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FLIGHT SERVICE EVALUATION OF COMPOSITE HELICOPTER COMPONENTS

Second Annual Report
MAY 1982 through September1983

Melvin J. Rich and David W. Lowry

SIKORSKY AIRCRAFT
DIVISION OF UNITED TECHNOLOGIES CORPORATION
Stratford, Conn.

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APRIL 1985

NASA
National Aeronautics and
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Langley Research Center
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FOREWORD

This report was prepared by Sikorsky Aircraft, Division of United Technologies Corporation, under NASA Contract NAS1-16542 and covers the work performed during the period of May 1982 through September 1983. This program was jointly funded by the Materials Division of NASA-Langley Research Center and Structures Laboratory, U.S. Army Research and Technology Laboratory (AVSCOM). The contract is monitored by Mr. Donald Baker of the Applied Materials Branch.

The authors wish to acknowledge the contributions of the following Sikorsky personnel: R. Gallagher, and T. Gilbertson, component testing; B. Ching environmental analysis; M.B. Ezzo, material coupon evaluation and M. Rogers, graphical presentations.

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FLIGHT SERVICE EVALUATION OF COMPOSITE HELICOPTER COMPONENTS
(Second Annual Report)

by
M.J. Rich and D.W. Lowry
Sikorsky Aircraft
Division of United Technologies Corporation
Stratford, Connecticut

SUMMARY

This second annual report presents the environmental effects data for up to four years service operation of S-76 tail rotor spars and three years for field exposed composite panels.

Four S-76 tail rotor spars were returned after three and four years of commercial operation in the Louisiana Gulf Coast region. Full scale fatigue tests were conducted on three and four year service spars. Two three year service spars were cut up for coupon testing. The full scale fatigue strengths of the three and four year spars were of equal strength and close to the baseline spar fatigue data.

Panels exposed for three years were returned for moisture measurements and strength tests. Environmental analyses were made of the returned tail rotor spars and composite panels. Both moisture and strength predictions were compared with measured data. The moisture absorption was close to the predictions. The affect on strength was close to laboratory conditioned strength data.

SECTION 1.0 INTRODUCTION AND BACKGROUND

The environmental effects program for composite structures was instituted to assess the affects of environment on selected composite materials. The program includes evaluation of in-service components and of field exposed panels. The in-service components are obtained from commercial S-76 operations in the Gulf Coast Region. The field exposed panels are obtained from locations in West Palm Beach (WPB), Florida and Stratford (STFD), Connecticut. The data is used to compare with laboratory test/and analytical methods.

The objective of this eight year program is to derive procedures for establishing in-service environmental factors for both design and component test verification.

The tasks for this program are: (1) determine the strength of composite structural components after in-service use, (2) compare such results with initial certification tests, (3) evaluate the effects of component moisture content, and (4) compare coupon test results for real time and accelerated environmental conditioning.

The schedule for this program is shown in Table I. The components selected for in-service evaluation are the tail rotor spar and the horizontal stabilizer. The tail rotor spar is an all graphite/ epoxy structure (AS1/6350 Ciba-Geigy System) designed by cyclic loads. The horizontal stabilizer is a full depth sandwich structure with crossplied Kevlar/epoxy (285/5143 Dupont, American Cyanamid System) skins on a Nomex honeycomb core. Each stabilizer is joined by a full depth aluminum honeycomb core spar that has unidirectional graphite/epoxy (AS1/6350) caps and overwrapped with Kevlar/epoxy (285/5143) fabric. The stabilizer is designed by static loads but will also be cyclicly tested under this program to ascertain in-service environmental effects on fatigue strength.

This second annual report is a continuation of the efforts reported for two year commercial operation of S-76 spars and field exposed panels (Reference 1). The technical background on moisture absorption characteristics, the test data for the two year exposures, and baseline test data are contained in Reference 1.

The continuation of the program provides tail rotor spars with increasing calendar time and absorbed moisture. It is expected that the environmental effects will increase with time.

To assess the affect of moisture and flight loads on tail rotor spars, four were returned during this reporting period. Full scale fatigue tests were conducted on a three and a four year service spar. Two three year service spars were cut up into coupons for testing. The spar coupons are to provide more detailed moisture absorption data as well as to provide static and fatigue strengths.

The three year field exposed composite panels data are now available for this reporting period. Both moisture and strength tests of three years exposure can now be compared with the previous period reported.

TABLE I

SCHEDULE FOR EVALUATION OF IN-SERVICE ENVIRONMENTAL EFFECTS ON ADVANCED COMPOSITE STRUCTURES

S-76 HELICOPTER
CONTRACT EFFECTIVE DATE 2-9-81

TASK			CALENDAR YEAR							
			81	82	83	84	85	86	87	88
1.0		In-Service Component Selection								
	1.1	Tracking	X	X	X	X	X	X	X	X
	1.2	Selection:								
		- Horizontal Stabilizer	X		X		X		X	
		- Tail Rotor Spar	X	X	X	X	X	X	X	X
2.0		Tests of In-Service Components								
	2.1	Horizontal Stabilizers:								
		- Fatigue Tests, Full Scale*			X				X	
		- Static Tests, Full Scale*	X		X		X		X	
	2.2	Tail Rotor Spars:								
		- Fatigue Tests, Full Scale*	X	X	X	X		X		X
		- Coupon Static/Fatigue Tests*		XX		X		X		
3.0		Material Evaluation	X	X	X	X	X	X	X	X
4.0		Analysis of test Results	X	X	X	X	X	X	X	X
5.0		Reports								
	5.1	Technical Letter Reports (Quarterly)								
	5.2	Oral Presentations		X	X	X	X	X	X	X
	5.3	NASA Reports		X	X	X	X	X	X	X

*Actual Times in Each Year Are Approximate

SECTION 2.0 IN-SERVICE COMPONENT SELECTION

The selection of components under NASA Contract NAS1-16542 are from aircraft operating in a humid hot region, generally located in the Gulf Coast Louisiana Region of the United States. Additional component data is available and will be referenced in this report.

Components are selected from high time helicopters. However, the commercial operator may not keep the same components on the aircraft and therefore, calendar and flight hours are specified for the components. The stabilizer and tail rotor spars are serialized and the operational data are obtained from their individual log cards.

The components selected for testing are from a commercial operator (Air Logistics), located in Louisiana.

COMPONENT	TOTAL OPERATING TIME	CALENDAR TIME IN FIELD
Stabilizer B-157-00076	1600 Hrs	17 Months*
Tail Rotor Paddle A-137-00034 Spar A-116-00094	2390 Hrs	29 Months*
Tail Rotor Paddle A-137-00085 Spar A-116-00150	2385 Hrs	37 Months
Tail Rotor Paddle A-137-00099 Spar A-116-00283	1884 Hrs	37 Months
Tail Rotor Paddle A-137-00068 Spar A-116-00237	1596 Hrs	41 Months**
Tail Rotor Paddle A-137-00031 Spar A-116-00114	3350 Hrs	49 Months

The environmental histories of components tested during this reporting period are documented in Section 7.

*Tested and reported in Reference 1.
**Reference Table X for environmental history.

SECTION 3.0 TESTS OF IN-SERVICE COMPONENTS

3.1 Horizontal Stabilizer

The first static tested horizontal stabilizer is reported in Reference (1). The second horizontal stabilizer, with four years service, has been returned to Sikorsky. This component will be checked for stiffness before fatigue and residual strength tests are conducted. Tests are scheduled for late 1983.

3.2 Tail Rotor Spars

To date, there have been eight tail rotor spars returned from service. Table II lists the spars and their test conditions. Moisture measurements and environmental analysis are reported for the spars with service in the Louisiana Gulf Coast region. These spars are first inspected and then fatigue tested. Moisture measurements are taken from coupons removed near the zone of crack initiation. In addition, two spars, S/N A116-00150 and 00283, were used only for moisture measurements and coupon strength testing.

3.3 Spar Moisture Measurements

Coupons were taken from the tail rotor spars for the purpose of determining the moisture contents. Locations are shown in Figure 1 for full scale fatigue tested spars.

The coupons taken from the tail rotor spar were between stations 5 to 7, the region of spar fatigue cracking. To accelerate the desorption tests some of the tail rotor coupons (from leading edge) were fragmented. The results of the fragmented desorption tests will be reported. Past desorption testing of tail rotor spar coupons have shown no final difference in desorption results whether the coupons are fragmented or not. However, the second set, solids, are being desorbed as a backup for data.

The desorption time history of the coupon for the B end at Sta. 6-7 leading edge Tail Rotor Spar S/N 00094 is typical and shown in Figure 2. The projected moisture absorbed is .26 percent weight. As illustrated in Figure 2, Fick's Law, used for moisture analysis, agrees closely with the experimental data.

TABLE II

SUMMARY OF RETURNED IN-SERVICE SPARS

Tail Rotor Spar S/N (Year Returned)	In-Service Location	In-Service Time[1] Months/Flight Hrs.	Status
A-116-00046* (1980)	WPB (Flight Test)	25 Months 150 Flight Hrs.	Spar fatigue tested
00064* (1980)	As Above	25 Months 150 Flight Hrs.	Spar fatigue tested
00094 (1981)	Gulf Coast (Commercial)	29 Months 2390 Flight Hrs.	Spar fatigue tested
00150 (1982)	As Above	37 Months 2385 Flight Hrs.	Coupons tested only
00283 (1982)	As Above	37 Months 1884 Flight Hrs.	Coupons tested only
00172* (1982)	As Above	39 Months 2533 Flight Hrs.	Spar fatigue tested
00237 (1982)	As Above	28 Months** 1596 Flight Hrs.	Spar fatigue tested
00114 (1983)	As Above	49 Months 3550 Flight Hrs.	Spar fatigue tested

NOTES:

(1) In some instances there is additional calendar exposure time and is so listed in the tail rotor spar history. Total exposure time is used for environmental analyses.

* Designates additional spars tested.

