.0,1F6.4)
000205 33 FTU(I)=FTU(I)*VF(I)
000207 34 FCU(I)=FCU(I)*VF(I)
000211 35 TT=TT+T(I)
000213 36 T(I)=T(I)*CK(I)
000215 37 A=A(I)/57.29578
000216 38 S1=SIN(A)
000219 39 S2=S1**2
000220 40 S3=S1*S2
000222 41 S4=S2**2
000224 42 C1=COS(A)
000225 43 C2=C1**2
000227 44 C3=C1*C2
000231 45 C4=C2**2
000235 46 S2A=SIN(2.*A)
000241 47 C2A=COS(2.*A)
000245 48 IF(1.-VF(I))18,18,16
000245 49 16 CONTINUE
000245 50 ULT=UF(I)*VF(I)+UR*(1.-VF(I))

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00252 C=SQRT(VF(I))
00254 EL=EF(I)*VF(I)+(1.-VF(I))*ER
00262 EC=EFT(I)
00263 ET=((C*EC+(1.-C)*ER)*ER)/(C*ER+(1.-2.*UR**2)*(1.-C)*(C*EC+(1.-C)*
1ER))*CK(I)
00302 UTL=JLT*ET/LL
00305 U=1.-ULT*JTL
00310 GLT=GR*(GF(I)+C+GR*(1.-C))/((1.-C)*(GF(I)+C+GR*(1.-C))+GR*C)*CK(I)
00324 GO TO 19
00324 18 CONTINUE
00324 EL=EF(I)
00326 ET=EF(I)
00327 U=1.-UF(I)**2
00332 GLT=GF(I)
00334 19 B11(I)=1./U*(EL+C4+LT*S4+(2.*EL*UTL+4.*U*GLT)*S2*C2)
00350 B22(I)=1./U*(ET+C4+EL*S4+(2.*EL*UTL+4.*U*GLT)*S2*C2)
00365 B33(I)=1./U*((EL+LT-2.*EL*UTL)*S2+C2+U*GLT*(C2-S2)**2)
00401 B12(I)=1./U*((EL+ET-4.*U*GLT)*S2*C2+EL*UTL*(C4+S4))
00416 B13(I)=1./U*((ET-EL*UTL-2.*U*GLT)*S3*C1-(EL-EL*UTL-2.*U*GLT)*S1*C3
C)
00437 B23(I)=1./U*((ET-EL*UTL-2.*U*GLT)*S1*C3-(EL-EL*UTL-2.*U*GLT)*S3*C1
C)
00461 E1=EL/(C4+EL*S4/ET+.25*(EL/GLT-2.*ULT)*S2A*S2A)
00473 E2=EL/(S4+EL*C4/ET+.25*(EL/GLT-2.*ULT)*S2A*S2A)
00505 G12=EL/(1.+2.*ULT+EL/ET-(1.+2.*ULT+EL/ET-EL/GLT)*C2A*C2A)
00524 U12=E1/EL*(ULT-.25*(1.+2.*ULT+EL/ET-EL/GLT)*S2A*S2A)
00537 U21=J12**E2/E1
00541 B1=S2A*(2.*ULT+LL/ET-.5*EL/GLT-C2*(1.+2.*ULT+EL/ET-EL/GLT))
00556 B2=S2A*(2.*ULT+EL/ET-.5*EL/GLT-S2*(1.+2.*ULT+EL/ET-EL/GLT))
00573 E1B=EL/(EL/E1-B1*B1*G12/EL)
00601 E2B=EL/(EL/E2-B2*B2*G12/EL)
00606 U21B=L23/EL*(U21*LL/E2+B1*B2*G12/EL)
00615 U12B=E1B/LL*(U12*EL/E1+B1*B2*G12/EL)
00623 G12B=EL*(1.-U12*U21)/(EL*(1.-U12*U21)/G12-B1*E1/EL*(B1+U21*B2)-
B2*
E2/LL*(B2+U12*B1))
00646 AL=(AR*(1.-VF(I))*ER+AF(I)*VF(I)*EF(I))/EL
00656 B=SQRT(VF(I)/3.1415926)
00663 AO=AR*(1.-2.*B)+2.*AFT(I)+B-UR*(AFT(I)-AR)*(1.-2.*B)
00677 EO=ER*AFT(I)/(EFT(I)*(1.-2.*B)+2.*ER*B)
00710 AT=(AO+EO*B+AR*ER*(1.-B))/ET
00717 A1=AL+C2+AT*S2
00722 A2=AL+S2+AT*C2
00726 A12=2.*(AT-AL)*S1*C1
00731 BT1(I)=L13+T(I)/(1.-U12*U21)
00737 BT2(I)=L23+T(I)/(1.-U12*U21)
00744 A1B(I)=A1-A12+B1*G12/EL
00751 A2B(I)=A2-A12+B2*G12/LL
C
00757 STRENGTH CALCULATIONS
00757 LT=0.
00757 ULT=0.
00760 UTL=0.
00761 PSI=1.
00763 U1=1./(3.*PSI)*(EL+LT+UTL+LL+ULT*ET)
00771 U2=1./(2.*PSI)*(PSI*GLT-.5*(JTL+EL+ULT*ET))
00801 U3=1./(2.*PSI)*(EL-LT)
00806 U4=1./(6.*PSI)*(EL+LT-(UTL+LL+ULT*ET)-4.*PSI*GLT)
00821 Q11L(I)=3.*U1+U2+U3+U4
00827 Q12L(I)=U1-U2-U4

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001031 Q12M(I)=U1-U2-U4
001033 Q22M(I)=3.*U1+U2+U3+U4
001040 Q11N(I)=3.*U1+U2+U3+COS(2.*A)+U4*COS(4.*A)
001057 Q12N(I)=U1-U2-U4*COS(4.*A)
001070 Q22N(I)=3.*U1+U2-U3+COS(2.*A)+U4*COS(4.*A)
001106 Q66N(I)=U1+U2-U4*COS(4.*A)
001117 A=.785398-A
001120 Q11S(I)=3.*U1+U2+U3+COS(2.*A)+U4*COS(4.*A)
001137 Q12S(I)=U1-U2-U4*COS(4.*A)
001150 Q22S(I)=3.*U1+U2-U3+COS(2.*A)+U4*COS(4.*A)
001166 Q66S(I)=U1+U2-U4*COS(4.*A)
001177 2. CONTINUE
001201 RHO=RHO/TT
001203 BB11=0.
001203 BB12=0.
001204 BB22=0.
001205 BB33=0.
001206 SBA1=0.
001207 SBA2=0.
001210 SB1=0.
001211 SB2=0.
001213 DO 30 I=1,K
001214 RHO=(VF(I)*RHOF(I)+(1.-VF(I))*RHOR)*T(I)/TT+RHO
001225 BB11=BB11+BB11(I)*T(I)
001227 BB12=BB12+BB12(I)*T(I)
001232 BB22=BB22+BB22(I)*T(I)
001235 BB33=BB33+BB33(I)*T(I)
001240 RQ11=Q11N(I)*T(I)/TT+RQ11
001244 RQ12=Q12N(I)*T(I)/TT+RQ12
001247 RQ22=Q22N(I)*T(I)/TT+RQ22
001252 RQ66=Q66N(I)*T(I)/TT+RQ66
001255 RS11=Q11S(I)*T(I)/TT+RS11
001260 RS12=Q12S(I)*T(I)/TT+RS12
001263 RS22=Q22S(I)*T(I)/TT+RS22
001266 RS66=Q66S(I)*T(I)/TT+RS66
001271 SBA1=SBA1+BT1(I)*A1B(I)
001274 SBA2=SBA2+BT2(I)*A2B(I)
001277 SB1=SB1+BT1(I)
001301 SB2=SB2+BT2(I)
001303 30 CONTINUE
001305 BX=BB11-BB12**2/BB22
001310 BY=BB22-BB12**2/BB11
001314 UXY=BB12/BB22
001315 UYX=BB12/BB11
001316 EX=BX/TT
001320 EY=BY/TT
001321 BXY=BB33
001323 GXY=BXY/TT
001324 AX=SBA1/SB1
001326 AY=SBA2/SB2
001331 21 WRITE(6,22)EX,UXY,EY,UYX,GXY,RHO,AX,AY
001355 22 FORMAT(/,5X,2,LCOMPOSITE PROPERTIES//6X,3HEX=E11.3,5X,4HUXY=F6.4/6
1X,3HEY=E11.3,5X,4HUYX=F6.4/6X,4HGXY=E10.3,5X,4HRHO=F6.4/
26X,3HAX=E11.3/6X,3HAY=E11.3/ /5X,54HNO.
3 FXIU FYTU FXCU FYCU FXY/)
001355 DO 40 I=1,K
001357 FXU=FTU(I)*(RQ11+RQ22-RQ12+RQ12)/(Q11L(I)*RQ22-Q12L(I)*RQ12)
001367 FYU=FTU(I)*(RQ11+RQ22-RQ12+RQ12)/(Q22M(I)*RQ11-Q12M(I)*RQ12)

```

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001376      FXCU=FCU(I)*(RQ11*RQ22-RQ12*RQ12)/(Q11L(I)*RQ22-Q12L(I)*RQ12)
001406      FYCU=FCU(I)*(RQ11*RQ22-RQ12*RQ12)/(Q12M(I)*RQ11-Q12M(I)*RQ12)
001415      FSTU=FTU(I)*(RS11*RS22-RS12*RS12)/(Q11L(I)*RS22-Q12L(I)*RS12)
001425      FSCU=FCU(I)*(RS11*RS22-RS12*RS12)/(Q11L(I)*RS22-Q12L(I)*RS12)
001435      FXY  =FSTU/((1.+(FSTU/FSCU)**2+FSTU/FSCU)**.5)/2.
001446      24 WRITE(6,26)I,FXTU,FYTU,FXCU,FYCU,FX
001466      26 FORMAT(17,3X,5F10.0)
001466      +. CONTINUE
001471      GO TO 1
001471      110 STOP
001473      END

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APPENDIX E
MATERIAL PROPERTIES, UNITS 1-6

S-GLASS/EPOXY

RESIN PROPERTIES

RHO= .0412 UR= .3500 ER= 4.700E+05 GR= 1.741E+05 AR= 4.000E-0

FIBER PROPERTIES

NO.	ALPHA	TF	VF	EF	EFT	GF	AF
1	90.00	.2000	.5000	1.260E+07	1.260E+07	4.000E+05	2.200E-06
2	24.00	.8000	.5000	1.260E+07	1.260E+07	4.000E+05	2.200E-06

COMPOSITE PROPERTIES

EX= 8.536E+05 UXY= .4794
EY= 3.957E+05 UYX= .2222
GXY= 1.961E+05 RHO= .0164
AX= -3.826E-06
AY= 1.533E-05

NO.	FXTU	FYTU	FXCU	FYCU	FXCY
1	20800	8382	13760	5545	3735
2	20800	8382	13760	5545	3735

4.3529

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1.741E+05 AR= 4.000E-05

GF	AF	AFT	UF	RHOF	FTU	FCU	CK
4.000E+05	2.200E-06	2.200E-06	.2200	.0900	325000	215000	.2500
4.000E+05	2.200E-06	2.200E-06	.2200	.0900	325000	215000	.2500

FXV

3735

3735

FRACTICABLE

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J

S-GLASS/EPOXY

RESIN PROPERTIES

RHO= .0412 UR= .3500 ER= 4.700E+05 GR= 1.741E+05 AR= 4.000E-05

FIBER PROPERTIES

NO.	ALPHA	TF	VF	EF	EFT	GF	AF	AFT
1	90.00	.2000	.5000	1.260E+07	1.260E+07	4.000E+05	2.200E-06	2.20
2	24.00	.8000	.5000	1.260E+07	1.260E+07	4.000E+05	2.200E-06	2.20

COMPOSITE PROPERTIES

EX= 1.774E+06 UXY= .4667
EY= 9.287E+05 UYX= .2444
GXY= 4.236E+05 RHO= .0328
AX= 7.622E-07
AY= 1.194E-05

NO.	FXTU	FYTU	FXCU	FYCU	FXU
1	42364	17271	28025	11426	8306
2	42364	17271	28025	11426	8306

4.1879

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741E+05

AR= 4.000E-05

GF	AF	AFT	UF	PHOF	FTU	FCU	CK
4.000E+05	2.200E-06	2.200E-06	.2200	.0900	325000	215000	.5000
4.000E+05	2.200E-06	2.200E-06	.2200	.0900	325000	215000	.5000

Y
06
06

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2

KEVLAR 49/LPOXY

PESIN PROPERTIES

RHO= .8412 UR= .3530 ER= 4.701E+05 GR= 1.741E+05 AR= 4.100E-05

FIBER PROPERTIES

NO.	ALPHA	TF	VF	EF	EFT	GF	AF	AFT
1	98.00	.2000	.5300	1.900E+07	1.000E+06	3.000E+05	-3.440E-06	3.000
2	24.00	.0300	.5000	1.900E+07	1.000E+06	3.000E+05	-3.440E-06	3.000

COMPOSITE PROPERTIES

EX= 1.243E+06 UXY= .4833
 EY= 5.215E+05 UYX= .2023
 GXY= 2.795E+05 RHO= .6117
 AX= -2.000E-05
 AY= 5.809E-06

NO.	FXTU	FYTU	FXDU	FYCU	FXU
1	24129	9670	4445	1782	1513
2	24129	9676	4445	1782	1513

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41E+05 AR= 4.00E-05

GF	AF	AFT	UF	RHOF	FTU	FCU	CK
000E+05	-3.440E-06	3.000E-05	.2200	.0524	380000	70000	.2500
000E+05	-3.440E-06	3.000E-05	.2200	.0524	380000	70000	.2500

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2

KEVLAR 49/EPOXY

RESIN PROPERTIES

RHO= .0412 UR= .3500 ER= 4.700E+05 GR= 1.741E+05 AR= 4.000E-05

FIBER PROPERTIES

NO.	ALPHA	TF	VF	EF	EFT	GF	AF	AFT
1	90.00	.2000	.5000	1.900E+07	1.000E+06	3.000E+05	-3.440E-06	3.000E
2	24.00	.8000	.5000	1.900E+07	1.000E+06	3.000E+05	-3.440E-06	3.000E

COMPOSITE PROPERTIES

EX= 2.529E+06 UXY= .4707
 EY= 1.109E+06 UYX= .2063
 GXY= 5.804E+05 RHO= .0234
 AX= -1.103E-05
 AY= 5.396E-06

NO.	FXTU	FYTU	FXCU	FYCU	FXU
1	48792	19702	8988	3629	3256
2	48792	19702	8988	3629	3256

4.3573

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741E+05 AR= 4.000E-05

GF	AF	AFT	UF	RHOF	FTU	FCU	CK
3.000E+05	-3.440E-06	3.000E-05	.2200	.0524	380000	70000	.5000
3.000E+05	-3.440E-06	3.000E-05	.2200	.0524	380000	70000	.5000

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56
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2

THORNEL 300/EPOXY

RESIN PROPERTIES

RHO= .0412 UR= .3500 ER= 4.700E+05 GR= 1.741E+05 AR= 4.000E-05

FIBER PROPERTIES

NO.	ALPHA	TF	VF	EF	EFT	GF	AF	
1	90.00	.2000	.5000	3.400E+07	1.300E+06	3.500E+06	-2.400E-07	2.
2	24.00	.8000	.5000	3.400E+07	1.300E+06	3.500E+06	-2.400E-07	2.

COMPOSITE PROPERTIES

EX= 2.203E+06 UXY= .4781
EY= 9.103E+05 UYX= .1975
GXY= 4.968E+05 RHO= .0131
AX= -8.847E-06
AY= 3.277E-06

NO.	FXTU	FYTU	FXCU	FYCU	FXU
1	20696	8314	13691	5500	3612
2	20696	8314	13691	5500	3612

4.4344

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741E+05 AR= 4.003E-05

GF	AF	AFT	UF	RHOF	FTU	FCU	CK
7.500E+06	-2.400E-07	2.960E-06	.2200	.0636	325000	215000	.2500
3.500E+06	-2.400E-07	2.960E-06	.2200	.0636	325000	215000	.2500

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THORNEL 300/EPOXY

RESIN PROPERTIES

RHO= .0412 UR= .3500 ER= 4.700E+05 GR= 1.741E+05 AR= 4.000E-05

FIBER PROPERTIES

NO.	ALPHA	TF	VF	EF	EFT	GF	AF	AI
1	90.00	.2000	.5000	3.400E+07	1.300E+06	3.500E+06	-2.400E-07	2.
2	24.00	.8000	.5000	3.400E+07	1.300E+06	3.500E+06	-2.400E-07	2.

COMPOSITE PROPERTIES

EX= 4.484E+06 UXY= .4603
 EY= 1.918E+06 UYX= .1969
 GXY= 1.035E+06 RHO= .0262
 AX= -3.869E-06
 AY= 3.107E-06

NO.	FXTU	FYTU	FXCU	FYCU	FXU
1	41962	17003	27759	11248	7877
2	41962	17003	27759	11248	7877

4.3324

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.741E+05

AR= 4.100E-05

GF	AF	AFT	UF	RHOF	FTU	FCU	CK
3.500E+06	-2.400E-07	2.960E-06	.2200	.0636	325000	215000	.5000
3.500E+06	-2.400E-07	2.960E-06	.2200	.0636	325000	215000	.5000

77
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APPENDIX F
MATERIALS PROPERTIES
UNITS 7-10

*FCR 25 2

KEVLAR 49/EPOXY

RESIN PROPERTIES

RHO= .0412 UR= .3500 CR= 4.700E+05 GR= 1.741E+05 AR= 4.000E-05

FIBER PROPERTIES

NO.	ALPHA	TF	VF	EF	EFT	GF	AF	AFT
1	90.00	.2300	.5000	1.900E+07	1.000E+06	3.000E+05	-3.440E-06	3.000
2	24.00	.8000	.6500	1.900E+07	1.000E+06	3.000E+05	-3.440E-06	3.000

COMPOSITE PROPERTIES

EX= 1.553E+06 UXY= .5977
EY= 5.232E+05 UYX= .2013
GXY= 3.571E+05 RHO= .0120
AX= -2.124E-05
AY= 6.293E-06

NO.	FXTU	FYTU	FXCU	FYCU	FXY
1	30173	9691	5558	1785	1837
2	30513	9800	5621	1805	1858

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741E+05

AR= 4.000E-05

GF	AF	AFT	UF	RHCF	FTU	FCU	CK*
.000E+05	-3.440E-06	3.000E-05	.2200	.0524	380000	70000	.2500
.000E+05	-3.440E-06	3.000E-05	.2200	.0524	380000	70000	.2500

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*FCR 50?

KEVLAR 49/EPOXY

RESIN PROPERTIES

RHO= .0412 UR= .3500 ER= 4.700E+05 GR= 1.741E+05 AR= 4.000E-05

FIBER PROPERTIES

NO.	ALPHA	TF	VF	EF	EFT	GF	AF	AFT
1	90.00	.2000	.5000	1.900E+07	1.000E+16	3.000E+05	-3.440E-06	3.00
2	24.00	.8000	.6500	1.900E+07	1.000E+06	3.000E+05	-3.440E-06	3.00

COMPOSITE PROPERTIES

EX= 3.156E+06 JXY= .5762
EY= 1.119E+06 UYX= .2044
GXY= 7.371E+05 RHO= .0241
AX= -1.168E-05
AY= 5.739E-06

NO.	FXTU	FYTU	FXCU	FYCU	FXV
1	61024	19760	11241	3640	3958
2	61711	19983	11368	3681	4003

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741E+05

AR= 4.000E-05

GF	AF	AFT	UF	RHOF	FTU	FCU	CK*
3.000E+05	-3.440E-06	3.000E-05	.2200	.0524	380000	70000	.5000
3.000E+05	-3.440E-06	3.000E-05	.2200	.0524	380000	70000	.5000

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03

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KEVLAR 49/EPOXY

RESIN PROPERTIES

RHO= .0412 UR= .3500 ER= 4.761E+05 GP= 1.741E+05 AR= 4.000E-05

FIBER PROPERTIES

NO.	ALPHA	TF	VF	EF	EFT	GF	AF	AFT
1	90.00	.2000	.5000	1.900E+07	1.000E+06	3.000E+05	-3.440E-06	3.000E-01
2	24.00	.8000	.3714	1.900E+07	1.000E+06	3.000E+05	-3.440E-06	3.000E-01

COMPOSITE PROPERTIES

EX= 9.650E+05 UXY= .3793
EY= 5.164E+05 UYX= .2337
GXY= 2.131E+05 RHO= .3114
AX= -1.993E-05
AY= 5.586E-06

NO.	FXTU	FYTU	FXCU	FYCU	FXU
1	18681	9665	3441	1783	1207
2	18374	9500	3385	1751	1187

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741E+05

AR= 4.000E-05

GF	AF	AFT	UF	RHOF	FTU	FCU	CK
0.000E+05	-3.440E-06	3.000E-05	.2200	.0524	380000	70000	.2500
0.000E+05	-3.440E-06	3.000E-05	.2200	.0524	380000	70000	.2500

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KEVLAR 49/EPOXY

RESIN PROPERTIES

RHO= .0412 UR= .3500 ER= 4.700E+05 GR= 1.741E+05 AR= 4.000E-05

FIBER PROPERTIES

NO.	ALPHA	TF	VF	EF	EFT	GF	AF	AFT
1	99.00	.2000	.5000	1.900E+07	1.000E+06	3.000E+05	-3.440E-06	3.00
2	24.00	.8000	.4333	1.900E+07	1.000E+06	3.000E+05	-3.440E-06	3.00

COMPOSITE PROPERTIES

EX= 2.241E+06 UXY= .4213
EY= 1.104E+06 UYX= .2976
GXY= 5.108E+05 RHC= .0231
AX= -1.359E-05
AY= 5.258E-06

NO.	FXTU	FYTU	FXCU	FYCU	FXCY
1	43148	19677	7948	3625	2923
2	42831	19532	7890	3598	2902

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41E+05

AR= 4.000E-05

GF	AF	AFT	UF	RHOF	FTU	FCU	CK
000E+05	-3.440E-06	3.000E-05	.2200	.0524	390000	70000	.5000
000E+05	-3.440E-06	3.000E-05	.2200	.0524	380000	70000	.5000

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KEVLAR 49/EPOXY

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FIBER PROPERTIES

VF = .3250
WF = .3793
RHOF = .0524
FTU = 325000.0
FCU = 70000.0
UF = .2200

EF = 1.900E+07
EFT = 1.700E+06
GF = 3.000E+05
AF = -2.000E-06
AFT = 3.000E-05

RESIN PROPERTIES

VR = .6750
WR = .6200
PHOR = .0412
FSU = 8000.0

ER = 4.700E+05
AR = 4.200E-05
UR = .3500

COMPOS

RHO =
FTU =
FCU =
FSU =

ALPHA	EX	EY	GXY	UXY	UVX	FXTU	FYTU	FZ
0.00	6.492E+06	6.998E+05	2.188E+05	.3177	.0732	R	-	227
1.00	6.488E+06	6.997E+05	2.107E+05	.3104	.0335	105375.5	4.1	227
2.00	6.473E+06	6.992E+05	2.161E+05	.3181	.0304	104633.3	16.5	226
3.00	6.449E+06	6.983E+05	2.252E+05	.3311	.0358	103417.4	37.3	226
4.00	6.415E+06	6.971E+05	2.379E+05	.3491	.0379	101757.9	66.4	225
5.00	6.372E+06	6.956E+05	2.540E+05	.3721	.0406	99694.3	103.9	223
6.00	6.318E+06	6.938E+05	2.734E+05	.3999	.0439	97273.5	149.9	222
7.00	6.257E+06	6.916E+05	2.966E+05	.4323	.0478	94546.9	204.5	220
8.00	6.176E+06	6.892E+05	3.227E+05	.4692	.0523	91568.4	267.8	217
9.00	6.089E+06	6.864E+05	3.520E+05	.5101	.0575	89391.7	339.8	214
10.00	5.989E+06	6.833E+05	3.842E+05	.5549	.0633	85068.9	420.9	211
11.00	5.878E+06	6.799E+05	4.192E+05	.6029	.0697	81648.5	511.0	208
12.00	5.754E+06	6.763E+05	4.568E+05	.6530	.0768	78174.7	610.5	203
13.00	5.619E+06	6.723E+05	4.969E+05	.7071	.0840	74686.3	719.5	198
14.00	5.469E+06	6.682E+05	5.392E+05	.7649	.0931	71217.0	838.2	191
15.00	5.318E+06	6.638E+05	5.836E+05	.8178	.1023	67795.0	966.8	184
16.00	5.136E+06	6.591E+05	6.298E+05	.8736	.1121	64443.7	1105.8	180
17.00	4.953E+06	6.543E+05	6.776E+05	.9292	.1228	61180.1	1255.8	177
18.00	4.759E+06	6.494E+05	7.267E+05	.9832	.1341	58019.3	1415.5	170
19.00	4.558E+06	6.442E+05	7.770E+05	1.0350	.1467	54971.1	1587.0	166
20.00	4.349E+06	6.390E+05	8.282E+05	1.0837	.1593	52042.3	1770.3	159
21.00	4.134E+06	6.337E+05	8.801E+05	1.1285	.1730	49237.2	1965.4	154
22.00	3.915E+06	6.284E+05	9.322E+05	1.1689	.1876	46557.7	2172.9	149
23.00	3.694E+06	6.232E+05	9.845E+05	1.2041	.2031	44003.7	2393.3	143
24.00	3.474E+06	6.181E+05	1.037E+06	1.2337	.2195	41574.0	2627.1	137
25.00	3.255E+06	6.129E+05	1.088E+06	1.2573	.2368	39266.0	2874.8	131
26.00	3.041E+06	6.081E+05	1.140E+06	1.2747	.2550	37076.3	3137.0	124
27.00	2.831E+06	6.035E+05	1.192E+06	1.2850	.2742	35001.0	3414.4	118
28.00	2.623E+06	5.994E+05	1.239E+06	1.2908	.2944	33035.7	3707.5	111
29.00	2.425E+06	5.957E+05	1.287E+06	1.2898	.3156	31175.7	4017.0	105
30.00	2.237E+06	5.926E+05	1.333E+06	1.2829	.3378	29416.1	4344.0	99
31.00	2.077E+06	5.903E+05	1.377E+06	1.2707	.3611	27752.2	4689.0	93
32.00	1.914E+06	5.884E+05	1.420E+06	1.2535	.3856	26173.9	5052.9	87
33.00	1.763E+06	5.883E+05	1.463E+06	1.2320	.4111	24691.6	5436.7	81
34.00	1.623E+06	5.891E+05	1.497E+06	1.2065	.4378	23285.7	5841.4	75
35.00	1.495E+06	5.912E+05	1.532E+06	1.1776	.4656	21956.5	6268.1	69
36.00	1.379E+06	5.951E+05	1.568E+06	1.1458	.4946	20699.0	6719.8	63
37.00	1.273E+06	6.007E+05	1.594E+06	1.1117	.5247	19511.7	7192.1	57
38.00	1.178E+06	6.085E+05	1.621E+06	1.0758	.5560	18388.0	7692.0	51
39.00	1.092E+06	6.188E+05	1.643E+06	1.0384	.5884	17325.1	8218.9	45
40.00	1.018E+06	6.310E+05	1.663E+06	1.0000	.6219	16319.4	8774.5	39
41.00	9.488E+05	6.448E+05	1.679E+06	.9610	.6565	15367.6	9360.2	33
42.00	8.895E+05	6.601E+05	1.692E+06	.9216	.6921	14466.8	9977.3	27
43.00	8.375E+05	6.810E+05	1.701E+06	.8822	.7287	13613.8	10629.4	21
44.00	7.925E+05	7.033E+05	1.706E+06	.8437	.7662	12815.0	11316.7	15
45.00	7.535E+05	7.536E+05	1.703E+06	.8043	.8043	12040.7	12041.7	9

TIFS

ER = 4.700E+05
AR = 4.000E-05
UR = .3500

COMPOSITE PROPERTIES

RHO = .0448
FTU = 105625.0
FCU = 22751.0
FSU = 8000.0

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UVX

FXTU

FYTU

FXCU

FYCU

FX

AX

AY

UVX	FXTU	FYTU	FXCU	FYCU	FX	AX	AY
0072							
0075	115375.5		22750.0	2430.0	1190.2	5.237E-08	7.714E-05
0078	104633.3	4.1	22735.4	2429.4	1254.9	4.438E-08	3.14E-05
0081	103417.4	16.5	22691.3	2427.7	1328.9	2.042E-08	3.013E-05
0084	101757.9	37.3	22617.3	2424.9	1412.9	-1.954E-08	3.012E-05
0087	99694.3	66.4	22512.6	2421.0	1508.1	-7.549E-08	3.011E-05
0090	97273.5	103.9	22376.1	2416.0	1615.3	-1.475E-07	3.008E-05
0093	94546.9	149.3	22216.4	2409.9	1735.4	-2.355E-07	3.005E-05
0096	91568.4	204.5	22020.0	2402.7	1869.3	-3.395E-07	3.001E-05
0099	89391.7	267.9	21761.1	2394.5	2017.9	-4.595E-07	2.997E-05
0102	88068.9	339.9	21482.1	2385.2	2181.7	-5.958E-07	2.992E-05
0105	81648.5	421.9	21153.1	2374.9	2351.4	-7.473E-07	2.985E-05
0108	78174.7	511.0	20820.6	2363.7	2557.3	-9.159E-07	2.978E-05
0111	74686.3	610.5	20389.1	2351.6	2769.6	-1.100E-06	2.971E-05
0114	71217.0	719.5	19951.7	2338.5	2998.3	-1.299E-06	2.961E-05
0117	67795.0	838.0	19459.9	2324.7	3243.0	-1.514E-06	2.951E-05
0120	64443.7	966.8	18973.9	2310.0	3503.3	-1.743E-06	2.937E-05
0123	61180.1	1105.8	18444.5	2294.7	3778.2	-1.987E-06	2.923E-05
0126	58019.7	1255.0	17723.6	2278.8	4066.5	-2.244E-06	2.906E-05
0129	54971.1	1415.3	17054.0	2262.3	4365.8	-2.514E-06	2.888E-05
0132	52042.3	1587.1	16359.3	2245.4	4677.7	-2.795E-06	2.866E-05
0135	49237.2	1770.3	15644.2	2228.1	4995.1	-3.087E-06	2.842E-05