** Reference Table X for Environmental History.

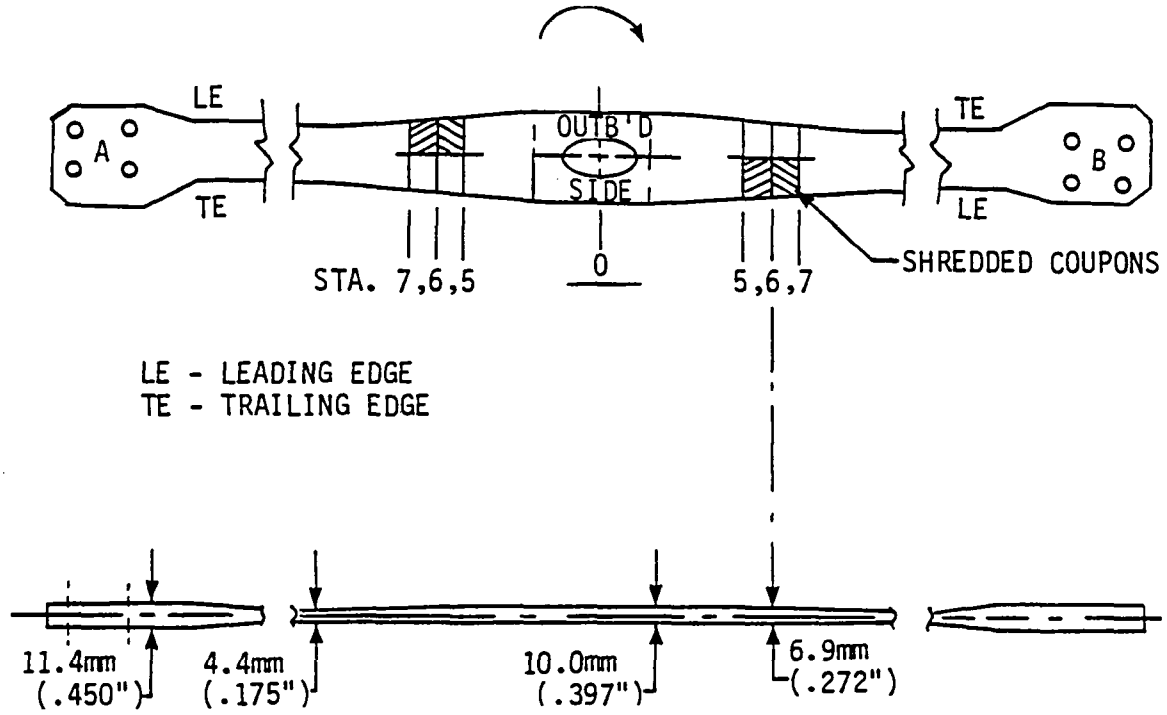

FIGURE 1. S-76 TAIL ROTOR SPAR - LOCATION OF MOISTURE MEASUREMENT COUPONS

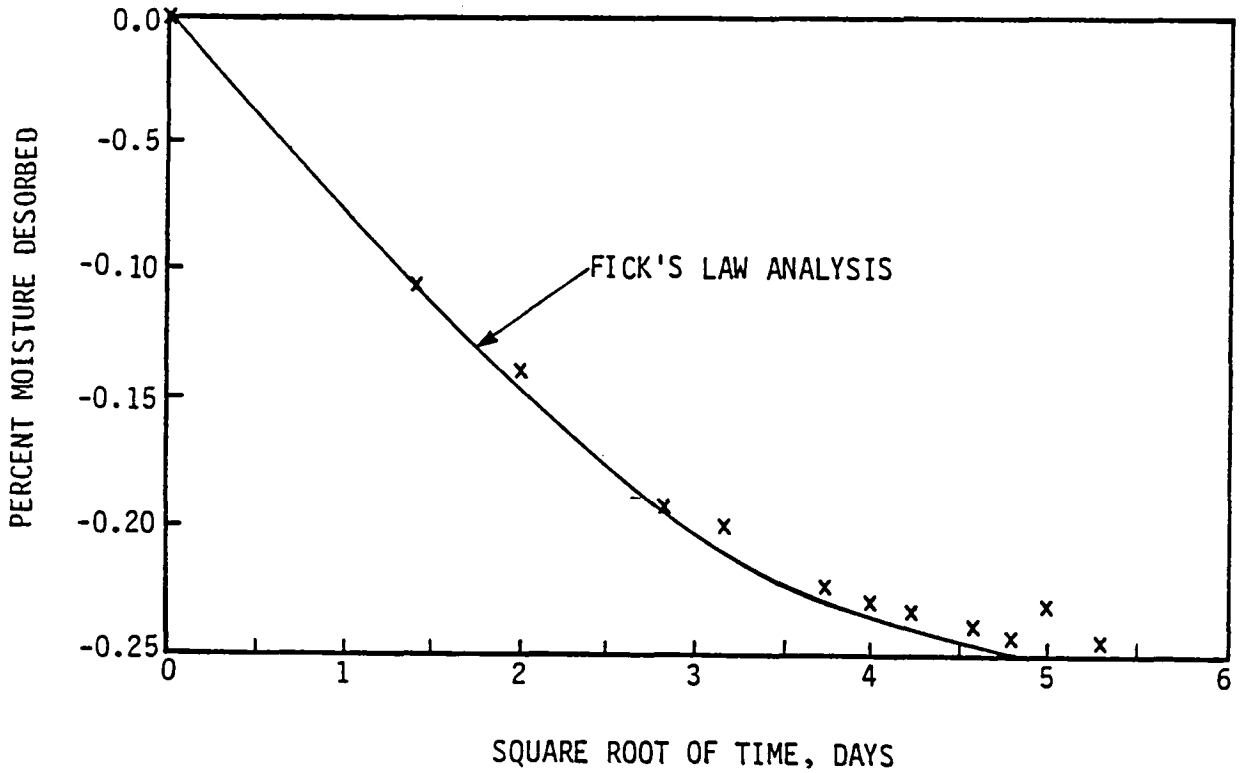

FIGURE 2. DESORPTION TIME HISTORY OF COUPON FROM TAIL ROTOR SPAR. S/N A-116-00094. (STATION 6-7 LE, END B).

The procedure for all the fatigue tested spars was to determine the moisture at the stations 5 to 7 and to average the data. The averaged moisture contents for the spars returned from commercial service in the Gulf Coast region are as follows:

Spar S/N	In-Service Time (Months)	Average Moisture (STA 5-7) Content, percent Weight
00094	29	.26
00150	37	.40
00283	37	.36
00172	39	.42
00237	28	.50
00114	49	Still being desorbed

In addition, moisture measurements were taken from STA 12.5-13.5 (two ends) for spars S/N 00150 and 00283. That data is to be used for spar coupon strength data in region STA 9.75 to 12.25 (constant thickness). Figure 3 presents the sketch of coupon locations for these spars.

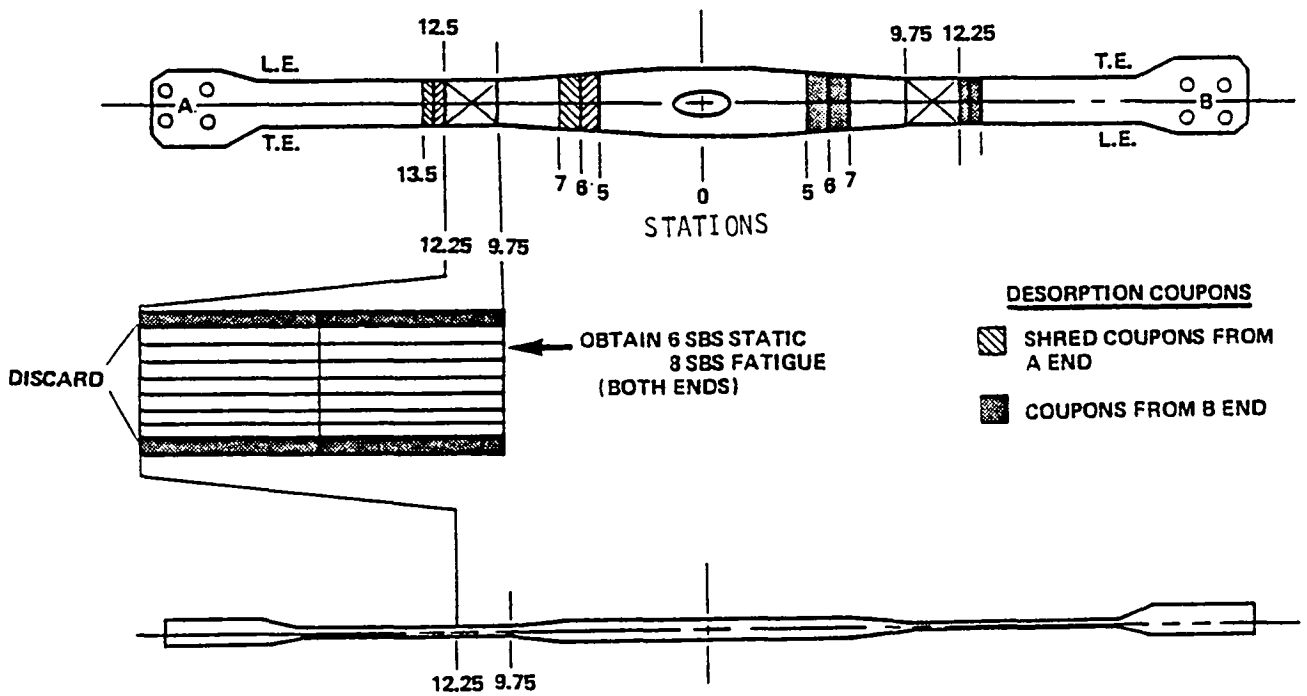

FIGURE 3. SKETCH OF COUPON LOCATIONS FROM SPARS A-116-00150 and A-116-00283

3.4 Spar Environmental Analysis and Correlation

The analysis and correlation is presented for in-service commercial operation in the Gulf Coast region.

The environmental histories for the spars is documented in Section 7. The analysis method is a computerized solution using Fick's Law with experimentally determined diffusion constants. The environmental data* was obtained from Reference (2).

The analysis time histories for each spar and the test measured moisture values are presented in Figures 4 through 9. Coupons from the tail rotor spar S/N 00114 are currently being desorbed to determine the moisture content. The results show that the measured (test) moisture level is slightly less than predicted without solar radiation effects. The comparison trend is illustrated in Figure 10.

*Solar radiation data was not available from Gulf Coast region (Lake Charles area). Therefore, all analysis is for ambient temperature and relative humidity (RH).