0138	46557.7	1965.4	14894.3	2210.7	5320.9	-3.386E-06	2.815E-05
0141	44003.7	2172.7	14126.0	2193.3	5649.4	-3.692E-06	2.784E-05
0144	41574.0	2393.3	13346.0	2176.0	5979.1	-4.001E-06	2.749E-05
0147	39266.0	2627.1	12551.7	2159.0	6307.7	-4.309E-06	2.709E-05
0150	37076.3	2874.8	11780.4	2142.6	6632.4	-4.613E-06	2.665E-05
0153	35001.0	3137.0	11029.2	2127.0	6951.1	-4.913E-06	2.614E-05
0156	33035.7	3414.4	10255.0	2112.5	7261.4	-5.188E-06	2.558E-05
0159	31175.7	3707.0	9524.0	2099.3	7561.3	-5.445E-06	2.495E-05
0162	29416.1	4017.0	8821.7	2087.0	7848.9	-5.675E-06	2.425E-05
0165	27752.2	4344.0	8152.6	2076.7	8122.5	-5.867E-06	2.347E-05
0168	26173.9	4689.0	7520.3	2072.1	8381.8	-6.011E-06	2.261E-05
0171	24691.6	5052.3	6927.3	2068.6	8622.8	-6.197E-06	2.166E-05
0174	23285.7	5436.7	6375.5	2068.7	8847.5	-6.413E-06	2.062E-05
0177	21956.5	5841.4	5855.5	2073.3	9054.3	-6.645E-06	1.948E-05
0180	20699.0	6268.1	5397.4	2082.8	9242.9	-6.884E-06	1.825E-05
0183	19511.7	6718.0	4970.6	2098.2	9413.0	-7.125E-06	1.693E-05
0186	18388.0	7192.1	4583.7	2120.4	9564.6	-7.375E-06	1.552E-05
0189	17325.1	7692.1	4235.7	2150.3	9697.7	-7.635E-06	1.404E-05
0192	16319.4	8218.3	3923.1	2180.1	9812.5	-7.905E-06	1.248E-05
0195	15367.6	8774.5	3645.1	2237.9	9909.3	-8.185E-06	1.088E-05
0198	14466.8	9360.2	3390.1	2298.2	9987.7	-8.475E-06	9.239E-06
0201	13613.0	9977.3	3162.4	2371.4	10048.6	-8.775E-06	7.589E-06
0204	12805.0	10629.4	2942.8	2459.2	10092.1	-9.085E-06	5.952E-06
0207	12040.7	11316.7	2737.9	2557.3	10117.9	-9.405E-06	4.357E-06
0210		12041.7	2545.4	2665.6	10126.5	-9.735E-06	2.814E-06

KEVLAR 49/EPOXY

THIS PAGE IS BEST QUALITY PRACTICABLE
FROM COPY FURNISHED TO DDC

FIBER PROPERTIES

VF = .6500
WF = .7026
RHOF = .0524
FTU = 325000.0
FCU = 70000.0
UF = .2200

EF = 1.900E+07
EFT = 1.000E+06
GF = 3.000E+05
AF = -2.000E-06
AFT = 3.300E-05

RESIN PROPERTIES

VR = .3500
WR = .2974
RHOR = .0412
FSU = 8000.0

COMPO

ER = 4.700E+05
AR = 4.000E-05
UR = .3500

RHO =
FTU =
FCU =
FSU =

ALPHA	EX	EY	GXY	UXY	UYX	FXTU	FYTU	F
.00	1.251E+07	8.266E+05	2.475E+05	.2655	.0175	211250.0		
1.00	1.251E+07	8.264E+05	2.513E+05	.2699	.0178	210439.9		451
2.00	1.248E+07	8.258E+05	2.622E+05	.2831	.0187	208044.5	5.1	451
3.00	1.243E+07	8.248E+05	2.803E+05	.3051	.0202	204164.8	27.4	451
4.00	1.236E+07	8.234E+05	3.056E+05	.3356	.0224	198957.9	45.9	451
5.00	1.228E+07	8.216E+05	3.379E+05	.3746	.0251	192621.2	81.7	451
6.00	1.217E+07	8.194E+05	3.770E+05	.4218	.0284	185375.5	127.9	447
7.00	1.203E+07	8.169E+05	4.228E+05	.4769	.0324	177448.3	194.5	447
8.00	1.188E+07	8.141E+05	4.750E+05	.5393	.0371	169058.8	251.3	439
9.00	1.169E+07	8.107E+05	5.334E+05	.6.85	.0422	160417.7	329.7	439
10.00	1.148E+07	8.070E+05	5.977E+05	.6838	.0481	151668.3	418.6	429
11.00	1.124E+07	8.030E+05	6.676E+05	.7643	.0546	142987.4	518.6	429
12.00	1.096E+07	7.987E+05	7.428E+05	.8490	.0619	134480.4	629.9	419
13.00	1.066E+07	7.940E+05	8.228E+05	.9366	.0698	126235.7	752.7	409
14.00	1.033E+07	7.891E+05	9.073E+05	1.0258	.0784	118316.9	887.4	399
15.00	9.958E+06	7.838E+05	9.959E+05	1.1151	.0878	110766.4	1034.7	389
16.00	9.564E+06	7.783E+05	1.0889E+06	1.2027	.0979	103609.6	1193.6	369
17.00	9.145E+06	7.726E+05	1.184E+06	1.2873	.1086	96857.9	1365.5	359
18.00	8.703E+06	7.666E+05	1.282E+06	1.3670	.1204	90512.3	1551.3	339
19.00	8.242E+06	7.603E+05	1.382E+06	1.4435	.1329	84565.8	1750.5	329
20.00	7.762E+06	7.543E+05	1.484E+06	1.5162	.1461	79000.0	1963.9	319
21.00	7.286E+06	7.480E+05	1.588E+06	1.5830	.1605	73816.4	2191.3	299
22.00	6.801E+06	7.417E+05	1.692E+06	1.6436	.1756	68973.5	2435.7	279
23.00	6.319E+06	7.354E+05	1.796E+06	1.6966	.1917	64472.0	2694.3	259
24.00	5.844E+06	7.292E+05	1.901E+06	1.7525	.2087	60276.5	2970.2	239
25.00	5.383E+06	7.232E+05	2.004E+06	1.8076	.2267	56371.5	3263.1	219
26.00	4.939E+06	7.174E+05	2.106E+06	1.8624	.2453	52736.9	3574.1	209
27.00	4.517E+06	7.120E+05	2.207E+06	1.9172	.2650	49353.5	3913.9	189
28.00	4.117E+06	7.071E+05	2.305E+06	1.9729	.2873	46203.0	4253.3	169
29.00	3.744E+06	7.024E+05	2.400E+06	2.0283	.3098	43268.2	4623.5	159
30.00	3.398E+06	6.992E+05	2.492E+06	2.0824	.3338	40533.0	5015.7	139
31.00	3.070E+06	6.966E+05	2.581E+06	2.1342	.3585	37982.2	5430.0	129
32.00	2.777E+06	6.951E+05	2.665E+06	2.1828	.3847	35602.0	5868.7	119
33.00	2.522E+06	6.946E+05	2.746E+06	2.2279	.4124	33379.4	6332.8	109
34.00	2.293E+06	6.962E+05	2.821E+06	2.2692	.4415	31302.5	6823.5	99
35.00	2.069E+06	6.993E+05	2.891E+06	2.3062	.4720	29360.4	7342.5	89
36.00	1.877E+06	7.046E+05	2.955E+06	2.3383	.5043	27540.9	7891.4	79
37.00	1.707E+06	7.124E+05	3.011E+06	2.3653	.5376	25840.9	8471.9	69
38.00	1.557E+06	7.231E+05	3.065E+06	2.3873	.5725	24245.8	9086.0	59
39.00	1.428E+06	7.372E+05	3.111E+06	2.4033	.6097	22749.8	9735.7	49
40.00	1.309E+06	7.551E+05	3.151E+06	2.4137	.6482	21345.7	10423.2	39
41.00	1.208E+06	7.773E+05	3.183E+06	2.4169	.6884	20027.0	11151.7	29
42.00	1.121E+06	8.046E+05	3.208E+06	.9653	.7304	18787.6	11921.7	19
43.00	1.045E+06	8.377E+05	3.226E+06	.9151	.7741	17622.1	12736.1	9
44.00	9.797E+05	8.773E+05	3.237E+06	.8664	.8194	16525.2	13603.4	0
45.00	9.247E+05	9.244E+05	3.241E+06		.8665	15432.7	14521.9	0

COMPOSITE PROPERTIES

ER = 4.700E+05 RHO = .0485
 AR = 4.000E-05 FTU = 211250.0
 UR = .3500 FCU = 45500.0
 FSU = 8000.0

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FROM COPY FURNISHED TO DDC

FXTU	FYTU	FXCU	FYCU	FX Y	AX	AY
211250.0	0	45500.0	2992.3	1508.6	-1.448E-06	2.931E-05
210439.9	5.1	45470.2	2991.5	1601.6	-1.457E-06	2.930E-05
208044.5	21.4	45380.0	2989.4	1709.1	-1.482E-06	2.930E-05
204164.8	45.9	45227.7	2985.9	1833.0	-1.525E-06	2.929E-05
198957.9	81.7	45010.1	2981.0	1975.1	-1.585E-06	2.927E-05
192621.2	127.9	44723.1	2974.6	2137.5	-1.664E-06	2.925E-05
185375.5	184.5	44361.6	2966.9	2322.2	-1.759E-06	2.922E-05
177448.3	251.8	43919.4	2957.9	2531.5	-1.872E-06	2.919E-05
169058.8	329.7	43390.2	2947.5	2767.4	-2.003E-06	2.915E-05
160417.7	418.6	42737.2	2935.8	3032.2	-2.151E-06	2.910E-05
151669.3	518.6	42043.7	2922.9	3327.9	-2.316E-06	2.904E-05
142987.4	629.9	41213.6	2908.7	3656.5	-2.500E-06	2.898E-05
134480.4	752.7	40272.0	2893.3	4019.7	-2.701E-06	2.890E-05
126235.7	887.4	39215.4	2876.9	4419.1	-2.919E-06	2.881E-05
118316.9	1034.3	38042.7	2859.3	4855.5	-3.155E-06	2.871E-05
110766.4	1193.6	36755.2	2840.8	5329.7	-3.419E-06	2.859E-05
103609.6	1365.3	35357.6	2821.4	5841.6	-3.679E-06	2.845E-05
96857.9	1551.3	33857.7	2801.2	6391.6	-3.964E-06	2.829E-05
90512.3	1750.5	32257.0	2780.2	6975.4	-4.265E-06	2.811E-05
84565.8	1953.9	30539.9	2758.7	7593.7	-4.582E-06	2.791E-05
79000.0	2191.9	28874.0	2736.8	8242.7	-4.911E-06	2.767E-05
73816.4	2435.7	27178.8	2714.6	8918.7	-5.252E-06	2.740E-05
68978.5	2694.3	25325.3	2692.4	9617.0	-5.602E-06	2.709E-05
64472.0	2971.2	23544.8	2670.3	10332.6	-5.959E-06	2.675E-05
60276.5	3263.1	21728.1	2648.6	11059.6	-6.319E-06	2.635E-05
56371.5	3574.1	20174.6	2627.6	11791.9	-6.679E-06	2.594E-05
52736.9	3917.9	18421.4	2607.5	12522.9	-7.033E-06	2.550E-05
49353.5	4253.3	16843.1	2588.8	13245.9	-7.375E-06	2.483E-05
46203.0	4623.5	15370.9	2571.9	13954.7	-7.700E-06	2.418E-05
43268.2	5015.3	13953.3	2557.3	14642.8	-7.997E-06	2.346E-05
40533.0	5430.0	12655.5	2545.4	15304.7	-8.259E-06	2.266E-05
37982.2	5868.7	11460.0	2536.8	15935.1	-8.474E-06	2.176E-05
35602.0	6332.8	10366.8	2532.4	16529.6	-8.631E-06	2.076E-05
33379.4	6823.5	9374.1	2532.8	17084.7	-8.715E-06	1.967E-05
31302.5	7342.5	8478.3	2539.0	17597.4	-8.712E-06	1.847E-05
29360.4	7891.4	7674.6	2551.0	18065.9	-8.608E-06	1.716E-05
27540.9	8471.9	6957.6	2572.7	18486.7	-8.387E-06	1.574E-05
25840.9	9096.0	6321.1	2602.6	18855.3	-8.134E-06	1.427E-05
24245.8	9735.7	5738.9	2642.5	19195.5	-7.836E-06	1.262E-05
22749.8	10423.2	5204.5	2694.5	19479.7	-7.482E-06	1.094E-05
21345.7	11151.7	4811.8	2761.8	19718.3	-7.065E-06	9.189E-06
20027.0	11921.7	4454.8	2847.4	19912.1	-6.580E-06	7.403E-06
18787.6	12738.1	4127.9	2949.5	20061.9	-6.031E-06	5.601E-06
17622.1	13603.4	3845.7	3073.2	20168.3	-5.425E-06	3.813E-06
16525.2	14521.8	3603.4	3221.3	20231.9	-4.752E-06	2.168E-06
15492.7	15494.0	3396.5	3396.8	20253.0	-4.032E-07	3.956E-07

KEVLAR 49/FPOXY

THIS PAGE IS BEST QUALITY PRACTICABLE
FROM COPY FURNISHED TO DDC

FIBER PROPERTIES

FESIN PROPERTIES

COMPOS

VF = .3714
WF = .4298
RHOF = .0524
FTU = 325000.0
FCU = 70000.0
UF = .2200

EF = 1.000E+07
EFT = 1.000E+06
GF = 3.000E+05
AF = -2.000E-06
AFT = 3.300E-05

VR = .6286
WR = .5710
RHOR = .0412
FSU = 8000.0

ER = 4.700E+05
AR = 4.000E-05
UP = .3500

RHO = .1
FTU = 1
FCU =
FSU =

ALPHA	EX	EY	GXY	UXY	UYX	FXTU	FYTU	FXC
.00	7.352E+06	7.164E+05	2.140E+05	.3317	.0294	120705.0	-0.7	2599
1.00	7.347E+06	7.162E+05	2.161E+05	.3046	.0297	120389.9	4.3	2598
2.00	7.330E+06	7.157E+05	2.223E+05	.3133	.0306	119453.7	17.1	2593
3.00	7.303E+06	7.148E+05	2.327E+05	.3278	.0321	117922.9	38.6	2584
4.00	7.265E+06	7.136E+05	2.471E+05	.3479	.0342	115839.4	68.7	2572
5.00	7.215E+06	7.121E+05	2.656E+05	.3735	.0369	113258.3	107.5	2555
6.00	7.152E+06	7.102E+05	2.881E+05	.4046	.0402	110243.7	155.0	2536
7.00	7.078E+06	7.081E+05	3.142E+05	.4408	.0441	106865.6	211.5	2513
8.00	6.991E+06	7.054E+05	3.441E+05	.4820	.0486	103196.1	276.9	2485
9.00	6.889E+06	7.022E+05	3.775E+05	.5277	.0533	99306.0	351.5	2452
10.00	6.774E+06	6.994E+05	4.143E+05	.5775	.0596	95262.9	435.3	2415
11.00	6.645E+06	6.961E+05	4.542E+05	.6311	.0661	91128.2	528.6	2372
12.00	6.501E+06	6.922E+05	4.972E+05	.6877	.0732	86957.1	631.6	2325
13.00	6.341E+06	6.882E+05	5.430E+05	.7468	.0811	82796.7	744.4	2272
14.00	6.168E+06	6.839E+05	5.913E+05	.8076	.0896	78685.8	867.3	2214
15.00	5.981E+06	6.794E+05	6.420E+05	.8693	.0988	74659.7	1000.5	2152
16.00	5.779E+06	6.747E+05	6.946E+05	.9310	.1087	70740.9	1144.5	2081
17.00	5.563E+06	6.697E+05	7.494E+05	.9918	.1194	66949.6	1299.3	2008
18.00	5.336E+06	6.646E+05	8.055E+05	1.0517	.1309	63299.9	1465.5	1929
19.00	5.100E+06	6.594E+05	8.630E+05	1.1107	.1431	59800.8	1643.4	1847
20.00	4.855E+06	6.541E+05	9.214E+05	1.1690	.1561	56457.9	1833.3	1761
21.00	4.603E+06	6.486E+05	9.806E+05	1.2267	.1700	53273.5	2035.7	1672
22.00	4.349E+06	6.432E+05	1.040E+06	1.2839	.1848	50247.2	2251.1	1581
23.00	4.091E+06	6.378E+05	1.100E+06	1.2858	.2004	47377.0	2479.9	1490
24.00	3.834E+06	6.324E+05	1.160E+06	1.3151	.2169	44659.2	2722.7	1397
25.00	3.581E+06	6.272E+05	1.219E+06	1.3381	.2344	42088.9	2990.1	1306
26.00	3.333E+06	6.223E+05	1.277E+06	1.3541	.2528	39660.6	3252.7	1215
27.00	3.092E+06	6.176E+05	1.335E+06	1.3631	.2722	37368.4	3541.2	1129
28.00	2.861E+06	6.134E+05	1.391E+06	1.3653	.2927	35205.7	3846.2	1040
29.00	2.640E+06	6.096E+05	1.445E+06	1.3609	.3142	33166.2	4168.6	963
30.00	2.431E+06	6.065E+05	1.498E+06	1.3503	.3368	31243.7	4509.1	887
31.00	2.235E+06	6.041E+05	1.549E+06	1.3341	.3605	29430.6	4868.7	815
32.00	2.053E+06	6.026E+05	1.597E+06	1.3127	.3854	27721.9	5248.3	748
33.00	1.884E+06	6.022E+05	1.643E+06	1.2868	.4114	26111.1	5649.0	685
34.00	1.728E+06	6.031E+05	1.686E+06	1.2571	.4387	24592.4	6071.7	628
35.00	1.586E+06	6.054E+05	1.726E+06	1.2238	.4671	23161.7	6517.7	576
36.00	1.457E+06	6.095E+05	1.763E+06	1.1879	.4963	21809.6	6988.3	529
37.00	1.341E+06	6.155E+05	1.798E+06	1.1498	.5278	20535.7	7484.8	486
38.00	1.237E+06	6.238E+05	1.826E+06	1.1101	.5600	19332.7	8008.6	448
39.00	1.144E+06	6.347E+05	1.852E+06	1.0691	.5934	18197.4	8561.4	413
40.00	1.061E+06	6.486E+05	1.878E+06	1.0274	.6281	17125.3	9144.7	381
41.00	9.881E+05	6.659E+05	1.903E+06	.9852	.6640	16112.6	9760.3	356
42.00	9.241E+05	6.872E+05	1.917E+06	.9430	.7010	15155.5	10410.3	331
43.00	8.687E+05	7.124E+05	1.913E+06	.9010	.7392	14255.8	11096.6	312
44.00	8.199E+05	7.426E+05	1.924E+06	.8594	.7784	13305.7	11821.5	294
45.00	7.782E+05	7.785E+05	1.926E+06	.8185	.8190	12586.7	12587.3	275

RES

COMPOSITE PROPERTIES

THIS PAGE IS BEST QUALITY PRACTICAL FROM COPY FURNISHED TO DDO

EP = 4.700E+05 RHO = .8454
AR = 4.000E-05 FTU = 120705.0
UP = .3500 FCU = 25098.0
FSU = 8000.0

BYX	FXTU	FYTU	FYCU	FYCU	FKY	AK	AV
1294	120705.0	-.7	25998.0	2512.9	1239.3	-3.122E-07	2.998E-05
1297	120389.9	4.3	25981.2	2512.3	1308.8	-3.204E-07	2.998E-05
1306	119453.7	17.1	25930.5	2517.6	1388.4	-3.448E-07	2.997E-05
1321	117922.9	38.6	25845.2	2507.7	1479.1	-3.856E-07	2.996E-05
1342	115839.4	68.7	25724.4	2503.6	1582.2	-4.428E-07	2.994E-05
1369	113258.3	107.5	25556.5	2498.4	1693.6	-5.163E-07	2.992E-05
1412	110243.7	155.0	25339.8	2492.0	1829.5	-6.062E-07	2.989E-05
1441	106865.6	211.5	25172.3	2484.5	1975.0	-7.125E-07	2.985E-05
1466	103196.1	276.9	24851.6	2476.1	2139.7	-8.353E-07	2.981E-05
1533	99306.0	351.5	24525.5	2466.3	2319.6	-9.745E-07	2.976E-05
1598	95262.9	435.3	24151.7	2455.7	2518.3	-1.130E-06	2.970E-05
1661	91128.2	528.6	23728.0	2444.7	2735.9	-1.302E-06	2.963E-05
1732	86957.1	631.5	23252.7	2432.4	2972.7	-1.497E-06	2.955E-05
1811	82796.7	744.4	22724.3	2417.8	3229.8	-1.694E-06	2.945E-05
1898	78686.8	867.3	22142.4	2403.4	3504.2	-1.915E-06	2.934E-05
1984	74659.7	1000.5	21507.0	2388.1	3799.2	-2.150E-06	2.922E-05
2077	70740.9	1144.5	20819.5	2372.2	4110.2	-2.400E-06	2.908E-05
2174	66949.6	1299.3	20082.2	2355.2	4438.8	-2.665E-06	2.891E-05
2279	63299.9	1465.9	19298.9	2338.4	4782.6	-2.943E-06	2.873E-05
2391	59800.8	1647.4	18474.3	2320.8	5139.7	-3.233E-06	2.852E-05
2511	56457.9	1833.3	17614.5	2302.2	5507.7	-3.534E-06	2.828E-05
2637	53273.5	2035.7	16726.7	2284.7	5884.3	-3.844E-06	2.801E-05
2768	50247.2	2251.1	15819.0	2266.5	6266.7	-4.161E-06	2.769E-05
2904	47377.0	2479.9	14900.1	2248.0	6651.9	-4.481E-06	2.734E-05
3049	44650.2	2722.7	13979.0	2230.7	7037.0	-4.802E-06	2.695E-05
3204	42088.9	2990.1	13054.7	2213.6	7418.9	-5.121E-06	2.651E-05
3368	39660.6	3252.7	12156.1	2197.3	7794.8	-5.429E-06	2.600E-05
3541	37368.4	3541.2	11281.9	2182.1	8161.7	-5.724E-06	2.543E-05
3722	35205.7	3846.2	10446.6	2168.4	8517.1	-6.098E-06	2.481E-05
3912	33166.2	4168.6	9639.3	2156.5	8858.6	-6.244E-06	2.409E-05
4111	31243.7	4519.1	8873.3	2146.8	9184.7	-6.452E-06	2.330E-05
4319	29430.6	4888.7	8154.2	2139.9	9491.6	-6.613E-06	2.243E-05
4534	27721.9	5248.3	7482.7	2136.3	9779.9	-6.715E-06	2.147E-05
4757	26111.1	5649.0	6852.4	2136.5	10047.8	-6.747E-06	2.041E-05
4987	24592.4	6071.7	6289.0	2141.3	10294.6	-6.695E-06	1.926E-05
5224	23160.7	6517.7	5756.5	2151.5	10519.6	-6.546E-06	1.801E-05
5468	21809.6	6998.3	5202.2	2167.8	10722.5	-6.285E-06	1.666E-05
5718	20535.7	7434.8	4654.4	2191.3	10903.2	-5.914E-06	1.523E-05
5974	19332.7	7908.6	4100.5	2223.1	11051.9	-5.389E-06	1.371E-05
6234	18197.4	8461.4	3548.1	2264.2	11198.6	-4.730E-06	1.212E-05
6501	17125.3	9144.7	3004.7	2316.1	11313.6	-3.923E-06	1.048E-05
6774	16112.6	9767.3	2556.3	2387.3	11407.2	-2.965E-06	8.808E-06
7051	15155.5	10410.3	2201.1	2450.4	11479.6	-1.860E-06	7.121E-06
7332	14250.8	11076.6	1836.0	2552.2	11531.2	-5.140E-07	5.447E-06
7614	13395.7	11821.5	1488.0	2663.6	11562.7	7.590E-07	3.811E-06
7900	12586.0	12587.0	1170.7	2794.9	11572.3	2.242E-06	2.239E-06

KEVLAR 49/EPDXY

THIS PAGE IS BEST QUALITY PRACTICABLE
FROM COPY FURNISHED TO DDO

FIBRE PROPERTIES

VF = .4733
WF = .4970
RHOF = .0524
FTU = 325000.0
FCU = 70000.0
UF = .2200

RESIN PROPERTIES

EF = 1.901E+07
EFT = 1.000E+06
GF = 3.000E+05
AF = -2.000E-06
AFT = 3.300E-05
VR = .5667
WR = .5070
RHOR = .0412
FSU = 8700.0

ER = 4.700E+05
AR = 4.000E-05
UR = .3500

COMPO

RHO=
FTU=
FCU=
FSU=

ALPHA	EX	EY	GXY	UXY	UYX	FXTU	FYTU	F
.00	8.499E+16	7.392E+05	2.210E+05	.2937	.0255	140822.5	.0	303
1.00	8.493E+06	7.391E+05	2.234E+05	.2970	.0258	140411.2	4.5	303
2.00	8.474E+06	7.385E+05	2.307E+05	.3068	.0267	139190.6	17.9	302
3.00	8.442E+16	7.376E+05	2.428E+05	.3271	.0282	137199.6	40.2	301
4.00	8.398E+06	7.363E+05	2.597E+05	.3459	.0303	134499.5	71.5	300
5.00	8.339E+16	7.347E+05	2.612E+05	.3749	.0330	131169.7	112.0	298
6.00	8.266E+06	7.328E+05	3.073E+05	.4100	.0363	127302.0	161.6	295
7.00	8.170E+06	7.308E+05	3.379E+05	.4510	.0403	122994.9	220.5	293
8.00	8.074E+16	7.279E+05	3.727E+05	.4975	.0448	118348.3	288.7	287
9.00	7.956E+06	7.251E+05	4.117E+05	.5492	.0500	113458.4	366.5	285
10.00	7.820E+16	7.217E+05	4.544E+05	.6055	.0559	108415.0	453.9	281
11.00	7.666E+06	7.181E+05	5.012E+05	.6659	.0624	103297.9	551.3	276
12.00	7.494E+16	7.143E+05	5.513E+05	.7297	.0695	98176.6	658.7	270
13.00	7.304E+06	7.101E+05	6.047E+05	.7961	.0774	93109.1	776.4	264
14.00	7.096E+16	7.057E+05	6.611E+05	.8642	.0859	88142.3	904.7	257
15.00	6.871E+06	7.010E+05	7.202E+05	.9331	.0952	83313.1	1043.8	249
16.00	6.628E+06	6.961E+05	7.817E+05	1.0017	.1052	78648.8	1194.1	240
17.00	6.369E+06	6.911E+05	8.454E+05	1.0688	.1157	74169.1	1355.9	231
18.00	6.097E+06	6.857E+05	9.118E+05	1.1335	.1275	69886.4	1529.5	221
19.00	5.812E+16	6.803E+05	9.778E+05	1.1945	.1398	65808.0	1715.5	211
20.00	5.518E+16	6.748E+05	1.0446E+06	1.2508	.1530	61936.4	1914.0	201
21.00	5.217E+16	6.692E+05	1.1155E+06	1.3015	.1669	58270.5	2125.3	191
22.00	4.912E+16	6.635E+05	1.1885E+06	1.3458	.1816	54806.8	2351.1	181
23.00	4.615E+16	6.579E+05	1.2644E+06	1.3829	.1976	51539.5	2590.5	169
24.00	4.301E+06	6.524E+05	1.3247E+06	1.4124	.2147	48461.5	2844.9	157
25.00	4.001E+06	6.471E+05	1.3938E+06	1.4341	.2319	45564.8	3114.6	144
26.00	3.709E+06	6.419E+05	1.4618E+06	1.4478	.2506	42840.7	3400.3	131
27.00	3.427E+06	6.371E+05	1.5285E+06	1.4537	.2707	40280.1	3702.8	117
28.00	3.157E+06	6.327E+05	1.5935E+06	1.4521	.2910	37874.2	4022.8	111
29.00	2.901E+06	6.289E+05	1.6575E+06	1.4437	.3126	35613.9	4361.2	103
30.00	2.661E+06	6.256E+05	1.7195E+06	1.4279	.3351	33490.5	4718.9	95
31.00	2.436E+16	6.232E+05	1.7785E+06	1.4065	.3599	31495.6	5096.9	88
32.00	2.227E+16	6.218E+05	1.8345E+06	1.3799	.3857	29621.2	5496.2	81
33.00	2.035E+06	6.214E+05	1.8875E+06	1.3487	.4119	27859.4	5917.8	74
34.00	1.860E+16	6.224E+05	1.9375E+06	1.3136	.4396	26203.1	6363.1	67
35.00	1.700E+16	6.250E+05	1.9845E+06	1.2754	.4683	24645.4	6837.2	60
36.00	1.556E+16	6.293E+05	2.0275E+06	1.2345	.4992	23179.8	7329.6	53
37.00	1.427E+06	6.358E+05	2.0665E+06	1.1918	.5317	21800.5	7853.8	46
38.00	1.311E+06	6.447E+05	2.101E+06	1.1476	.5661	20501.6	8407.4	39