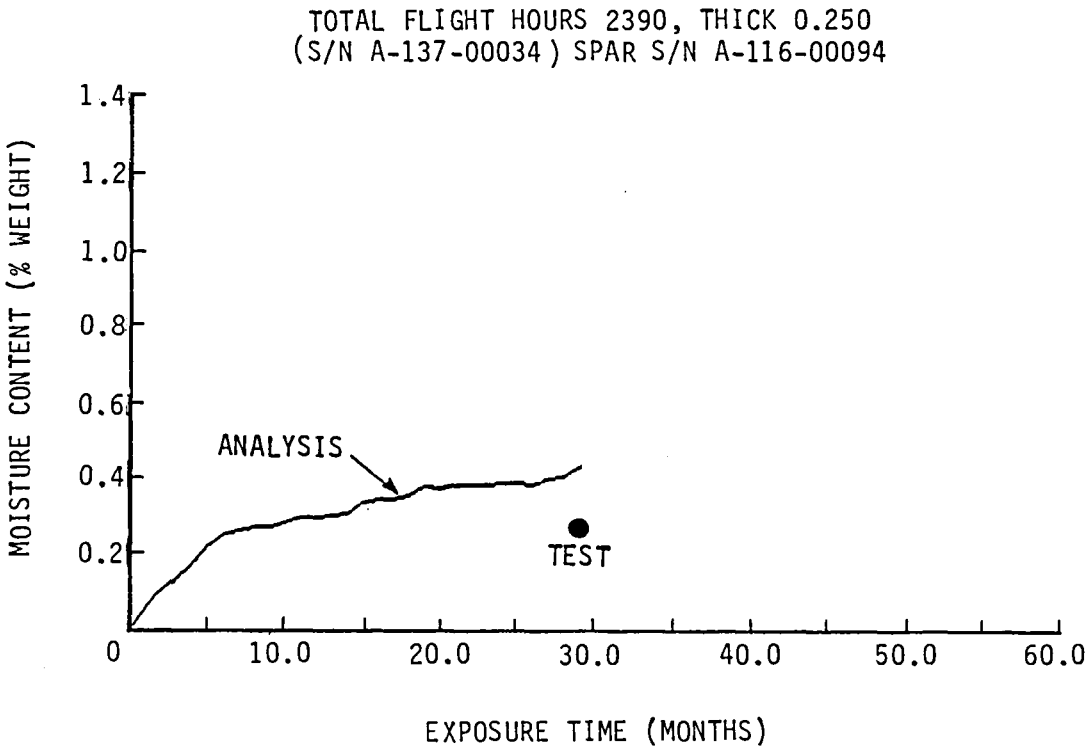

FIGURE 4. MOISTURE ABSORPTION FOR TAIL ROTOR SPAR A-116-00094

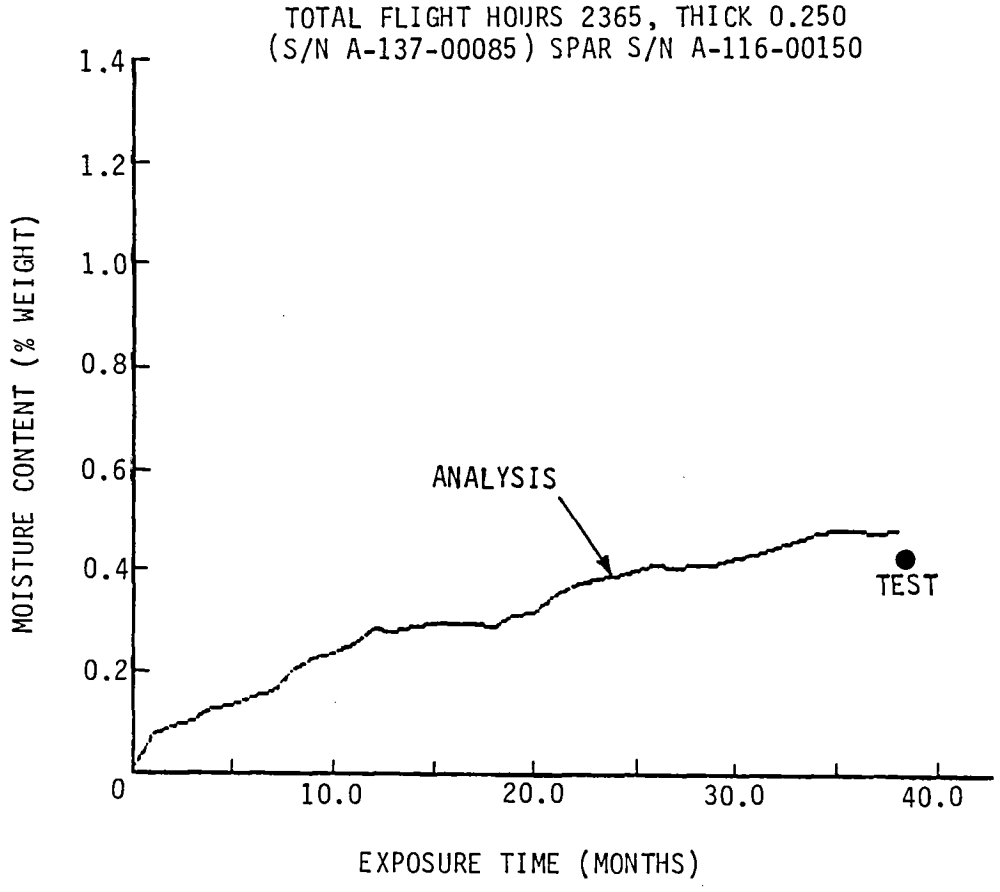

FIGURE 5. MOISTURE ABSORPTION FOR TAIL ROTOR SPAR A-116-00150

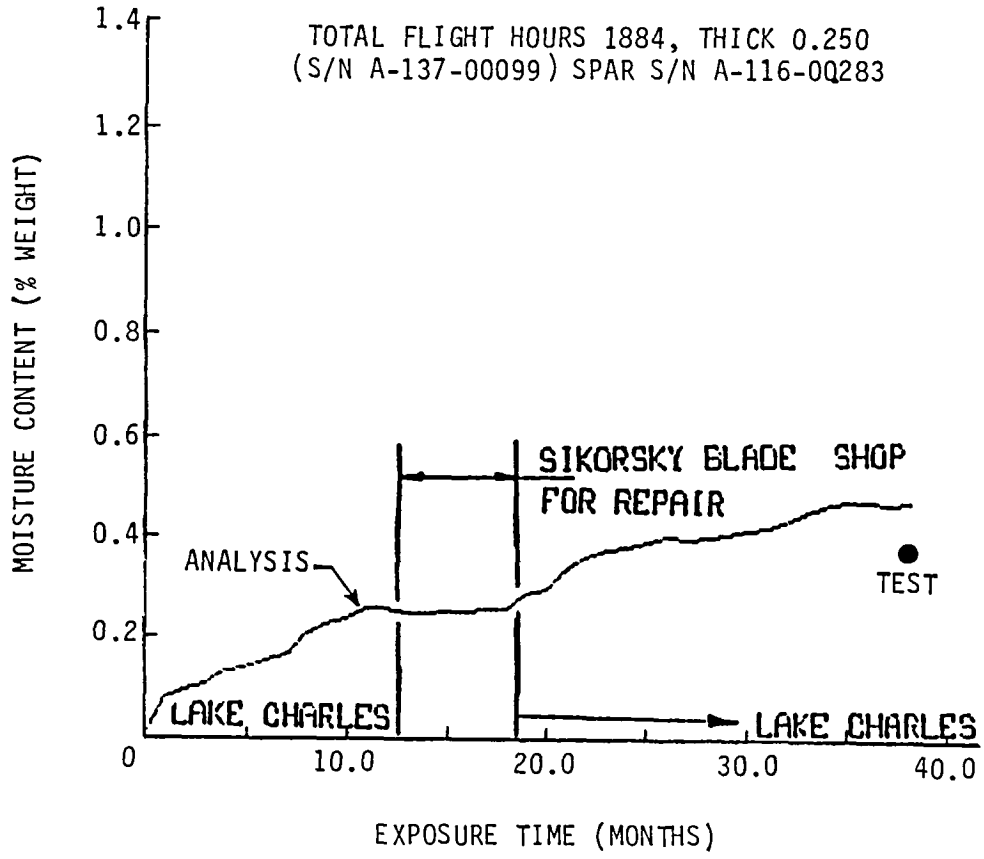

FIGURE 6. MOISTURE ABSORPTION FOR TAIL ROTOR SPAR A-116-00283

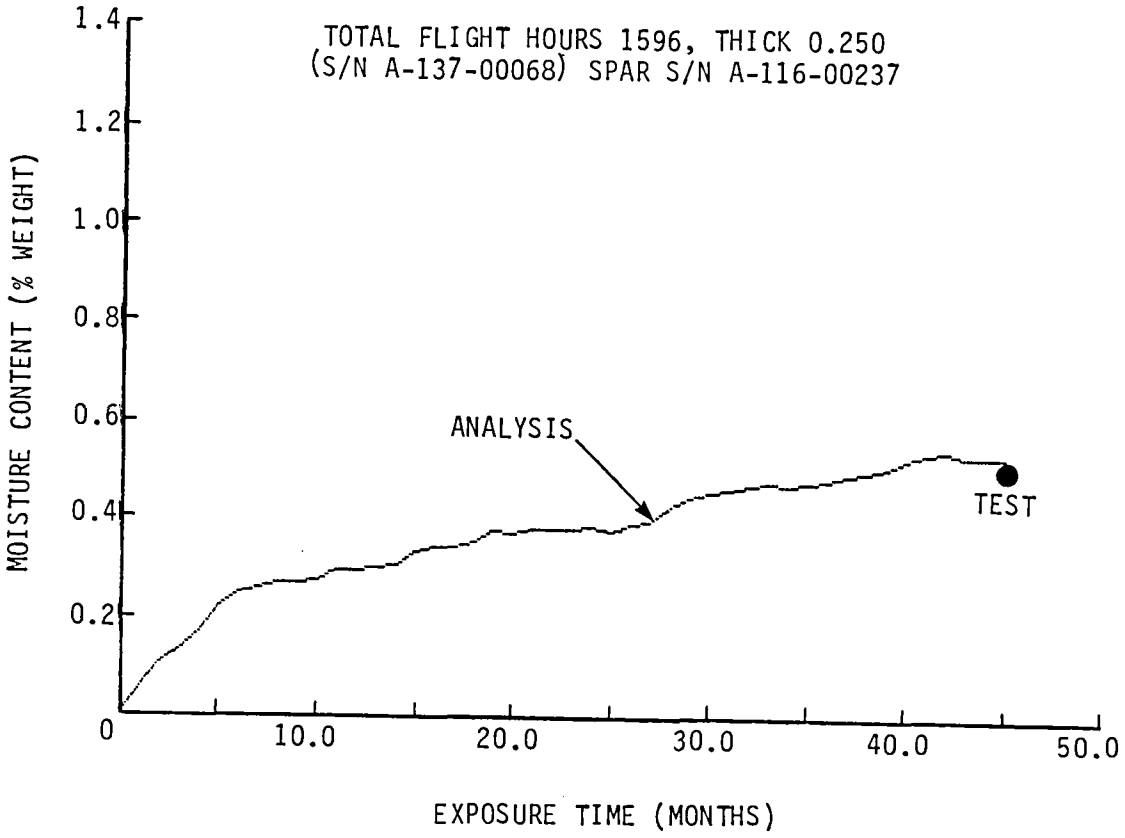

FIGURE 7. MOISTURE ABSORPTION FOR TAIL ROTOR SPAR A-116-00237

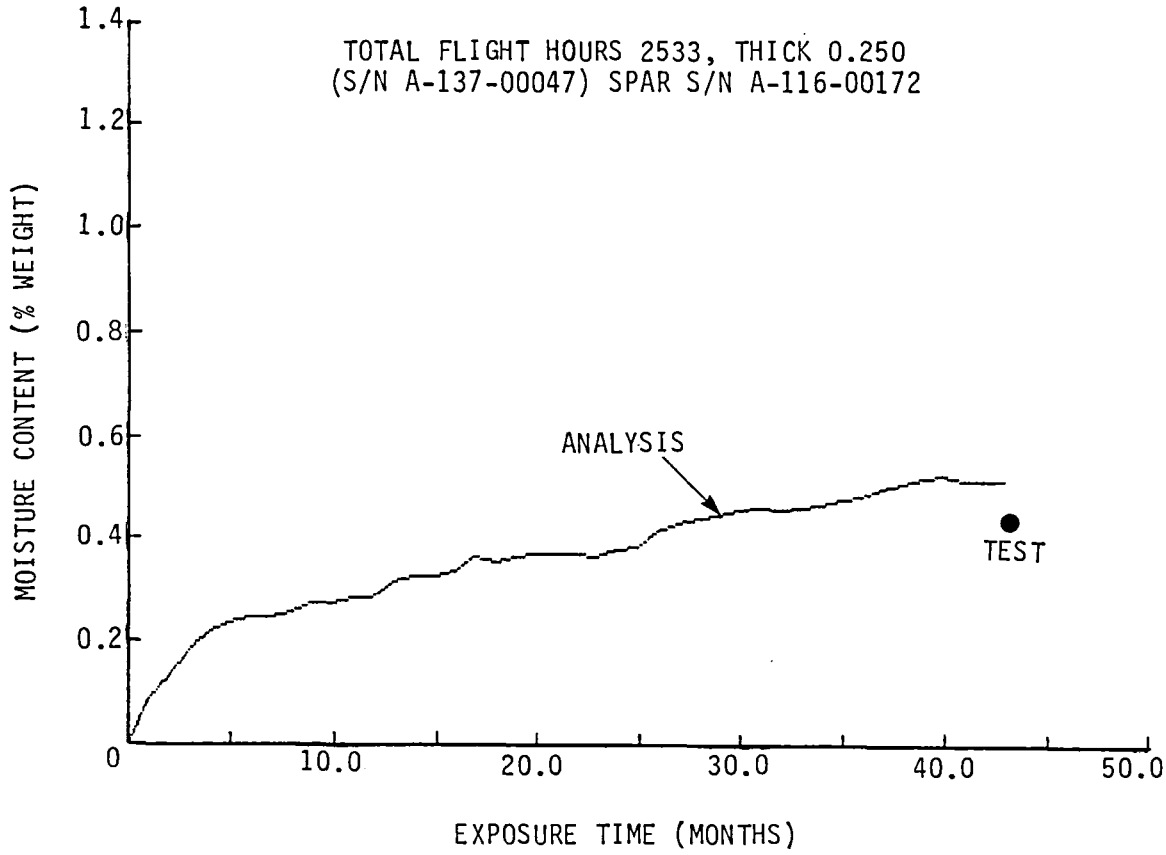

FIGURE 8. MOISTURE ABSORPTION FOR TAIL ROTOR SPAR A-116-00172

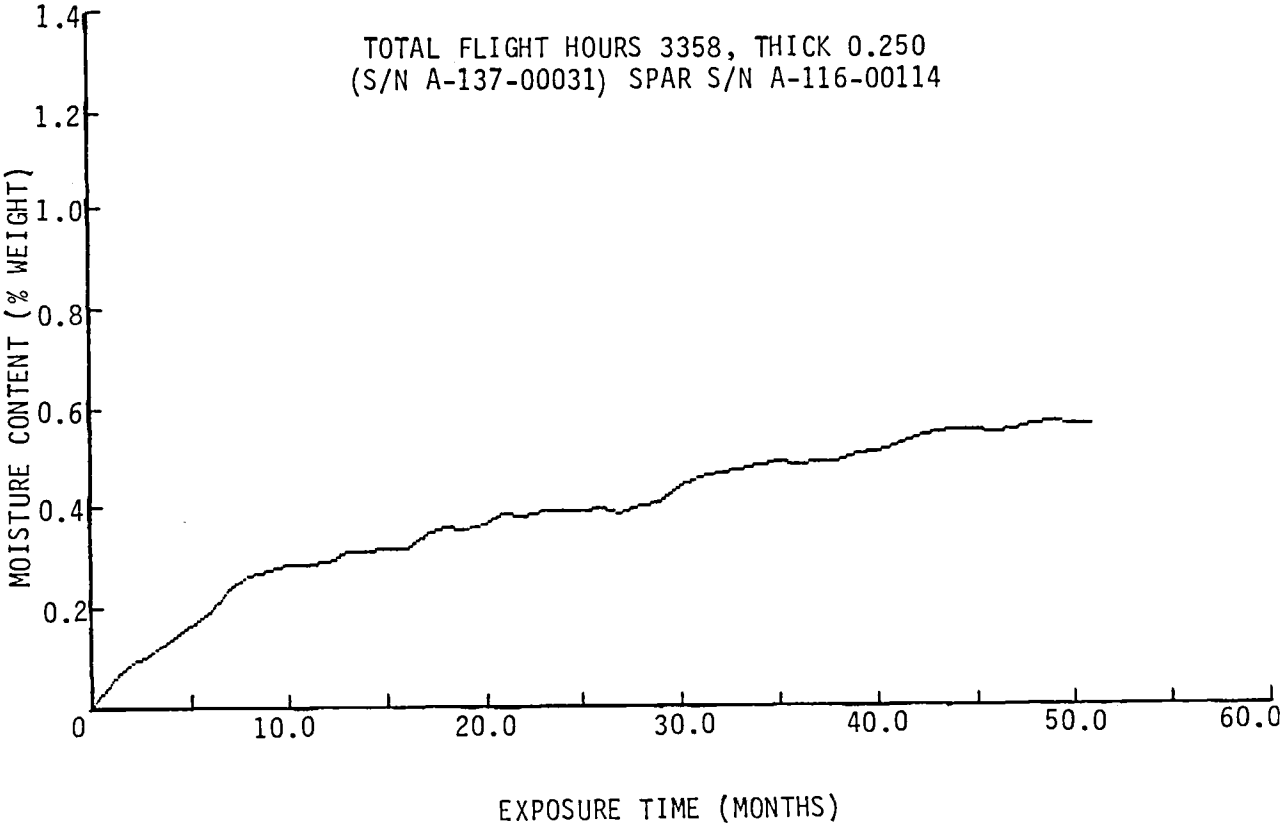

FIGURE 9. PREDICTED MOISTURE ABSORPTION FOR TAIL ROTOR SPAR A-116-00114

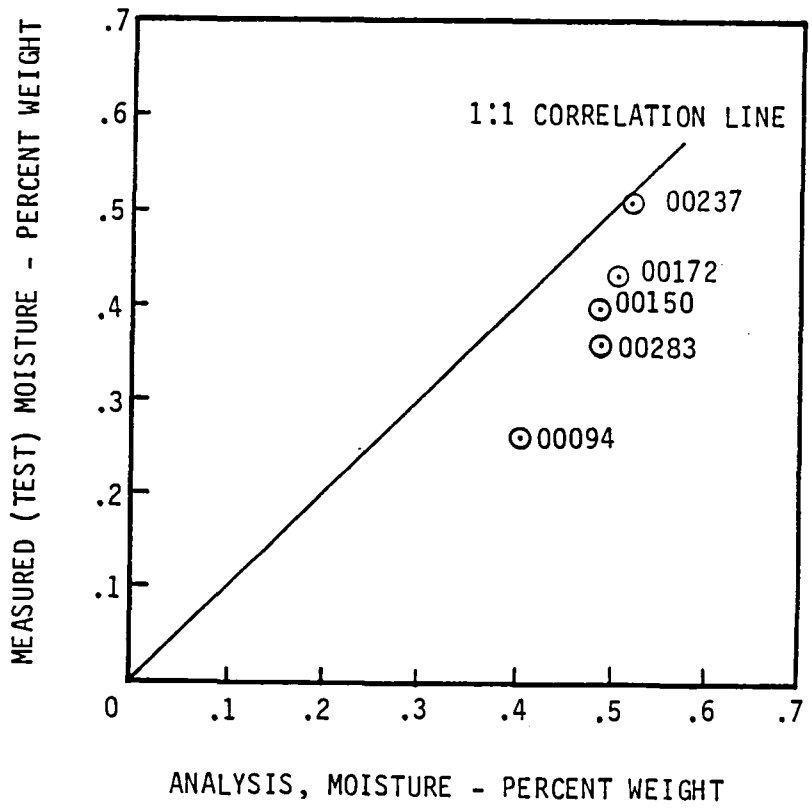

FIGURE 10. MEASURED VS. ANALYSIS MOISTURE CONTENTS OF IN-SERVICE S-76 SPARS

3.5 Spar Tests

The tail rotor spars are cyclicly loaded for combined edgewise (inplane) and flatwise bending with a steady centrifugal (axial) loading. The spars are clamped between an aircraft flange and retention plate. A short stub spar is used to take the place normally occupied by another blade spar (perpendicular to the test spar). The tail rotor combined load fatigue test setup and a schematic diagram of the methods for load introduction are those shown in Reference 1.

The load magnitudes are those stated in Table VIII of Reference 1. The steady centrifugal loading is kept constant for all tests and represents the centrifugal force developed at 110 percent of normal rotor speed. The cyclic loadings, edgewise and flatwise bending and torsional, are in phase and held in proportion. Absolute test levels are varied for the specific test so that fatigue fractures can be obtained between the range of 10^5 to 5×10^6 cycles. The resultant cyclic moment at strain gage location EB2S (Reference 1, Figure 19) is measured and monitored by calibrated strain gages.

The fatigue tests of a spar can produce two test points. The first (designated A) is the first fracture on one side of the spar. The other side (designated B) can continue to be tested until its fracture.

The full scale fatigue test results are listed in Table III along with the service history and measured moisture. A cyclic shear stress - cycles (S-N) diagram is shown in Figure 11. The fatigue curve shape was based on short beam shear (SBS) coupon tests. The mode of fracture of the tail rotor spars appears to start from an interlaminar shear delamination. The curve shape constants were derived from the following formula:

$$\frac{fs\ (N)}{da\ (E)} = 1 + \frac{\beta}{N^{\gamma}}$$

where: fs is the cyclic shear stress, a crack origin, and is the combination of shears from flatwise and edgewise bending and torsion.

fs (N) is the cyclic shear stress for N cycles.

da (E) is the cyclic shear stress at endurance.

β, γ are empirical constants and equal 0.138 for the SBS coupons and the full scale tail rotor spar tests.