39.00	1.209E+16	6.564E+05	2.131E+06	1.1026	.5987	19278.0	8992.0	32
40.00	1.118E+06	6.712E+05	2.157E+06	1.0571	.6346	18124.8	9609.6	25
41.00	1.038E+06	6.897E+05	2.179E+06	1.0115	.6718	17037.5	10262.2	18
42.00	9.686E+05	7.123E+05	2.196E+06	.9651	.7104	16011.8	10951.9	11
43.00	9.079E+05	7.396E+05	2.208E+06	.9211	.7507	15043.8	11681.1	4
44.00	8.555E+05	7.721E+05	2.215E+06	.8769	.7914	14129.9	12452.2	1
45.00	8.105E+05	8.105E+05	2.218E+06	.8336	.8337	13266.6	13266.6	2

COMPOSITE PROPERTIES

EP = 4.700E+05
 AR = 4.000E-05
 UR = .3500

RHO = .0461
 FTU = 140822.5
 FCU = 30331.0
 FSU = 8000.0

THIS PAGE IS BEST QUALITY PRACTICABLE
 FROM COPY FURNISHED TO DDG

IX	FXTU	FYTU	FXCU	FYCU	FXV	AX	AY
255	140822.5	.3	30331.0	2619.9	1301.4	-6.833E-07	2.979E-05
258	140411.2	4.5	30311.2	2619.3	1376.7	-6.921E-07	2.978E-05
267	139190.6	17.9	30251.7	2617.5	1463.1	-7.170E-07	2.978E-05
282	137199.6	40.2	30151.4	2614.4	1562.0	-7.587E-07	2.976E-05
303	134499.5	71.6	30099.0	2610.1	1674.7	-8.170E-07	2.975E-05
331	131169.7	112.0	29822.6	2604.7	1802.4	-8.920E-07	2.972E-05
363	127302.0	161.6	29589.6	2598.0	1946.6	-9.837E-07	2.970E-05
403	122994.9	220.5	29307.3	2590.2	2108.5	-1.092E-06	2.966E-05
448	118348.3	288.7	28972.7	2581.2	2289.5	-1.218E-06	2.962E-05
500	113458.4	366.5	28582.6	2571.1	2490.6	-1.360E-06	2.957E-05
559	108415.0	453.9	28173.8	2559.9	2713.1	-1.519E-06	2.951E-05
621	103207.9	551.3	27623.4	2547.6	2957.7	-1.695E-06	2.944E-05
695	98176.6	658.7	27049.7	2534.4	3225.2	-1.887E-06	2.936E-05
774	93109.1	776.4	26478.9	2520.1	3515.9	-2.095E-06	2.927E-05
859	88142.3	904.7	25712.2	2505.0	3829.9	-2.322E-06	2.916E-05
952	83313.1	1043.8	24929.3	2489.0	4166.9	-2.563E-06	2.904E-05
1052	78648.8	1194.1	24092.1	2472.3	4526.3	-2.820E-06	2.890E-05
1160	74169.1	1355.9	23193.7	2454.8	4906.8	-3.092E-06	2.873E-05
1275	69886.4	1529.6	22239.3	2436.8	5307.0	-3.378E-06	2.855E-05
1398	65808.0	1715.5	21235.5	2418.3	5724.6	-3.677E-06	2.834E-05
1530	61936.4	1914.0	20190.4	2399.4	6157.3	-3.987E-06	2.811E-05
1669	58270.5	2125.9	19113.9	2380.3	6602.2	-4.308E-06	2.783E-05
1818	54806.8	2351.1	18016.1	2361.2	7056.0	-4.635E-06	2.752E-05
1976	51539.5	2590.6	16918.7	2342.2	7515.3	-4.968E-06	2.717E-05
2147	48461.5	2844.9	15803.1	2323.5	7976.4	-5.302E-06	2.677E-05
2319	45564.8	3114.6	14710.7	2305.5	8435.6	-5.633E-06	2.633E-05
2506	42840.7	3400.3	13642.2	2288.4	8899.1	-5.957E-06	2.582E-05
2707	40280.1	3702.8	12617.2	2272.4	9333.3	-6.268E-06	2.525E-05
2911	37874.2	4022.8	11604.2	2257.9	9764.3	-6.558E-06	2.462E-05
3128	35613.9	4361.2	10670.1	2245.4	10180.4	-6.821E-06	2.391E-05
3358	33492.5	4718.9	9799.2	2235.2	10577.3	-7.047E-06	2.311E-05
3599	31495.6	5096.9	8948.3	2227.9	10953.1	-7.225E-06	2.223E-05
3852	29621.2	5496.2	8176.5	2224.1	11305.9	-7.345E-06	2.125E-05
4118	27859.4	5917.8	7455.9	2224.4	11634.1	-7.393E-06	2.018E-05
4396	26203.1	6363.1	6816.0	2229.6	11930.4	-7.356E-06	1.901E-05
4688	24645.4	6833.2	6225.4	2240.4	12212.2	-7.221E-06	1.774E-05
4992	23179.6	7329.6	5692.1	2257.8	12460.9	-6.973E-06	1.638E-05
5317	21800.5	7853.9	5213.2	2282.9	12682.4	-6.600E-06	1.491E-05
5661	20501.8	8407.4	4795.6	2316.8	12876.7	-6.089E-06	1.337E-05
6017	19278.0	8992.0	4415.8	2360.9	13044.1	-5.431E-06	1.175E-05
6386	18124.8	9609.6	4070.3	2416.6	13184.8	-4.620E-06	1.007E-05
6768	17037.5	10262.2	3775.4	2485.6	13299.3	-3.652E-06	8.158E-06
7184	16011.8	10951.9	3517.6	2569.6	13387.8	-2.532E-06	6.533E-06
7627	15043.8	11681.1	3293.4	2670.7	13450.8	-1.265E-06	4.721E-06
8094	14129.9	12452.2	3099.6	2791.1	13488.5	1.331E-07	3.249E-06
8587	13266.6	13266.0	2933.1	2933.3	13501.0	1.645E-06	1.644E-06

FIBER PROPERTIES

RESIN PROPERTIES

VF = .5300
WF = .6840
RHOF = .0900
FTU = 325000.0
FCU = 215100.0
UF = .2200

EF = 1.260E+07
EFT = 1.260E+07
GF = 4.000E+05
AF = 2.200E-06
AFT = 2.200E-06

VR = .5000
WR = .3140
PHOR = .412
FSU = 8000.0

ER = 4.700E+05
AP = 4.000E-05
UR = .3500

COM

RHO
FTU
FCU
FSU

ALPHA	EX	EY	GVY	UXY	UYX	FXTU	FYTU	
.00	6.535E+06	1.823E+06	2.631E+05	.2850	.0795	162500.0	.0	10
1.00	6.531E+06	1.822E+06	2.651E+05	.2851	.0798	162193.1	8.1	10
2.00	6.517E+06	1.819E+06	2.709E+05	.2895	.0808	161278.8	31.9	10
3.00	6.494E+06	1.815E+06	2.807E+05	.2951	.0825	159775.1	71.8	10
4.00	6.461E+06	1.810E+06	2.943E+05	.3030	.0848	157711.4	127.9	10
5.00	6.427E+06	1.802E+06	3.116E+05	.3130	.0879	155125.9	200.1	10
6.00	6.389E+06	1.797E+06	3.327E+05	.3252	.0916	152068.7	288.6	10
7.00	6.303E+06	1.782E+06	3.573E+05	.3396	.0959	148589.8	393.6	10
8.00	6.239E+06	1.775E+06	3.854E+05	.3561	.1010	144747.0	515.3	10
9.00	6.159E+06	1.759E+06	4.168E+05	.3745	.1068	140598.9	653.3	10
10.00	6.069E+06	1.741E+06	4.513E+05	.3950	.1133	136204.2	809.6	10
11.00	5.969E+06	1.723E+06	4.889E+05	.4173	.1205	131619.5	982.3	9
12.00	5.867E+06	1.703E+06	5.296E+05	.4414	.1284	126898.7	1173.3	9
13.00	5.741E+06	1.684E+06	5.723E+05	.4671	.1371	122091.4	1383.0	9
14.00	5.612E+06	1.663E+06	6.177E+05	.4944	.1465	117242.7	1610.7	9
15.00	5.473E+06	1.639E+06	6.654E+05	.5220	.1566	112392.5	1857.4	9
16.00	5.325E+06	1.613E+06	7.149E+05	.5526	.1676	107575.4	2123.7	8
17.00	5.168E+06	1.584E+06	7.662E+05	.5832	.1793	102821.0	2409.3	8
18.00	5.002E+06	1.561E+06	8.191E+05	.6145	.1916	98153.9	2716.7	8
19.00	4.828E+06	1.532E+06	8.733E+05	.6467	.2051	93594.3	3044.6	8
20.00	4.646E+06	1.503E+06	9.279E+05	.6781	.2192	89157.6	3394.4	7
21.00	4.458E+06	1.471E+06	9.835E+05	.7098	.2341	84856.7	3766.8	7
22.00	4.264E+06	1.438E+06	1.041E+06	.7410	.2499	80699.7	4162.5	7
23.00	4.066E+06	1.403E+06	1.096E+06	.7713	.2665	76692.9	4582.3	6
24.00	3.863E+06	1.371E+06	1.152E+06	.8005	.2840	72839.8	5027.2	6
25.00	3.659E+06	1.338E+06	1.207E+06	.8282	.3023	69141.9	5498.0	6
26.00	3.454E+06	1.301E+06	1.262E+06	.8540	.3215	65599.1	5995.8	5
27.00	3.249E+06	1.264E+06	1.316E+06	.8776	.3415	62209.9	6521.6	5
28.00	3.046E+06	1.228E+06	1.369E+06	.8988	.3624	58971.7	7076.5	5
29.00	2.847E+06	1.192E+06	1.421E+06	.9173	.3841	55880.9	7661.9	4
30.00	2.653E+06	1.157E+06	1.471E+06	.9328	.4067	52933.5	8279.0	4
31.00	2.465E+06	1.122E+06	1.517E+06	.9451	.4300	50124.9	8929.2	4
32.00	2.285E+06	1.087E+06	1.563E+06	.9543	.4541	47450.2	9614.0	3
33.00	2.114E+06	1.053E+06	1.606E+06	.9600	.4790	44904.2	10335.0	3
34.00	1.957E+06	1.020E+06	1.648E+06	.9625	.5045	42461.7	11093.7	3
35.00	1.800E+06	9.947E+05	1.684E+06	.9615	.5306	40177.4	11892.2	3
36.00	1.663E+06	9.681E+05	1.718E+06	.9573	.5573	37906.0	12732.1	2
37.00	1.536E+06	9.449E+05	1.751E+06	.9500	.5844	35902.4	13615.7	2
38.00	1.421E+06	9.250E+05	1.778E+06	.9397	.6119	33921.5	14544.9	2
39.00	1.313E+06	9.100E+05	1.803E+06	.9266	.6397	32038.3	15522.2	2
40.00	1.224E+06	9.001E+05	1.824E+06	.9100	.6676	30248.2	16549.9	2
41.00	1.151E+06	8.958E+05	1.841E+06	.8920	.6954	28546.4	17630.5	1
42.00	1.087E+06	8.974E+05	1.855E+06	.8726	.7230	26928.7	18767.1	1
43.00	1.022E+06	9.043E+05	1.864E+06	.8500	.7502	25390.8	19962.2	1
44.00	9.833E+05	9.232E+05	1.871E+06	.8274	.7760	23928.7	21219.0	1
45.00	9.436E+05	9.490E+05	1.877E+06	.8027	.8027	22538.7	22540.9	1

COMPOSITE PROPERTIES

ER = 4.700E+05
 AP = +.100E-15
 UR = .3500
 RHO = .0656
 FTU = 162500.0
 FCU = 107500.0
 FSU = 8.00.0

**THIS PAGE IS BEST QUALITY PRACTICABLE
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FXTU	FYTU	FKCU	FYCU	FXV	AX	AY
162500.0	.0	107500.0	29489.2	5435.0	3.559E-06	1.175E-05
162193.1	8.0	107434.4	29476.7	5695.0	3.557E-06	1.175E-05
161278.8	31.9	107237.2	29439.0	5995.5	3.551E-06	1.175E-05
159775.1	71.8	106977.7	29376.2	6341.0	3.540E-06	1.176E-05
157711.4	127.9	106444.5	29298.3	6734.6	3.526E-06	1.176E-05
155125.9	200.1	105845.8	29175.4	7177.9	3.507E-06	1.177E-05
152687.7	288.6	105199.3	29037.5	7671.9	3.483E-06	1.178E-05
148589.8	393.6	104232.4	28874.6	8216.8	3.456E-06	1.179E-05
144747.0	515.3	103212.0	28686.8	8811.7	3.424E-06	1.180E-05
140598.9	653.3	102452.2	28474.2	9455.3	3.387E-06	1.182E-05
136204.2	809.6	101728.7	28237.0	10145.7	3.346E-06	1.183E-05
131619.5	982.3	99259.3	27975.3	10880.6	3.300E-06	1.185E-05
126898.7	1173.3	97634.4	27689.4	11657.3	3.250E-06	1.186E-05
122091.4	1383.0	95851.5	27379.4	12473.0	3.195E-06	1.188E-05
117242.7	1610.7	93979.0	27045.7	13324.9	3.134E-06	1.190E-05
112392.5	1857.4	91966.0	26688.7	14209.8	3.069E-06	1.192E-05
107575.4	2123.7	89543.1	26308.9	15124.7	2.999E-06	1.194E-05
102821.0	2409.3	87122.1	25906.7	16065.5	2.925E-06	1.195E-05
98153.9	2716.7	84546.6	25483.0	17032.0	2.845E-06	1.197E-05
93594.3	3044.6	81822.4	25038.6	18017.9	2.759E-06	1.199E-05
89157.0	3394.4	78957.3	24574.3	19020.8	2.671E-06	1.200E-05
84856.7	3766.8	75951.5	24091.3	20037.2	2.576E-06	1.201E-05
80699.7	4162.5	72848.2	23591.1	21063.4	2.478E-06	1.202E-05
76692.9	4582.3	69652.8	23075.0	22095.6	2.375E-06	1.202E-05
72839.8	5027.2	66373.5	22545.1	23129.7	2.271E-06	1.202E-05
69141.9	5498.0	62971.1	22007.3	24161.6	2.163E-06	1.201E-05
65599.1	5995.8	59553.4	21452.2	25186.7	2.054E-06	1.198E-05
62209.9	6521.6	56150.2	20894.5	26209.5	1.945E-06	1.195E-05
58971.7	7.76.5	52742.6	20333.5	27199.1	1.840E-06	1.190E-05