N is in 10^6 cycles

Initially the tail rotor spar fatigue parameter was the edgewise bending moment (Figure 20, Reference 1). Further investigation disclosed a shear stress combination which resulted in improved curve fitting of data and reduced the coefficient of variation. A constant, steady, centrifugal load, applied during the tests, was not a variable. The lower S-N curve line was fitted to the approximately 2 year WPB service time spar tests.

The 3 year service spars appear to show more scatter than for previous years. S/N 00237 is well above the mean of exposed blades while S/N 00172 is just about on the two year WPB trend line.

The fatigue test of the four year exposed spar S/N 00114 shows no strength reduction from the mean RTD baseline curve.

Table IV presents the environmental factors for the in-service tail rotor full scale fatigue tests. A comparison of environmental factors derived from lab conditions (Figure 7 Reference 1) and in-service spars is presented in Figure 12.

Data for coupons taken from spars S/N 00150 and 00283 are reported under Material Evaluation, Section 4.0.

TABLE III. FATIGUE TEST AND DATA SUMMARY FOR TAIL ROTOR SPARS

Tail Rotor Serial Number	In-Service Location	In-Service Time Months/Flt. Hrs.		Shear Stress MP_a (psi)	Cycles to Fracture	Moisture, Percent Weight
00046	West Palm Beach, Fla. (Flight Test)	25 Months 150 Flight Hrs.	A	27.4 (3978)	$.25 \times 10^6$	$.29^{(1)}$
			B	27.4 (3986)	$.38 \times 10^6$	
00064	West Palm Beach, Fla. (Flight Test)	25 Months, 150 Flight Hrs.	A	29.8 (4320)	$.035 \times 10^6$	$.32^{(1)}$
			B	29.8 (4320)	$.071 \times 10^6$	
00094	Gulf Coast Region, La. (Commercial)	29 Months, 2390 Flight Hrs.	A	26.8 (3892)	$.286 \times 10^6$	$.26^{(2)}$
			B	27.0 (3922)	$.170 \times 10^6$	
00172	Gulf Coast Region, La. (Commercial)	39 Months 2533 Flight Hrs.	A	29.5 (4272)	$.218 \times 10^6$	$.42^{(2)}$
			B	29.5 (4272)	$.218 \times 10^6$	
00237	Gulf Coast Region, La. (Commercial)	28 Months[3] 1596 Flight Hrs.	A	31.2 (4518)[4]	$.267 \times 10^6$	$.50^{(2)}$
00114	Gulf Coast Region, La. (Commercial)	49 Months 3350 Flight Hrs.	A	30.5 (4416)[4]	$.839 \times 10^6$	To be determined

NOTES:

(1) Calculated from moisture measurements of spar

(2) Average of moisture measurements near fracture zone.

(3) 14 months spare, 28 months of flight service, 3 months lost by shipper. (Reference Table X)

(4) Fracture recorded on one side only.

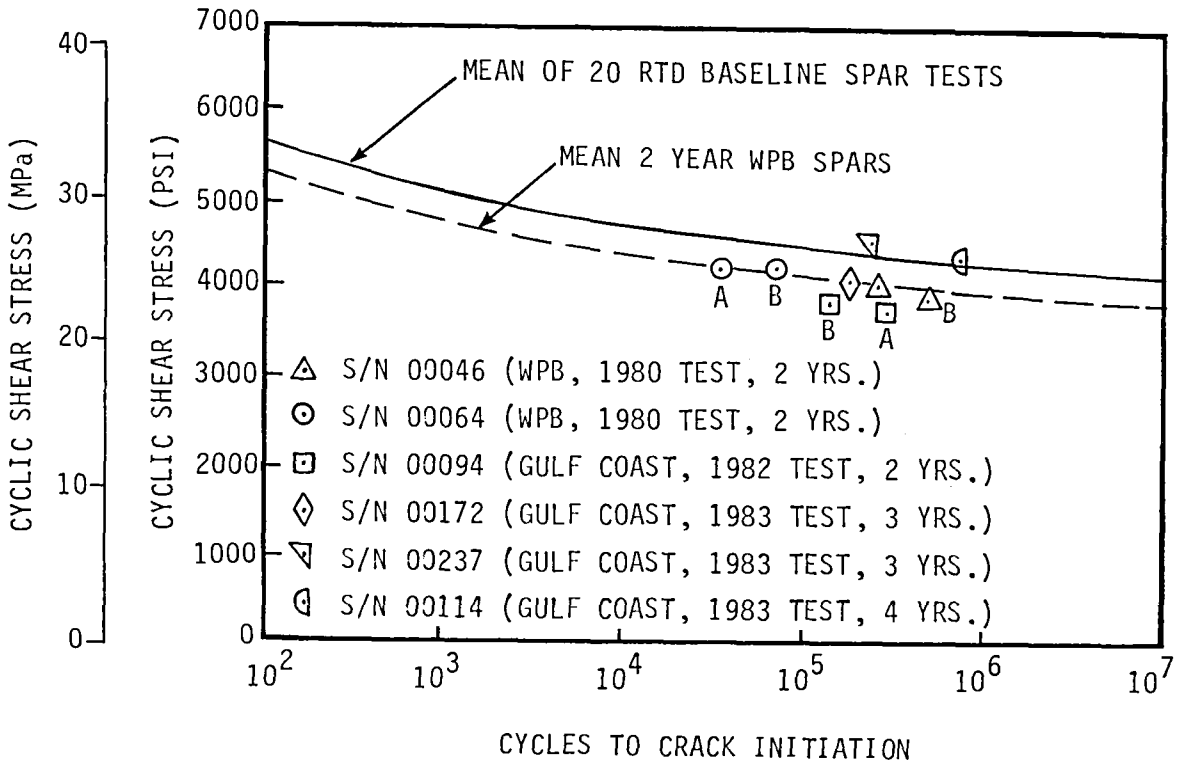

FIGURE 11. SHEAR STRESS-FATIGUE CYCLE RESULTS FOR S-76 TAIL ROTOR SPARS

TABLE IV. SUMMARY OF TAIL ROTOR SPAR FATIGUE TESTS

Tail Rotor Spar Tests and Service Data	Moisture Content, % WGT Near Fracture Zone	Cyclic Shear Stress at 10^7 Cycles (Fig. 11) MP_a	(psi)	Environmental Factor	
				Projected from Coupon Tests (Fig. 7, Ref. 1)	In-Service Component Test
Initial Certification Zero Time Structure	~0	28.6	(4150)	-	-
S/N 00094, 29 Months and 2390 Flight Hrs. in Gulf Coast Region, Louisiana	.26 at Station 6	26.9	(3900)	.95	.94
S/N 00237, 41 Months and 1596 Flight Hrs. in Gulf Coast Region, Louisiana	.50 at Station 6	29.5	(4275)	.93	1.03
S/N 00172, 39 Months and 2533 Flight Hrs. in Gulf Coast Region, Louisiana	.42 at Station 6	26.6	(3860)	.95	.93
S/N 00114, 49 Months and 3350 Flight Hrs. in Gulf Coast Region, Louisiana	To Be Determined (.56 Predicted)	29.1	(4233)	.91 (Predicted)	1.02

$$\text{ENVIRONMENTAL FACTOR} = \frac{\text{FIELD OR LAB STRENGTH}}{\text{RTD STRENGTH}}$$

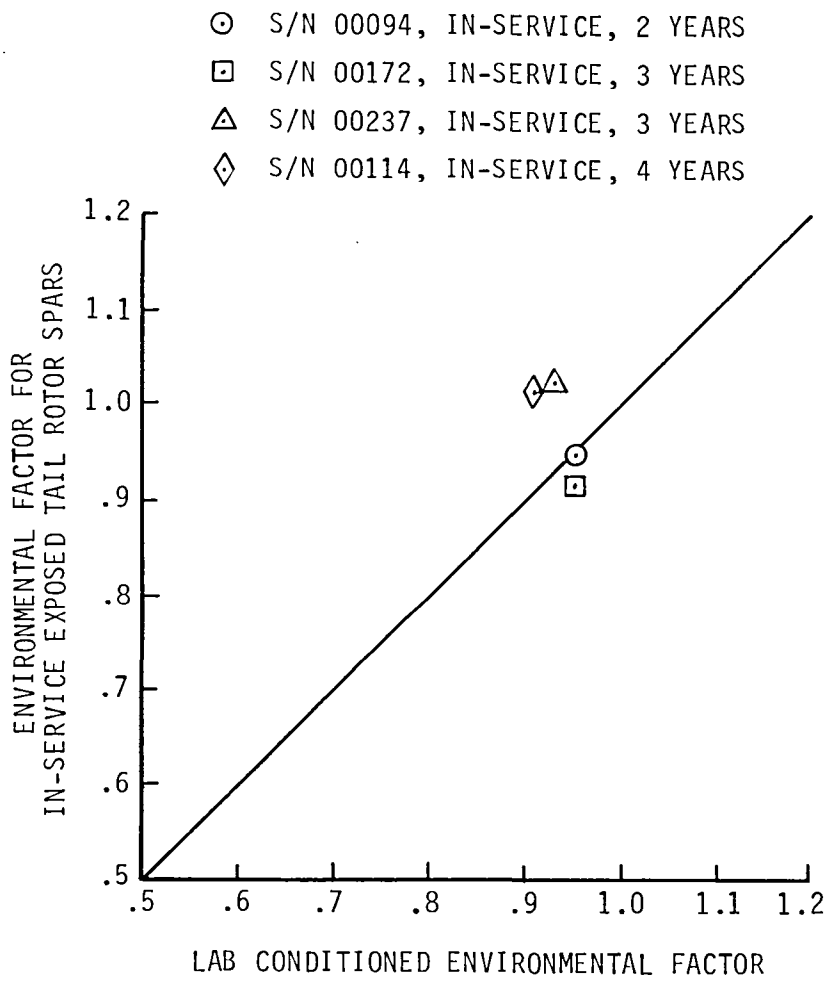

FIGURE 12. COMPARISON OF ENVIRONMENTAL FACTORS FOR IN-SERVICE TAIL ROTOR SPARS AND LABORATORY CONDITIONED COUPONS

SECTION 4.0 MATERIAL EVALUATION

4.1 Exposed Composite Panel Data

AS1/6350 graphite/epoxy and 285/5143 Kevlar/epoxy panels have been exposed to the outdoor environments at Stratford, Connecticut and West Palm Beach, Florida. Each year panels are returned and cut up into coupons for desorption and testing (Reference 1).

The graphite/epoxy panels are 6, 14, and 33 plies. Each ply is nominally .305 mm (12 mils) thick. The Kevlar/epoxy panels are 5 plies. Each ply is nominally .228 mm (9 mils) thick.

Static and fatigue tests are conducted on coupons from exposed panels and compared with baseline RTD data. The data available at this time (up to three years exposure) are reported.

4.2 Moisture Measurements

The coupons were desorbed at 150°F and a typical average desorption time history is presented in Figure 13 for the six ply graphite/epoxy coupon. Generally, there are 4 coupons taken from two panels and the data is averaged. The environmental history for the West Palm Beach exposed composite panels is listed in Section 7.2. The data for the three year exposed panels is documented in Section 7.2 for properties that will be referenced in this report. Section 7.2 (Table XV) contains the weather bureau data for WPB.

A summary of the moisture measurements for panels with two and three years exposure is presented in Table V. The desorption data for the tail rotor spar coupon is also listed in Table V for comparison.

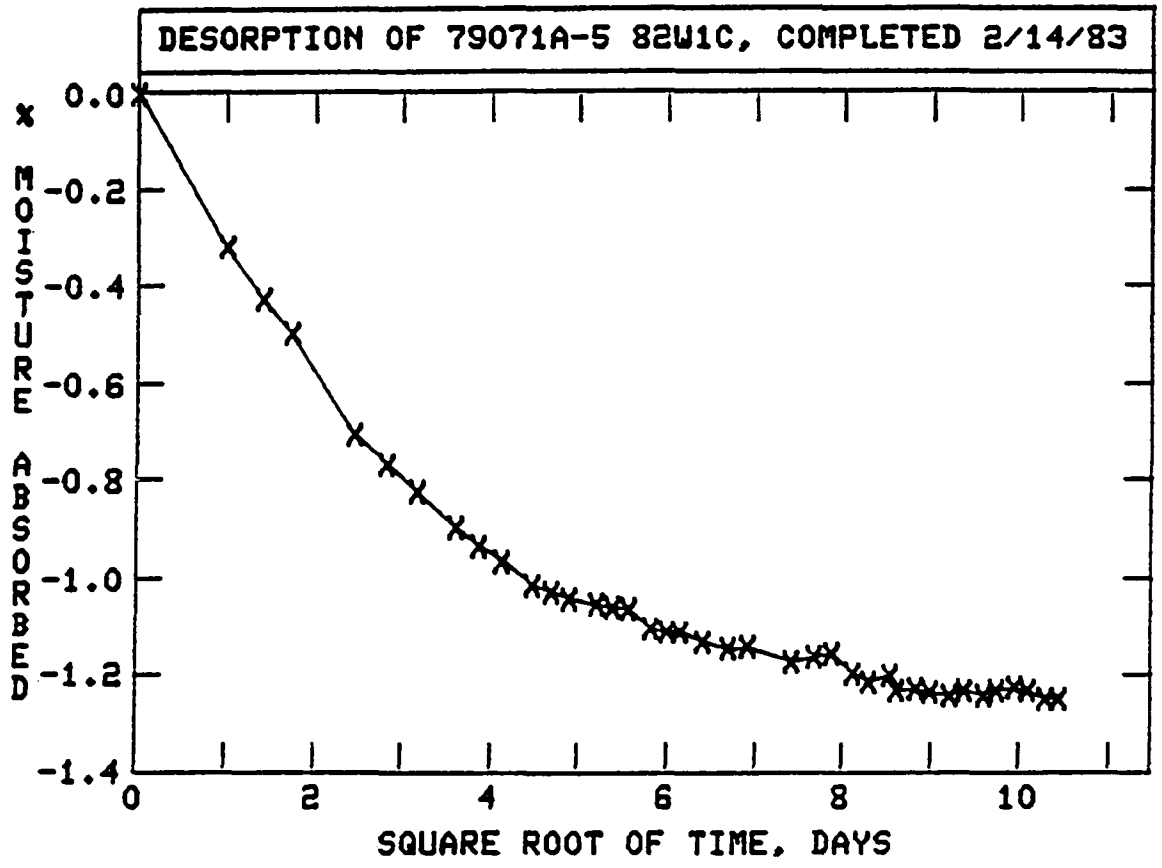

FIGURE 13. MOISTURE DESORPTION, 6 PLY, GRAPHITE/EPOXY SPECIMENS FROM WPB

TABLE V

Exposed Panel and In-service Spar Test
Coupon Moisture Values

Number of Plies	Material	Location	Moisture Absorbed, % Weight 2 Years	3 Years
6	Gr/Ep	WPB	1.02	1.22
6	Gr/Ep	STFD	.86	1.00
14	Gr/Ep	STFD	.37	.46
33	Gr/Ep	WPB	.27	.37
33	Gr/Ep	STFD	.18	.23
14 (S/N 00150)*	Gr/Ep	Gulf Coast		.55
14 (S/N 00283)*	Gr/Ep	Gulf Coast		.46
5	Kevlar/Epoxy	WPB	1.60	2.08
5	Kevlar/Epoxy	STFD	1.53	1.74

*Spar (S/N)

4.3 Analysis and Correlation

Moisture - time profiles were developed for panels and aircraft components. Local climatological data from exposure locations was used in predicting the expected moisture absorption. Figures 14, 15 and 16 show measured moisture values plotted on predicted moisture versus calendar time profiles for representative panel configurations. Solar radiation values were not available for all weathering locations, and were not included in the predicted moisture levels shown in Figures 15 and 16. Including the effects of solar radiation in the moisture prediction generally serves to reduce the local relative humidity, thereby reducing the predicted amount of absorbed moisture, as seen in Figure 14. In practice, there are difficulties collecting precise solar radiation readings and surface wind velocities which are used to determine solar effects. As seen in the figures, using the analysis without solar effects, the measured values when plotted on the curves of predicted moisture versus calendar time fall within an acceptable range of scatter especially for the graphite/epoxy panels. Deviation is expected, owing in part, to variations in flight hours. Larger scatter is exhibited in the profiles for the Stratford weathering locations, which is attributed to the additional factor of snowfall.