55880.9	7661.9	49372.6	19772.9	28174.7	1.738E-06	1.183E-05
52933.5	8279.0	46057.1	19216.5	29125.1	1.645E-06	1.174E-05
50124.9	8929.2	42852.5	18670.1	30044.3	1.563E-06	1.163E-05
47450.2	9614.0	39753.9	18138.0	30927.1	1.497E-06	1.148E-05
44914.2	10335.0	36734.5	17626.5	31758.6	1.453E-06	1.129E-05
42481.7	11093.7	33934.8	17142.4	32563.8	1.438E-06	1.107E-05
40177.4	11892.2	31372.3	16693.0	33307.8	1.459E-06	1.079E-05
37906.0	12732.1	28941.3	16286.5	33996.1	1.525E-06	1.046E-05
35912.4	13615.7	26712.2	15932.1	34624.4	1.643E-06	1.008E-05
33921.5	14544.9	24691.9	15639.3	35198.7	1.824E-06	9.628E-06
32038.3	15522.2	22883.7	15418.9	35685.4	2.075E-06	9.118E-06
30248.2	16549.9	21287.5	15292.1	36111.2	2.402E-06	8.548E-06
28546.4	17624.5	19900.1	15240.0	36453.5	2.809E-06	7.923E-06
26928.7	18767.1	18715.7	15308.1	36739.9	3.295E-06	7.255E-06
25390.8	19962.2	17726.0	15496.5	36933.7	3.855E-06	6.557E-06
23928.7	21219.0	16921.1	15819.5	37058.4	4.473E-06	5.848E-06
22538.7	22540.9	16289.5	16290.4	37093.3	5.149E-06	5.148E-06

KEVLAR 49/EPOXY

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FIBER PROPERTIES

RESIN PROPERTIES

VF = .5300
WF = .5598
RHOF = .0524
FTU = 325000.0
FCU = 70000.0
UF = .2200

EF = 1.900E+07
EFT = 1.000E+06
GF = 3.000E+05
AF = -2.000E-06
AFT = 3.300E-05

VR = .5000
WR = .4402
RHOR = .0412
FSU = 8000.0

ER = 4.700E-05
AR = 4.000E-05
UR = .3500

COMP

RH1 =
FTU =
FCU =
FSU =

ALPHA	EX	EY	GXY	UXY	UYX	FXTU	FYTU	
0.00	9.735E+06	7.648E+05	2.288E+05	.2850	.0224	162500.0	.0	35
1.00	9.728E+06	7.646E+05	2.316E+05	.2887	.0227	161975.1	4.7	34
2.00	9.706E+06	7.641E+05	2.400E+05	.2996	.0236	160419.4	18.6	34
3.00	9.670E+06	7.631E+05	2.540E+05	.3179	.0251	157887.9	42.0	34
4.00	9.618E+06	7.618E+05	2.734E+05	.3433	.0272	154466.9	74.7	34
5.00	9.551E+06	7.602E+05	2.983E+05	.3757	.0299	150267.2	116.9	34
6.00	9.467E+06	7.582E+05	3.284E+05	.4149	.0332	145415.2	168.5	34
7.00	9.366E+06	7.558E+05	3.636E+05	.4606	.0372	140044.9	230.0	33
8.00	9.246E+06	7.531E+05	4.038E+05	.5124	.0417	134289.7	301.2	33
9.00	9.106E+06	7.501E+05	4.488E+05	.5700	.0470	128276.0	382.4	32
10.00	8.947E+06	7.467E+05	4.983E+05	.6328	.0529	122118.7	473.7	32
11.00	8.766E+06	7.430E+05	5.521E+05	.7000	.0593	115918.1	575.3	31
12.00	8.563E+06	7.390E+05	6.109E+05	.7708	.0665	109758.8	687.4	31
13.00	8.339E+06	7.347E+05	6.715E+05	.8445	.0744	103709.4	810.3	31
14.00	8.093E+06	7.301E+05	7.365E+05	.9198	.0830	97823.4	944.3	29
15.00	7.825E+06	7.252E+05	8.047E+05	.9957	.0923	92140.9	1089.6	29
16.00	7.537E+06	7.202E+05	8.756E+05	1.0709	.1023	86690.1	1246.7	29
17.00	7.230E+06	7.149E+05	9.491E+05	1.1442	.1131	81489.3	1415.7	29
18.00	6.907E+06	7.094E+05	1.025E+06	1.2143	.1247	76548.6	1597.2	29
19.00	6.569E+06	7.038E+05	1.102E+06	1.2798	.1371	71871.5	1791.6	29
20.00	6.221E+06	6.981E+05	1.181E+06	1.3397	.1503	67455.7	1999.2	28
21.00	5.865E+06	6.922E+05	1.260E+06	1.3929	.1644	63290.9	2220.7	28
22.00	5.505E+06	6.864E+05	1.340E+06	1.4385	.1794	59390.2	2456.5	28
23.00	5.145E+06	6.806E+05	1.421E+06	1.4759	.1953	55720.7	2707.2	28
24.00	4.788E+06	6.749E+05	1.501E+06	1.5046	.2121	52279.3	2973.4	28
25.00	4.438E+06	6.693E+05	1.580E+06	1.5245	.2299	49054.2	3255.9	28
26.00	4.099E+06	6.640E+05	1.659E+06	1.5355	.2487	46033.2	3555.2	28
27.00	3.773E+06	6.590E+05	1.736E+06	1.5379	.2686	43204.1	3872.3	28
28.00	3.463E+06	6.545E+05	1.812E+06	1.5321	.2896	40555.1	4207.3	28
29.00	3.170E+06	6.505E+05	1.885E+06	1.5188	.3117	38074.6	4562.9	28
30.00	2.896E+06	6.472E+05	1.956E+06	1.4985	.3349	35751.5	4938.4	28
31.00	2.641E+06	6.447E+05	2.024E+06	1.4721	.3594	33575.2	5335.3	28
32.00	2.406E+06	6.432E+05	2.090E+06	1.4403	.3851	31535.8	5754.3	28
33.00	2.191E+06	6.429E+05	2.151E+06	1.4041	.4121	29623.8	6198.1	28
34.00	1.995E+06	6.440E+05	2.209E+06	1.3639	.4404	27830.5	6666.4	28
35.00	1.817E+06	6.468E+05	2.263E+06	1.3208	.4701	26147.8	7161.3	28
36.00	1.658E+06	6.515E+05	2.312E+06	1.2754	.5011	24568.0	7684.2	28
37.00	1.516E+06	6.584E+05	2.357E+06	1.2284	.5336	23083.9	8236.7	28
38.00	1.389E+06	6.678E+05	2.397E+06	1.1803	.5676	21689.1	8820.5	28
39.00	1.276E+06	6.803E+05	2.433E+06	1.1315	.6030	20377.4	9437.7	28
40.00	1.178E+06	6.961E+05	2.465E+06	1.0826	.6399	19143.2	10090.3	28
41.00	1.091E+06	7.150E+05	2.489E+06	1.0339	.6784	17981.3	10780.3	28
42.00	1.015E+06	7.399E+05	2.507E+06	.9857	.7183	16886.8	11510.3	28
43.00	9.499E+05	7.691E+05	2.521E+06	.9362	.7595	15855.3	12282.4	28
44.00	8.934E+05	8.039E+05	2.529E+06	.8918	.8024	14882.7	13100.5	28
45.00	8.450E+05	8.451E+05	2.532E+06	.8464	.8465	13965.2	13966.0	28

COMPOSITE PROPERTIES

ER = 4.70E+05
 AR = 4.00E-05
 UR = .350
 RH0 = .0468
 FTU = 162500.0
 FCU = 35000.0
 FSU = 8000.0

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 FROM COPY FURNISHED TO DDJ

FXTU	FYTU	FYCU	FYCU	FXU	AX	AY
162500.0	.0	35000.0	2733.5	1765.9	-9.861E-07	2.361E-05
161975.1	4.7	34977.1	2732.8	1446.9	-9.946E-07	2.261E-05
160419.4	18.6	34908.1	2731.0	1540.2	-1.020E-06	2.360E-05
157887.9	42.0	34791.7	2727.7	1547.2	-1.062E-06	2.958E-05
154466.9	74.7	34626.1	2723.2	1769.4	-1.121E-06	2.357E-05
150267.2	116.9	34408.7	2717.5	1958.5	-1.198E-06	2.954E-05
145415.2	168.6	34176.4	2710.5	2065.9	-1.291E-06	2.952E-05
140044.9	230.0	33805.3	2702.3	2243.2	-1.401E-06	2.948E-05
134289.7	301.2	33411.6	2692.9	2442.1	-1.529E-06	2.944E-05
128276.0	382.4	32951.0	2682.3	2663.9	-1.673E-06	2.939E-05
122118.7	473.7	32419.4	2670.5	2910.2	-1.835E-06	2.933E-05
115918.1	575.3	31913.0	2657.7	3182.1	-2.014E-06	2.926E-05
109758.8	687.4	31128.6	2643.8	3480.6	-2.210E-06	2.919E-05
103749.4	810.3	30353.9	2628.0	3806.4	-2.423E-06	2.910E-05
97823.4	944.3	29518.0	2613.1	4159.9	-2.652E-06	2.899E-05
92140.9	1089.6	28591.5	2596.2	4541.1	-2.898E-06	2.887E-05
86690.1	1246.7	27586.9	2578.6	4949.3	-3.161E-06	2.873E-05
81489.3	1415.7	26508.7	2560.3	5383.6	-3.439E-06	2.857E-05
76548.6	1597.2	25363.7	2541.4	5842.4	-3.731E-06	2.838E-05
71871.5	1791.6	24160.7	2521.9	6323.6	-4.036E-06	2.818E-05
67456.7	1999.2	22910.4	2502.1	6824.4	-4.354E-06	2.794E-05
63298.9	2220.7	21625.3	2482.1	7341.7	-4.683E-06	2.767E-05
59390.2	2456.5	20319.1	2462.0	7871.8	-5.019E-06	2.736E-05
55720.7	2707.2	19005.9	2442.0	8410.7	-5.361E-06	2.701E-05
52279.3	2973.4	17700.3	2422.4	8953.9	-5.706E-06	2.661E-05
49054.2	3255.9	16415.8	2403.5	9496.9	-6.049E-06	2.617E-05
46033.2	3555.2	15155.5	2385.4	10035.3	-6.394E-06	2.566E-05
43204.1	3872.3	13950.6	2368.6	10564.3	-6.738E-06	2.509E-05
40555.1	4207.3	12810.6	2353.3	11079.7	-7.072E-06	2.445E-05
38074.6	4562.9	11723.0	2340.1	11577.5	-7.293E-06	2.373E-05
35751.5	4938.4	10703.4	2329.4	12054.0	-7.523E-06	2.294E-05
33575.2	5335.3	9755.4	2321.8	12506.0	-7.721E-06	2.205E-05
31535.8	5754.8	8880.6	2317.3	12931.0	-7.855E-06	2.107E-05
29623.8	6198.1	8079.1	2318.1	13326.7	-7.917E-06	1.998E-05
27830.5	6666.4	7349.7	2323.6	13691.5	-7.894E-06	1.880E-05
26147.8	7161.3	6690.2	2335.1	14024.4	-7.770E-06	1.752E-05
24568.0	7684.2	6097.2	2353.7	14324.7	-7.533E-06	1.613E-05
23083.9	8236.7	5567.1	2380.3	14592.2	-7.167E-06	1.465E-05
21689.1	8820.6	5095.6	2416.5	14826.7	-6.651E-06	1.307E-05
20377.4	9437.7	4678.6	2463.4	15028.6	-6.005E-06	1.143E-05
19143.2	10090.3	4311.3	2522.8	15198.3	-5.193E-06	9.724E-16
17981.3	10780.3	3939.7	2596.5	15336.3	-4.210E-06	7.982E-06
16886.8	11510.3	3593.3	2681.4	15443.0	-3.084E-06	6.227E-06
15855.3	12282.4	3286.2	2794.9	15518.5	-1.801E-06	4.485E-06
14882.7	13100.5	3026.7	2924.2	15564.2	-3.824E-07	2.784E-16
13965.2	13966.6	3077.3	3077.3	15579.3	1.153E-06	1.152E-16

APPENDIX G
DRAWINGS

8

7

1

B

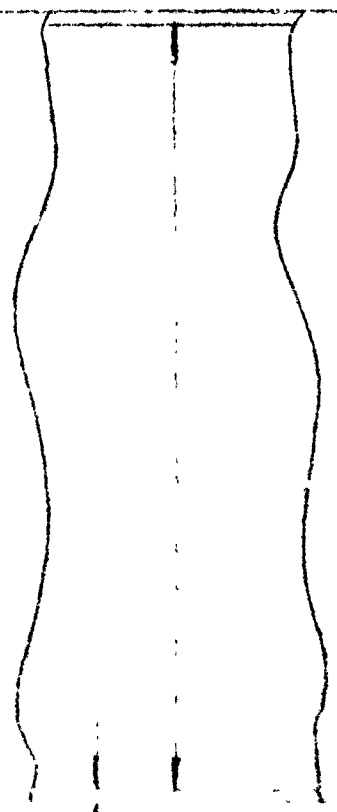
6

2

3

72.0°

16.0



B

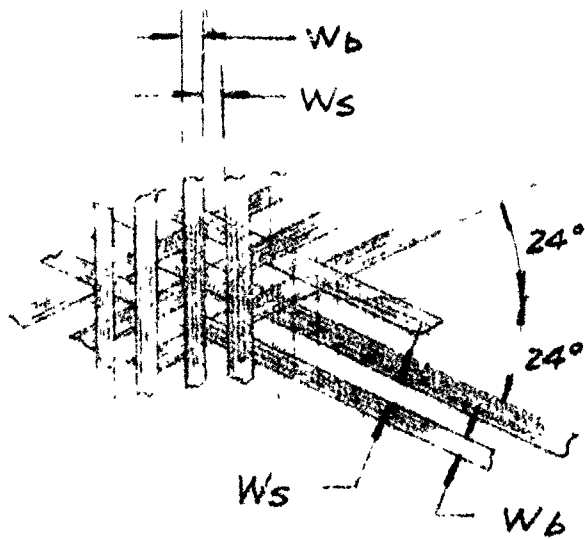
t. THICK

5'



3 4

— 16.00 DIA.

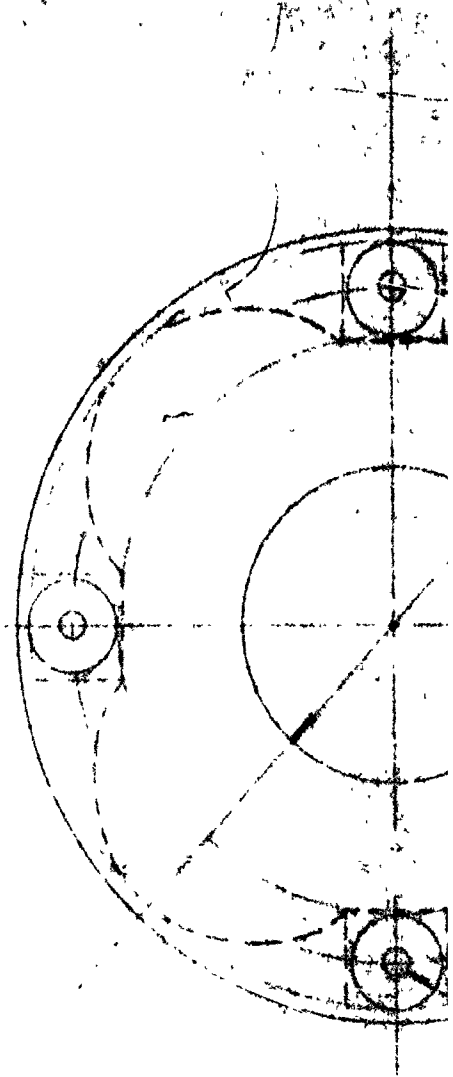
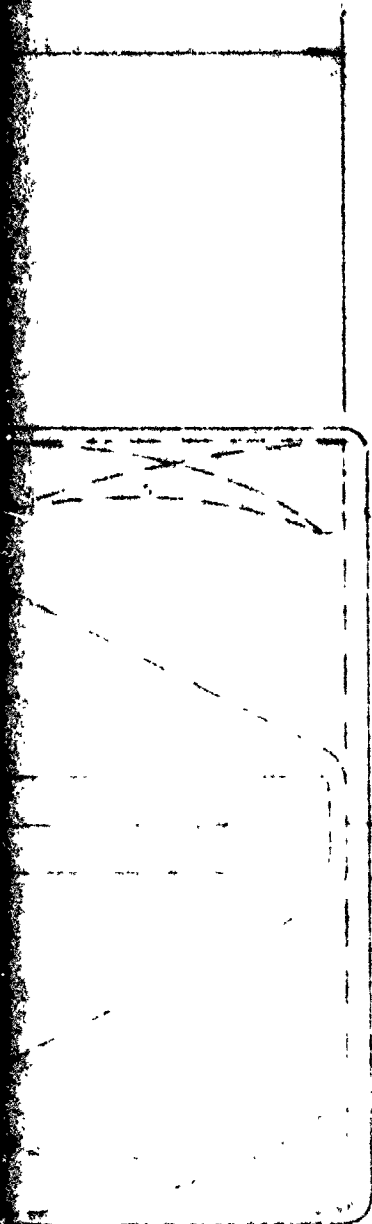


t, THICKNESS

3

4

2



6.50 DIA.

4

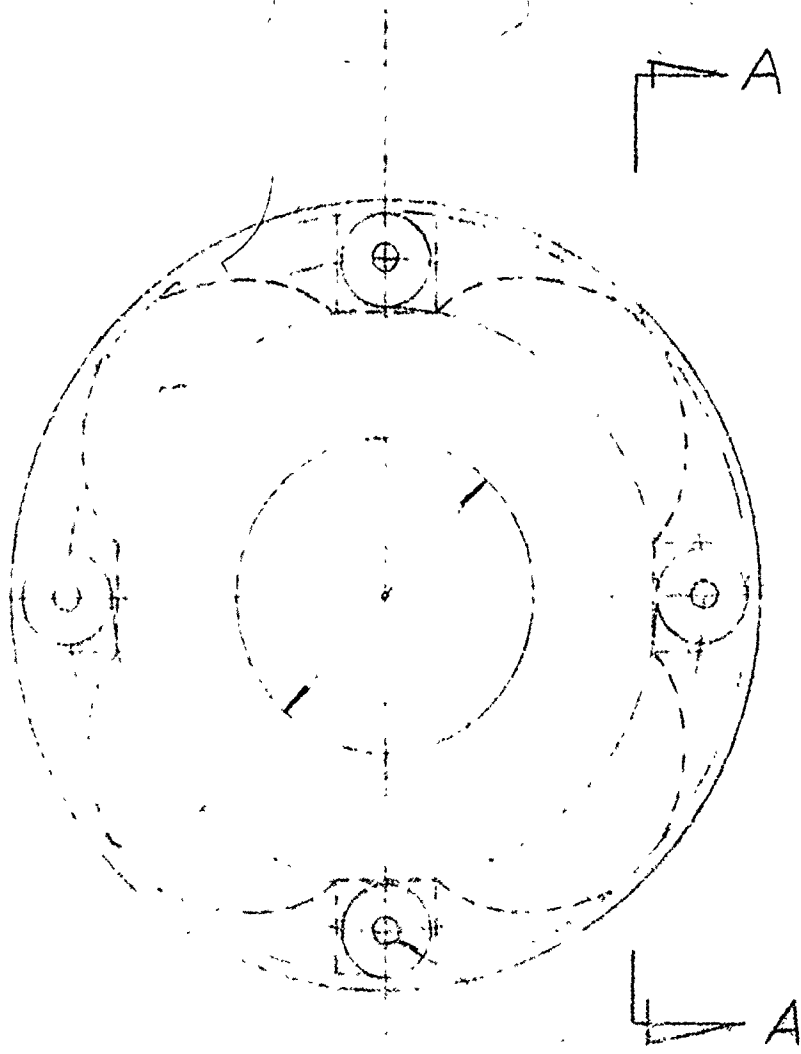
2

1

5

REVISIONS

LTR	DESCRIPTION	DATE
A	INCORPORATED CHANGE PER ARMY REQUEST DATED 5 OCT 77	12 OCT 77



D

C

1A.

500 ± .010 DIA 4 HOLES
 EQ. SPACED ON
 14.000 DIA

2.00

4.0

8.00
(TYP)

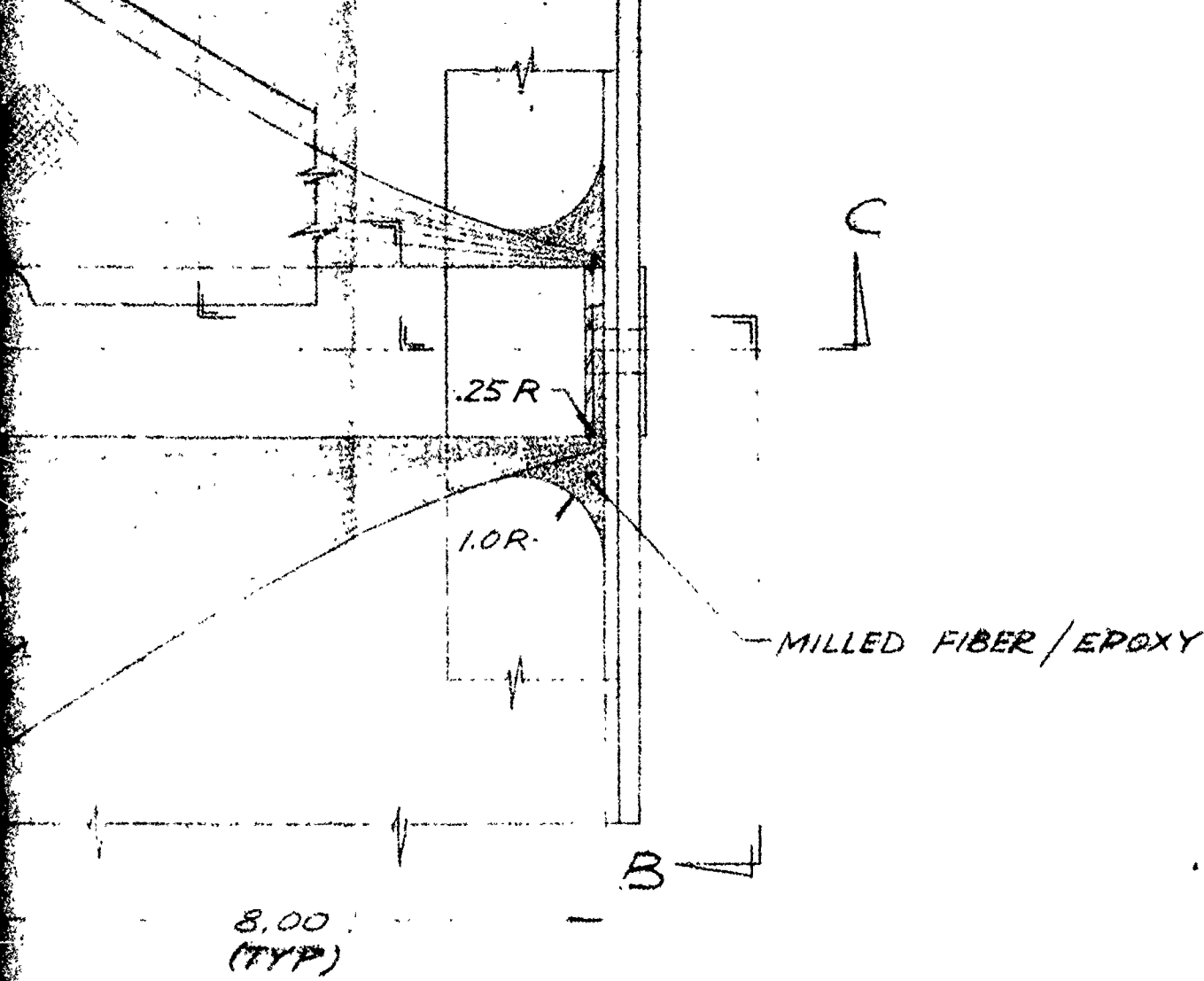
LONGO BROOM -
S-2 GLASS / EPOXY
 $\alpha = 0^\circ$

SECTION A-A
SCALE: $\frac{1}{2}$

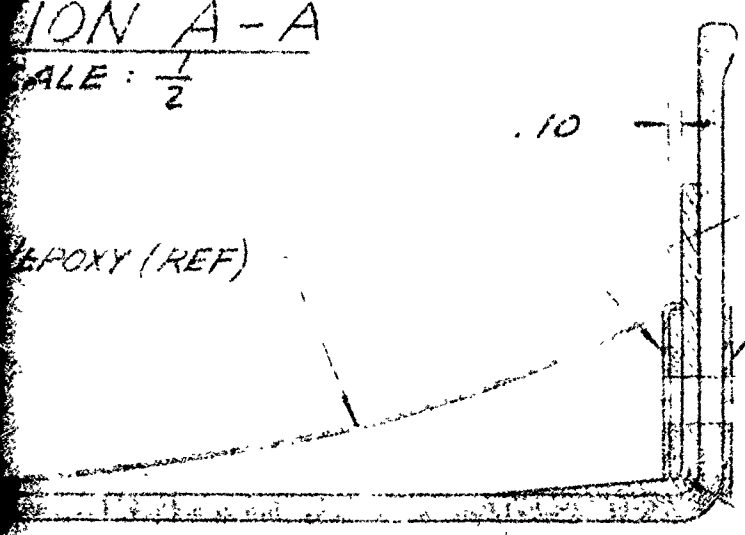
GLASS FABRIC / EPOXY (REF)
1.05 THICK

SECTION C-C
SCALE: $\frac{1}{2}$

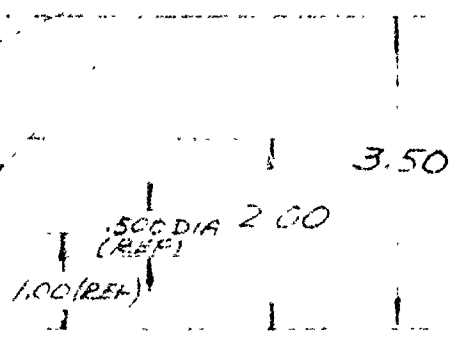
2 PLI
@ BI
WARP
2 IN
TYP



SECTION A-A
SCALE: $\frac{1}{2}$



.08 THICK ALUM 6061-T6
BONDED WITH RESIN



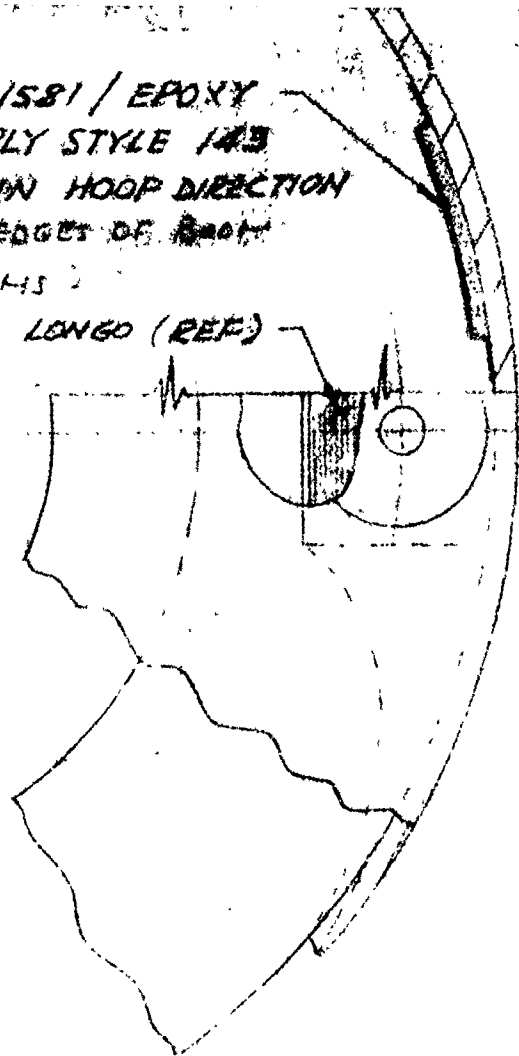
RING - E GLASS STYLE 1581 / EPOXY
.100 THICK

SECTION C-C (TOP - ALL FITTINGS)

SCALE

2 PLYS STYLE 1581 / EPOXY
 @ BIAS. PLY STYLE 143
 WARP FIBER IN HOOP DIRECTION
 2 IN. BEYOND EDGES OF BOOT
 TYP - BOTH BOOMS

LONGO (REF)



SECTION B-B

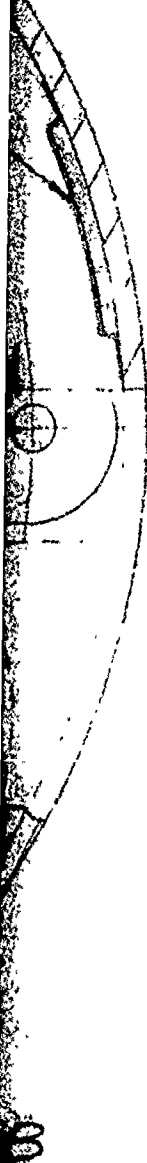
SCALE: $\frac{1}{2}$

EPOXY

THICK ALUM 6061-T6
 REINFORCED WITH RESIN

F.C.R	t _{CALC} IN.	t _{ACT.} IN.	W _B
25%	.4081	.6530	.604
50%	.2084	.2918	.574

GLASS STYLE 1581 / EPOXY



NOTES:

1. MATERIAL:

2. W.S.
 W₂
 F.C.R.
 F.C.R.

3. CONSTRUCT
 80%
 20%

4. FIBER VOLUME
 V_f = .
 V_f = .3
 V_f = .4

t _{CALL} IN.	t _{ACT.} IN.	W ₂	W _S	NO. CIRC LAYER	NO OF HEL LAYERS	NO. OF HOOP PLY
.4081	.6530	.604	1.813	19	32	17
.2084	.2918	.574	.574	40	15	9

END VIEW
TYPICAL BOTH ENDS

MATERIAL : FIBER - KEVLAR 49 ($V_f = .65$ FOR t_{CALC})
RESIN - EPON 826 / TONOX LC

W_s : SPACE WIDTH

W_b : BAND WIDTH

F.C.R. : FIBER COVER RATIO

$$F.C.R. = \frac{W_b}{(W_b + W_s)} \times 100\%$$

CONSTRUCTIONS :


80% OF t $\pm 24^\circ$ HELICAL WINDINGS
20% OF t 90° HOOP WINDINGS

FIBER VOLUME RATIO :

$V_f = .50$ ALL HOOP WINDINGS
 $V_f = .3714$ HELICAL WINDINGS F.C.R. = 25% FOR t_{ACTUAL}
 $V_f = .4333$ HELICAL WINDINGS F.C.R. = 50% FOR t_{ACTUAL}

FIBER SCIENCE, INC.		
GARDENA, CALIFORNIA 90248		
TITLE		
FINAL DESIGN EVALUATION SPECIMEN, SPACEWIND COMPOSITE STRUCTURE		
DWG SIZE	CODE IDENT	DWG NO.
D	32500	1105 - 002
SCALE	AS NOTED	DRAWN CHU 7-14-71 SHEET 1 OF 1

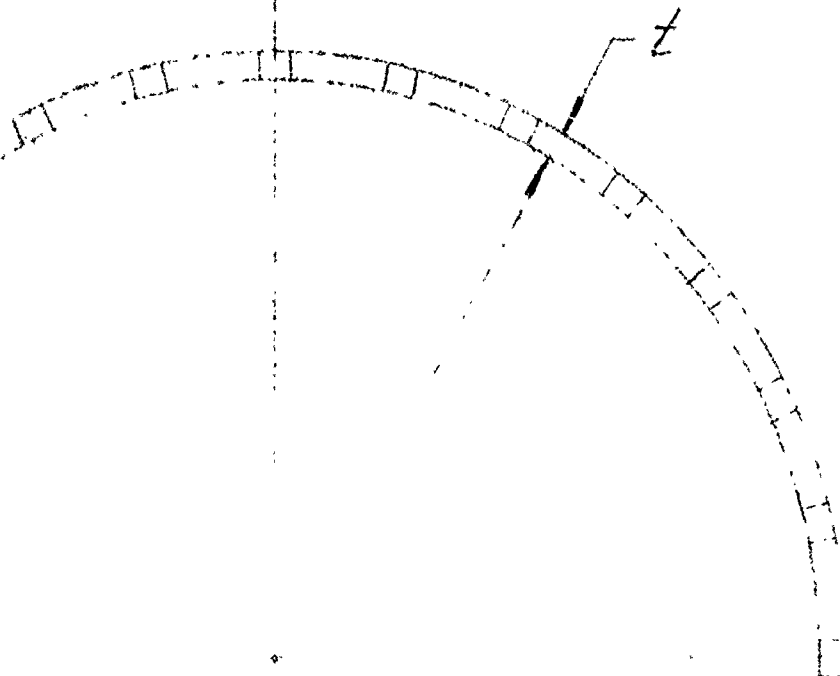
A
B
A

NO	** F.C.R. %	*** F.A.C.R. %	MATERIAL 	t IN.	W _S IN.	W _b IN.
1	25	57.81	S-2 GLASS	.526	1.85	.62
2	50	87.50	S-2 GLASS	.261	.62	.62
3	25	57.81	KEVLAR 49	.368	1.85	.62
4	50	87.50	KEVLAR 49	.185	.62	.62
5	25	57.81	THORNEL 300	.212	1.85	.62
6*	50	87.50	THORNEL 300	.106	1.85	.62

* SANDWICH WALL CONSTRUCTION: $t_f = .053$ IN., $t_c =$

** F.C.R. = $W_b / (W_s + W_b)$

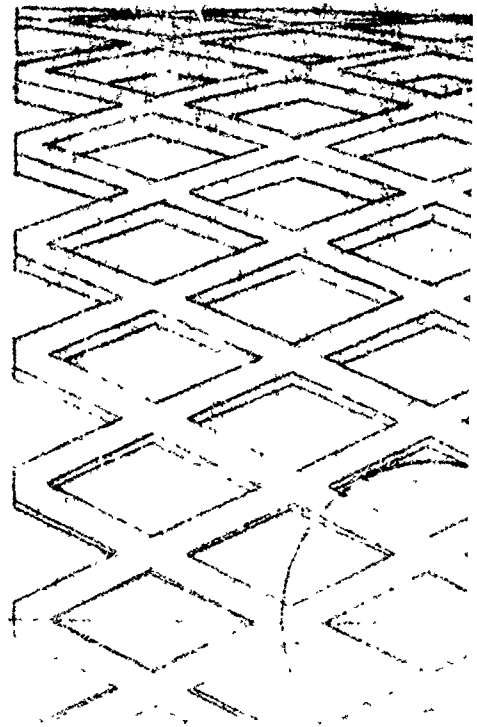
*** F.A.C.R. = FIBER COVER AREA / TOTAL AREA



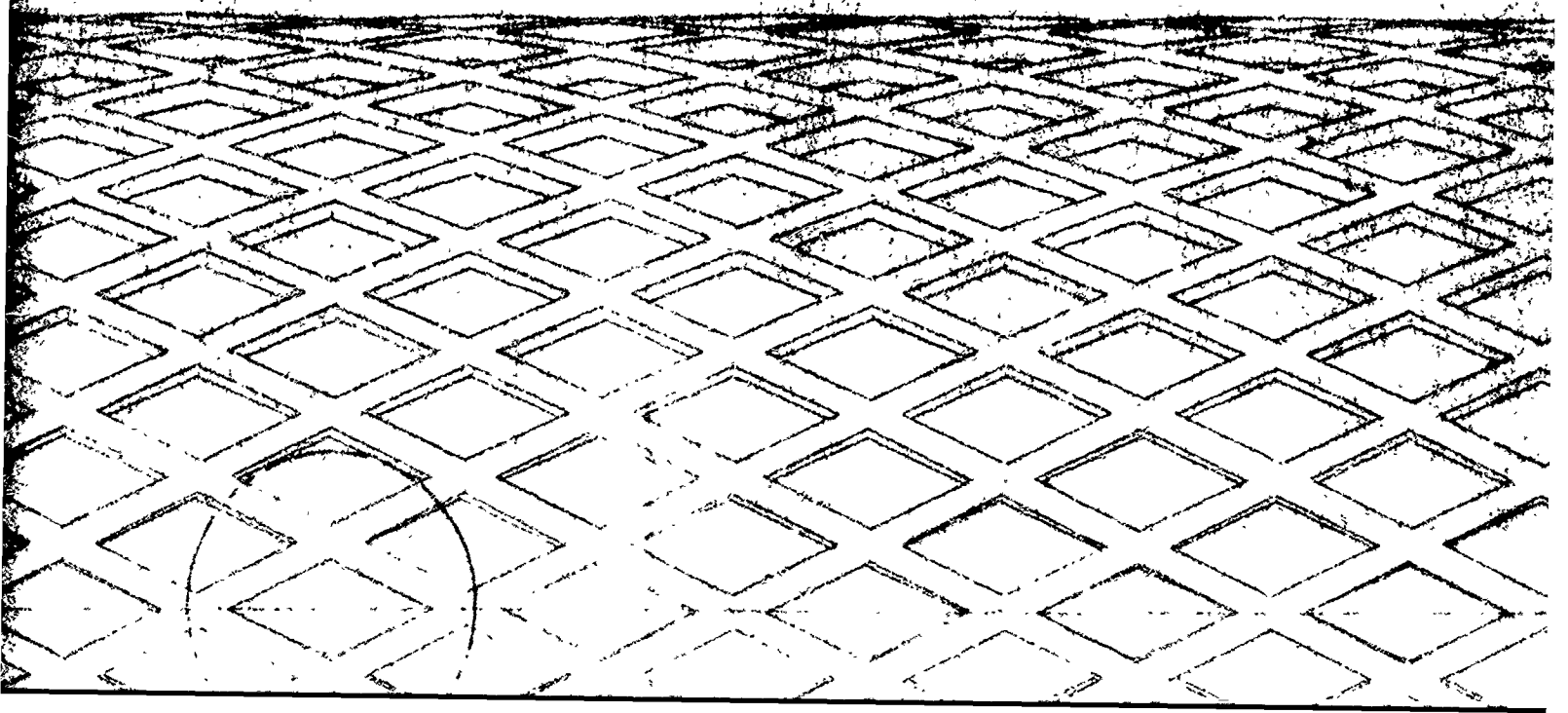
W _s IN.	W _b IN.	NO. CIR LAYER
1.85	.62	28
.62	.62	56
1.85	.62	28
.62	.62	56
1.85	.62	28
1.85	.62	56

.053 IN., $t_c = .25$ IN.