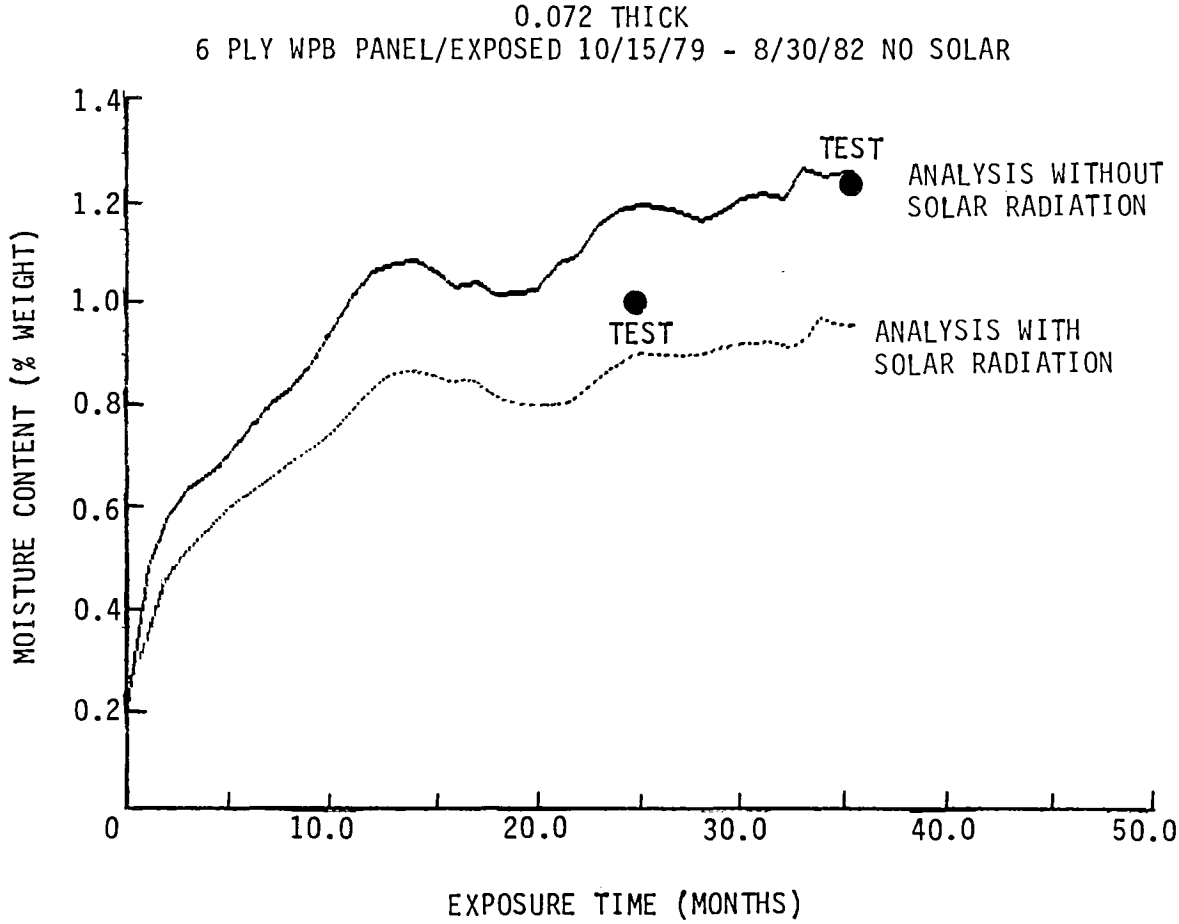

FIGURE 14. MOISTURE ABSORPTION, 6 PLY GRAPHITE/EPOXY PANEL EXPOSED AT WPB

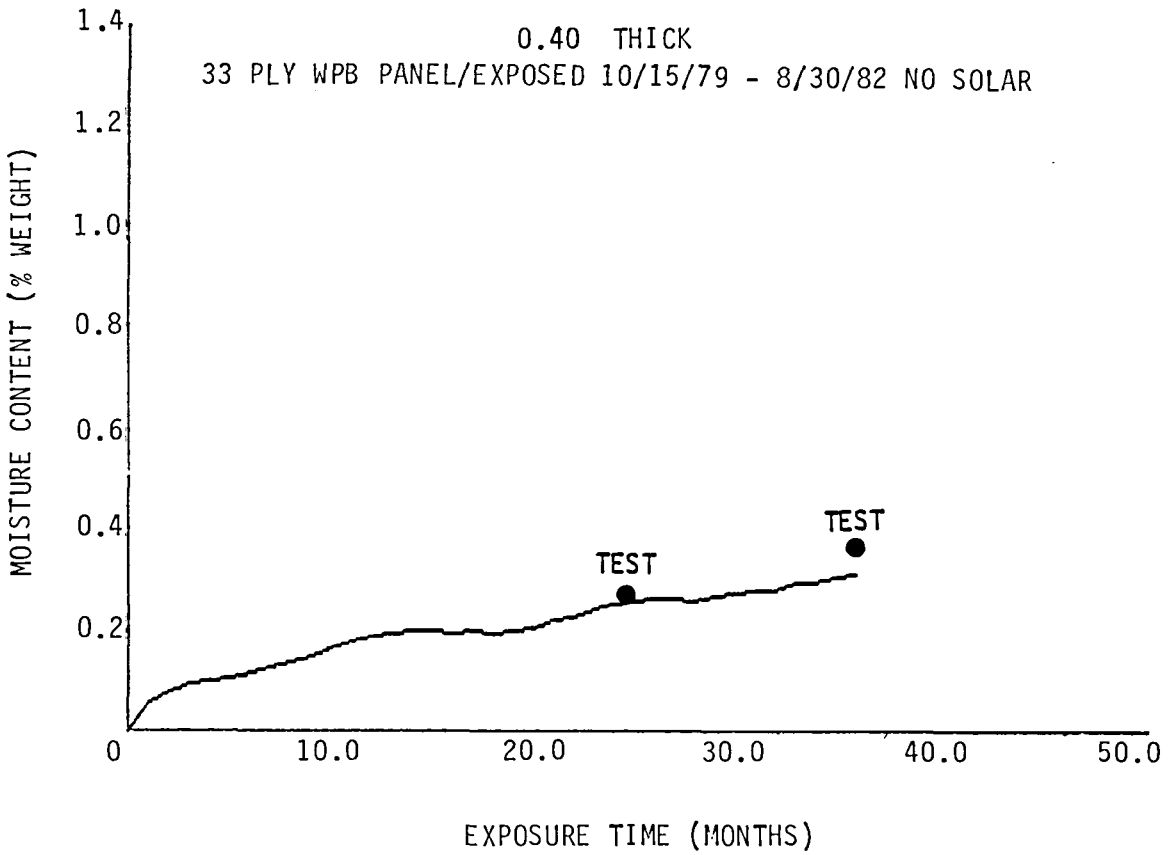

FIGURE 15. MOISTURE ABSORPTION, 33 PLY GRAPHITE/EPOXY PANEL EXPOSED AT WPB

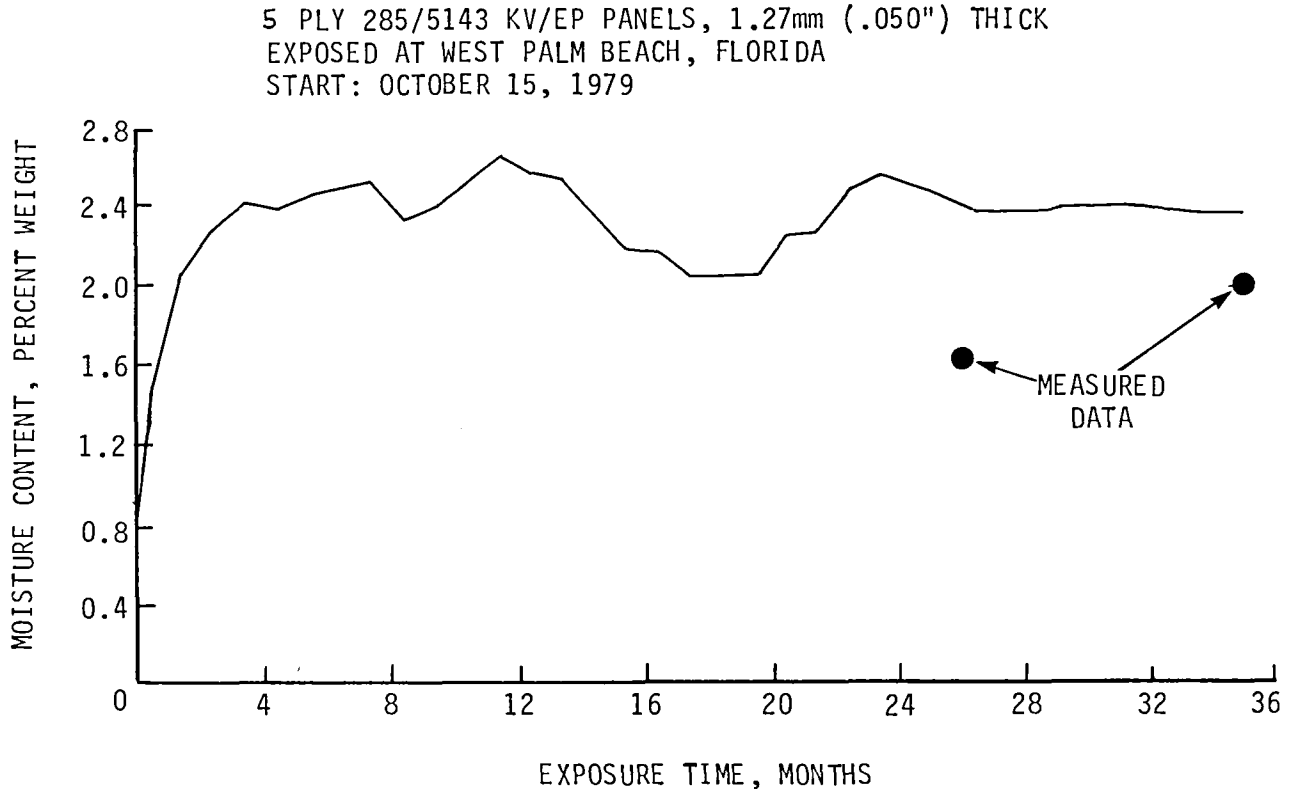

FIGURE 16. MOISTURE ABSORPTION FOR KEVLAR/EPOXY PANELS, WPB

4.4 Coupon Strength Tests

4.4.1 Static Strength

The static strengths of the graphite/epoxy and Kevlar/epoxy coupons are summarized in Table VI. The important aspects are the trend of strength with absorbed moisture and the comparison with the initial baseline data used for design.

The SBS static strength for the exposed panels closely follows the trend used for design as shown in Figure 17. The flex static strength, shown in Figure 18 indicates a higher strength than predicted.

Overall, the environmental factors for static strength, shown in Table VII, agree closely with predicted values used for design.

4.4.2 Fatigue Strength

The SBS fatigue data for the 33 ply coupons is presented in Figures 19 to 21 for the original baseline, two and three years exposure. In addition, coupons were taken from tail rotor spars S/N 00150 and 00283 and such data is presented in Figures 22 to 25. The data is compared in Figure 26 for the fatigue strength versus moisture. A conservative environmental factor of .8 was used for the full scale test evaluation and corresponded to a projected 1.1% moisture content. The environmental factor (EF) line is then a linear reduction from the RTD baseline fatigue strength and the .8 value at 1.1% moisture. The data of coupons from exposed panels and in-service spars lies above the EF line and therefore indicates that the fatigue strength projections are conservative. This environmental factor (EF) line was obtained from interlaminar shear fatigue strength for AS1/6350 Graphite. The strength was found to be a linear function of the absorbed moisture level. The ratio of fatigue strength (at moisture level) to room temperature dry (RTD) fatigue strength is given in Reference 1, Figure 7.

TABLE VI

SUMMARY OF COUPON TEST RESULTS

Test/ Number of Specimens, Material	Plies	Strength MP_a	Strength (KSI)	ΔM % Wgt	Exposure
SBS/23, G/E	8	110.3	(16.0)	.2	Original RTD Baseline (Design)
SBS/19, G/E	6	113.1	(16.4)	.2	RTD Baseline (Panel Coupons)
SBS/37, G/E	6	93.8	(13.6)	1.02	2 yrs WPB
SBS/18, G/E	6	100.7	(14.6)	.86	2 yrs STFD
SBS/36, G/E	6	88.3	(12.8)	1.22	3 yrs WPB
SBS/36, G/E	6	93.8	(13.6)	1.00	3 yrs STFD
SBS/17, G/E	33*	86.9	(12.6)	0	RTD Baseline (Panel Coupons)
SBS/15, G/E	33*	84.1	(12.2)	.27	2 yrs WPB
SBS/15, G/E	33*	83.4	(12.1)	.18	2 yrs STFD
SBS/15, G/E	33*	77.9	(11.3)	.37	3 yrs WPB
SBS/15, G/E	33*	75.9	(11.0)	.23	3 yrs STFD
FLEX/20,G/E	6	1696.5	(246.0)	.2	RTD Baseline (Panel Coupons)
FLEX/33,G/E	6	1897.2	(275.1)	1.02	2 yrs WPB
FLEX/12,G/E	6	1877.2	(272.2)	.86	2 yrs STFD
FLEX/36,G/E	6	1698.6	(246.3)	1.22	3 yrs WPB
FLEX/36,G/E	6	1682.7	(244.0)	1.00	3 yrs STFD
FLEX/18,G/E	33*	1209.3	(175.4)	0	RTD Baseline (Panel Coupons)
FLEX/18,G/E	33*	1246.6	(180.8)	.27	2 yrs WPB
FLEX/18,G/E	33*	1260.3	(182.8)	.18	2 yrs STFD
FLEX/12,G/E	33*	1185.5	(171.9)	.37	3 yrs WPB
FLEX/12,G/E	33*	1235.2	(179.1)	.23	3 yrs STFD
TEN./18,K/E	5	631.5	(91.6)	.70	RTD Baseline (Panel Coupons)
TEN./10,K/E	5	632.4	(91.7)	1.60	2 yrs WPB
TEN./9,K/E	5	666.9	(96.7)	1.53	2 yrs STFD
TEN./7,K/E	5	677.0	(98.2)	2.08	3 yrs WPB
TEN./7,K/E	5	667.3	(96.8)	1.74	3 yrs STFD

*Includes cross plies

TABLE VII. SUMMARY OF EXPOSED PANEL STRENGTH ENVIRONMENTAL FACTORS

Exposure Location	Number of Plies	Material	Measured Moisture, % Wgt	Environmental Factors, Room Temperature			
				SBS Static	SBS Fatigue	Flex Static	Tension Static
Stratford	6	Graphite/Epoxy	.86	.89	-	.88	-
Conn.	14	Graphite/Epoxy	.37	.90	.91	.95	-
2 Years	33	Graphite/Epoxy	.18	.96	1.05	1.04	-
	5	Kevlar/Epoxy	1.53	-	-	-	1.05
West Palm	6	Graphite/Epoxy	1.02	.86	-	.84	-
Beach, Fla.	33	Graphite/Epoxy	.27	.97	1.02	1.03	-
2 Years	5	Kevlar/Epoxy	1.61	-	-	-	1.00
Stratford	6	Graphite/Epoxy	1.00	.83	-	.79	-
Conn.	14	Graphite/Epoxy	.48	.81	-	1.02	-
3 Years	33	Graphite/Epoxy	.23	.87	-	1.02	-
	5	Kevlar/Epoxy	1.72	-	-	-	1.02
West Palm	6	Graphite/Epoxy	1.22	.78	-	.80	-
Beach, Fla.	33	Graphite/Epoxy	.37	.89	.95	.98	-
3 Years	5	Kevlar/Epoxy	2.08	-	-	-	1.02