AREA

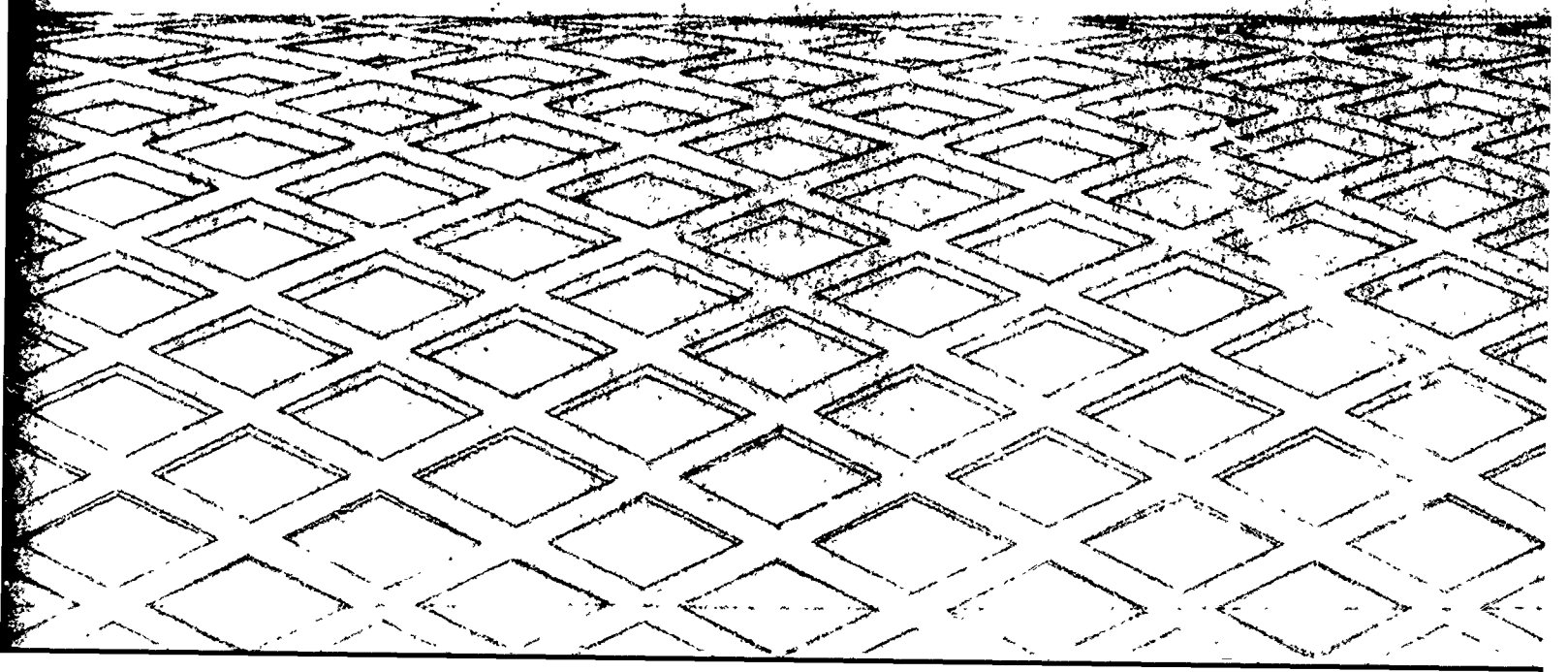


72.00



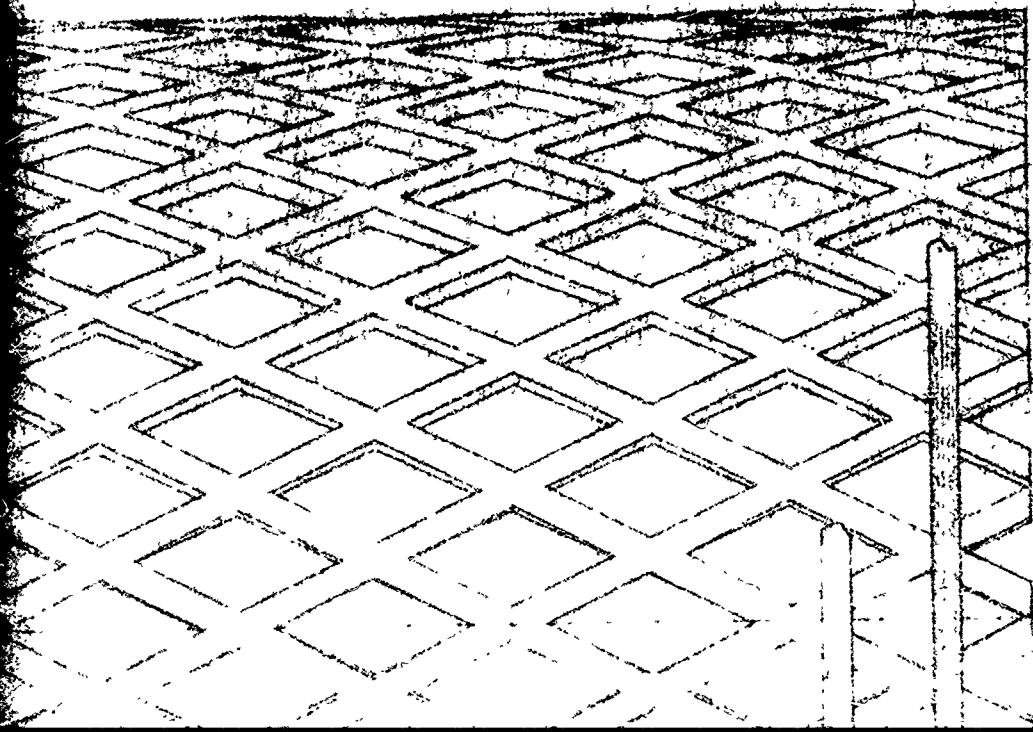
1 2 3 4

72.00



1945

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24.00
DIA

WS

The drawing shows a curved, semi-circular structure with a dashed line indicating a diameter of 24.00. The structure is composed of a series of parallel lines, suggesting a fiber-reinforced material. A label 'WS' is located to the right of the structure.

2) ALL FIBER MATERIALS IMPREGNATED WITH APCO 2453 / APCO 2330 EPOXY RESIN SYSTEM.

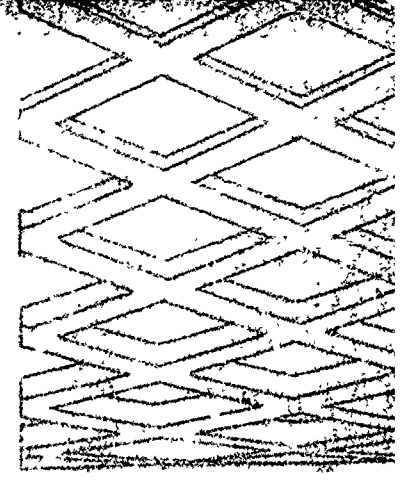
1 CONSTRUCTION:

20 % $\pm 90^\circ$ HOOP WINDING

80 % $\pm 24^\circ$ HELICAL WINDING

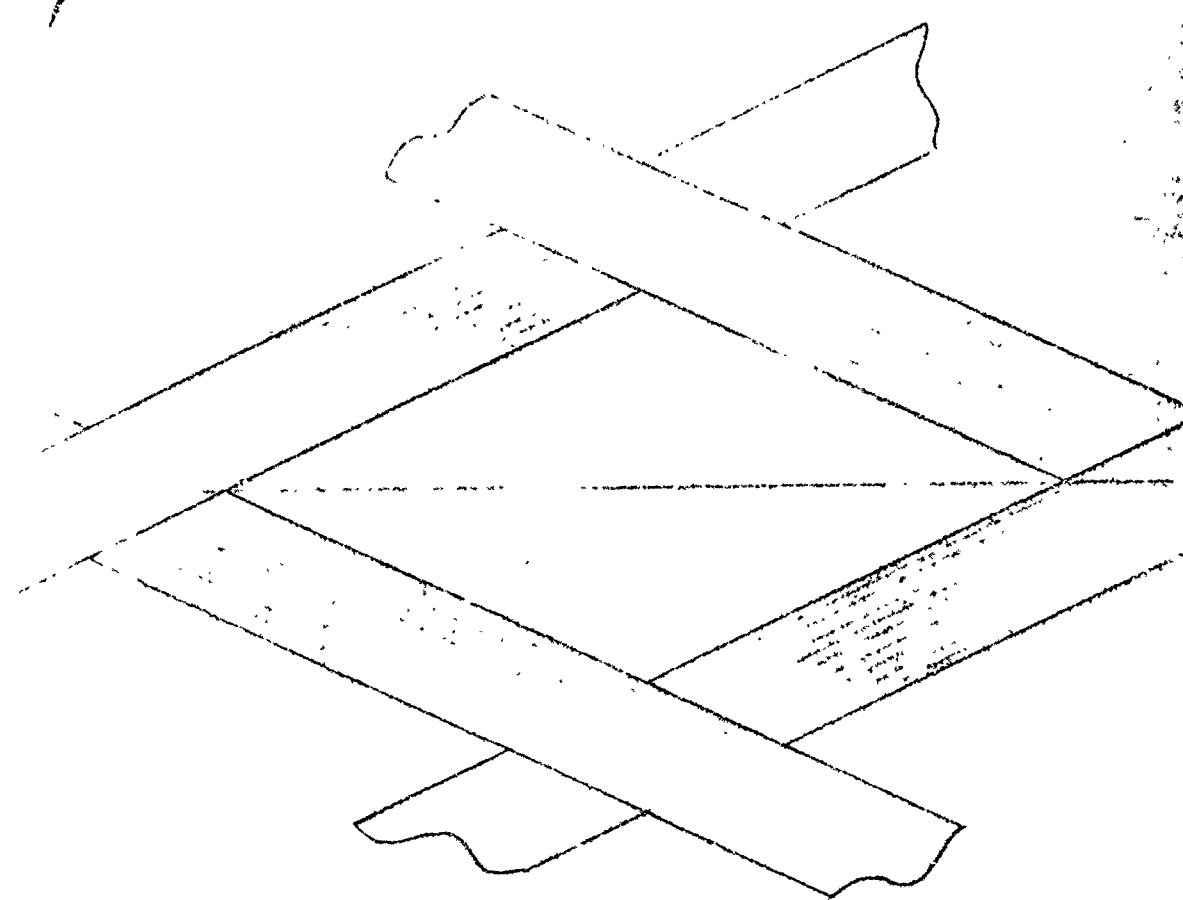
NOTES:

10



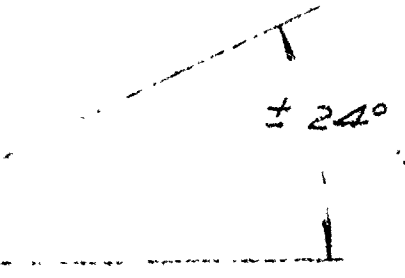
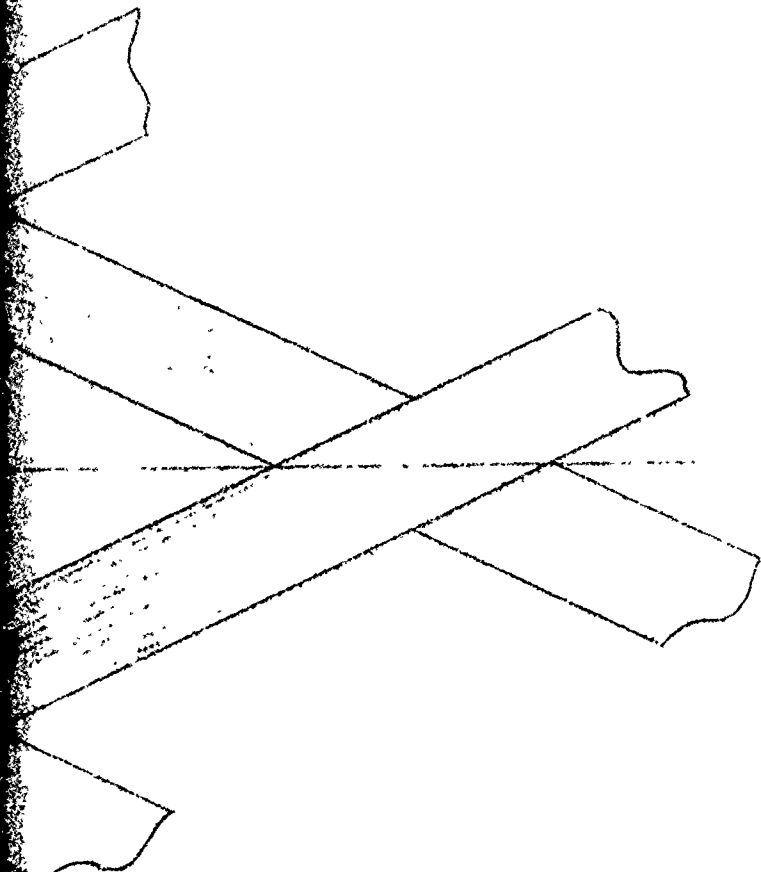
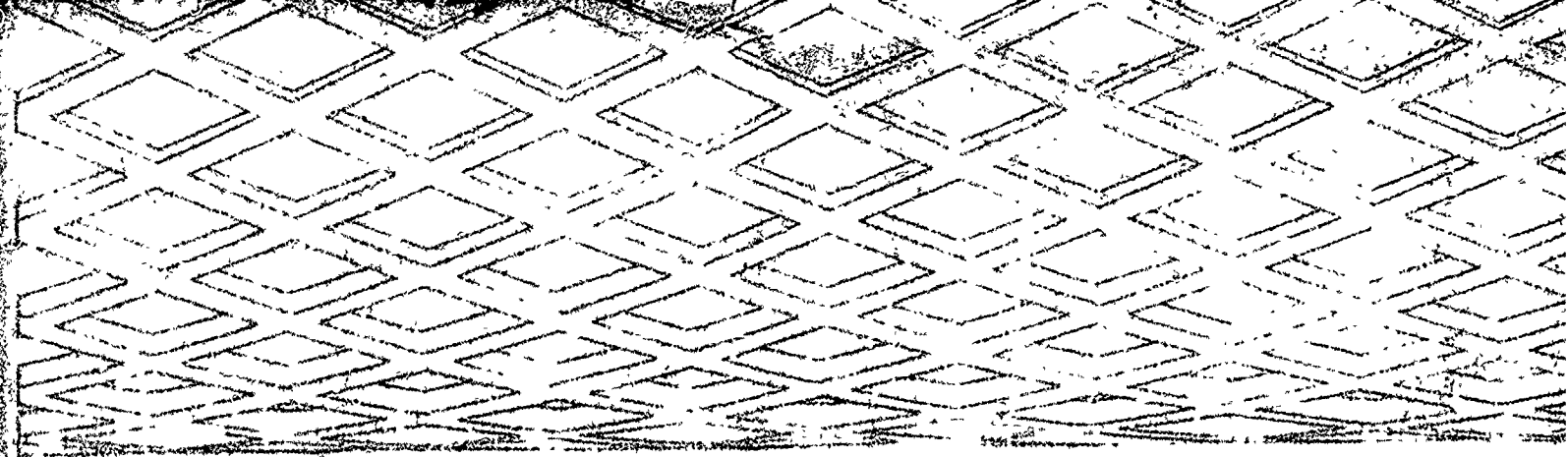
W_0

W_5



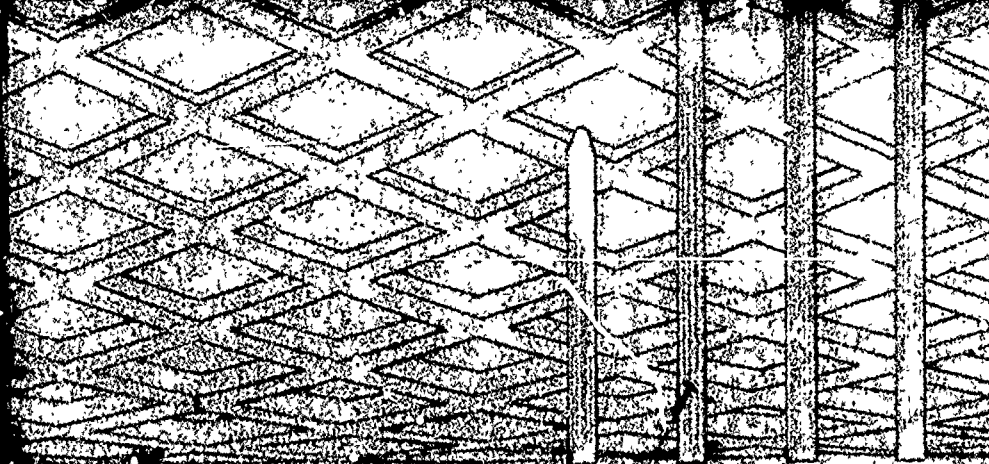
WITH APCO
SYSTEM.

DETAIL A (HOOP WINDING NOT



WINDING NOT SHOWN

	CODE IDENT	PART NO.	DESCRIPTION
QTY REQD			LIST OF
	UNLESS OTHERWISE NOTED DIMENSIONS ARE IN INCHES TOLERANCES DECIMAL FINISH ANGULAR XX ± .02 ✓ ± /° XXX ± .030 ✓ DO NOT SCALE		DATE
	FINISH		DRAWN S. CHU 3-8-77
			CHECK
			DESIGN
			STRESS
			ENGR



HOOP WINDING (TYP)

DESCRIPTION	MATERIAL	SPECIFICATION	ZONE	ITEM NO.
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LIST OF MATERIALS

DRAWN <i>S. CHU</i>		DATE <i>3-8-77</i>	FIBER SCIENCE, INC. GARDENA, CALIFORNIA 90248		
CHECK					
DESIGN			TITLE <i>SPACEWOUND EVALUATION SPECIMEN</i>		
STRESS					
ENGR					
DESIGN ACTIVITY APPD			DWG SIZE	CODE IDENT	DWG NO.
			D	32500	<i>1105-001</i>

APPENDIX H
NOMENCLATURE

NOMENCLATURE

A	Area, in ²
B	Angle, deg.
C _c	Buckling coefficient
E _e	Modulus of elasticity, psi
F	Allowable stress, psi
FA	Fiber area per unit
FACR	Fiber area coverage ratio
FCR	Fiber coverage ratio
FCOA	Fiber cross-over area ratio
G	Shear modulus, psi
I	Moment of inertia, in ⁴
I _o	Moment of inertia about neutral axis, in ⁴
IO	Inside diameter, in.
K	Torsional constant, in ⁴
L	Dimension, in.
M	Moment, in-lb
n	Coefficient
P	Load, lb
Q	Moment area, in ³
R	Radius, in.
\bar{R}	Mid wall radius, in.
S	Shear, lb
t	Thickness, in.
V	Volume ratio
W	Dimension, in.
y	Dimension, in.
α	Winding angle, deg.
ρ	Density, lb/in ³
σ	Unit stress, psi
τ	Unit shear stress, psi

SUBSCRIPTS

b denotes band
bco denotes between cross-overs
c denotes composite or core
co denotes cross-over
cr denotes critical
cu denotes compression ultimate
e denotes equivalent
f denotes fiber
fco denotes fiber cross-over
fbco denotes fiber between cross-overs
i denotes inside
max denotes maximum
o denotes outside
su denotes shear ultimate
x denotes "x" direction
y denotes "y" direction
z denotes "z" direction
ll denotes direction parallel to fibers