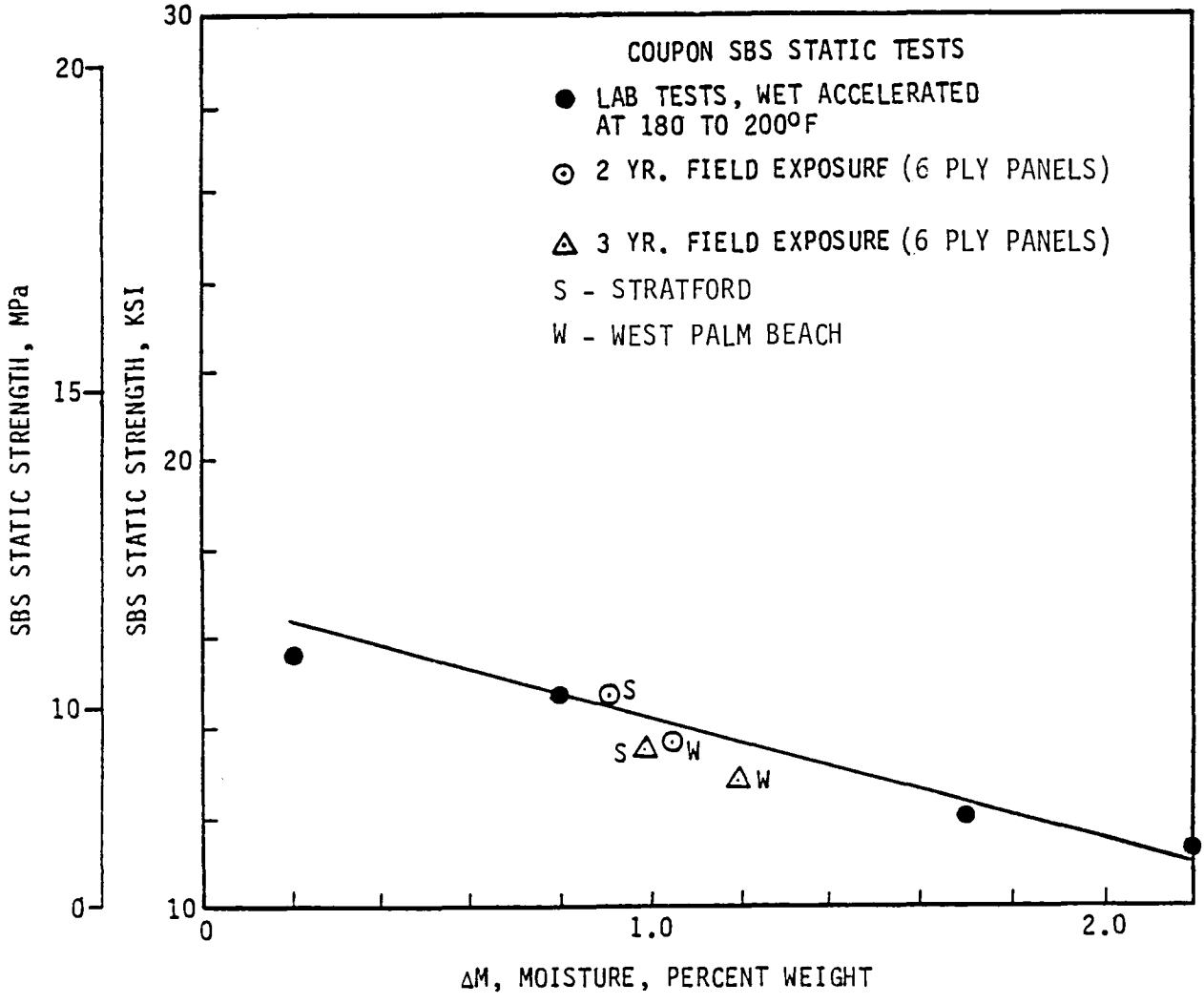

FIGURE 17. REDUCTION OF SBS STATIC STRENGTH WITH MOISTURE, GRAPHITE/EPOXY

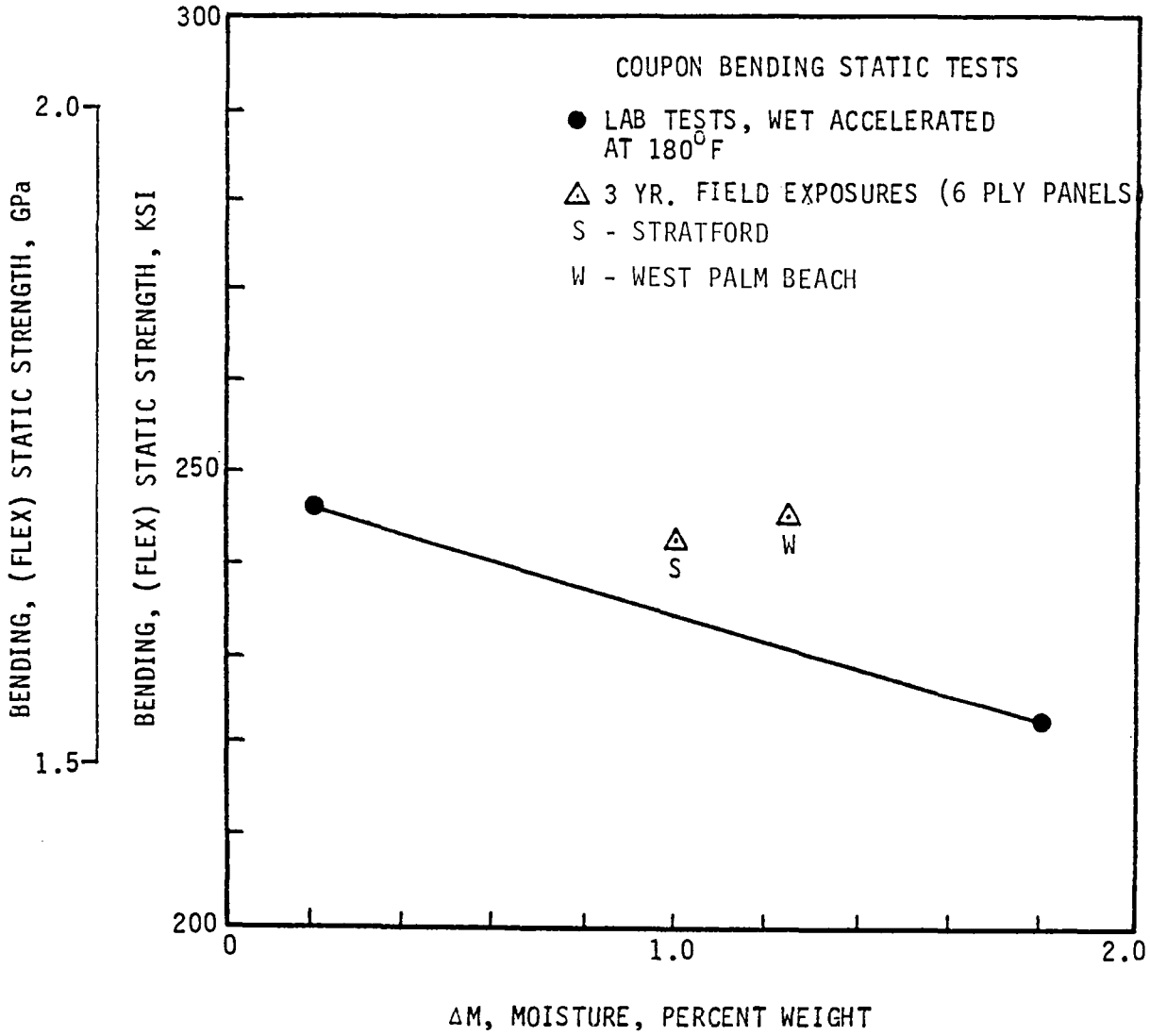

FIGURE 18. AFFECT OF MOISTURE CONTENT ON BENDING STRENGTH, GRAPHITE/EPOXY

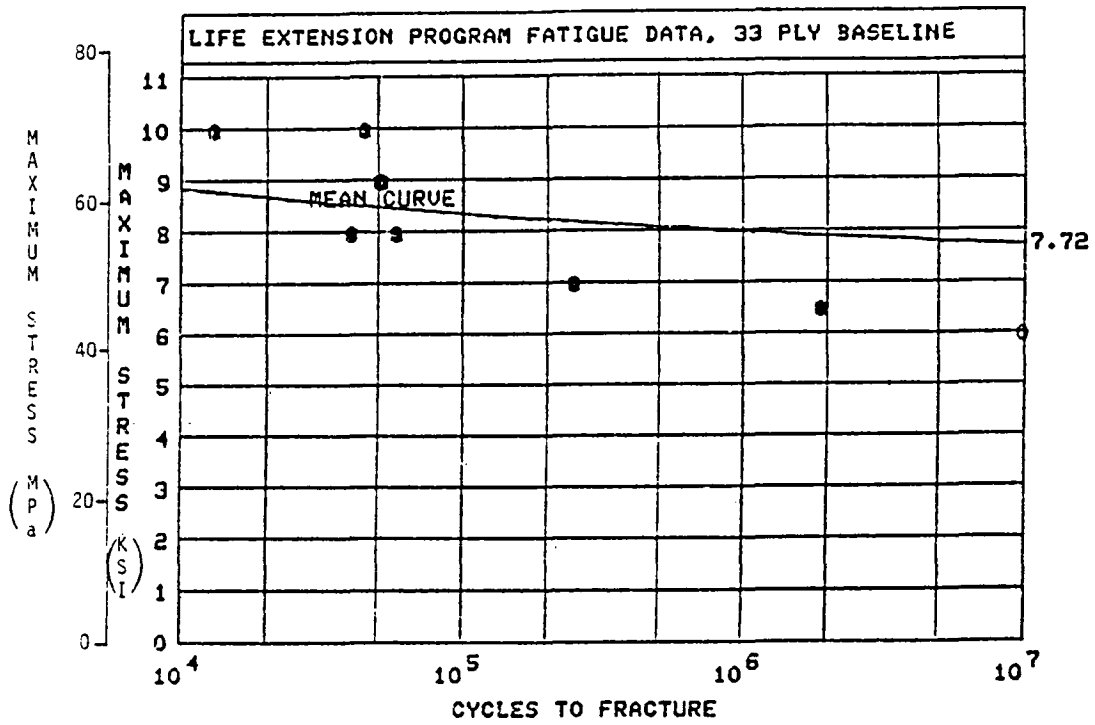

FIGURE 19. SBS FATIGUE STRENGTH, 33 PLY PANELS, BASELINE

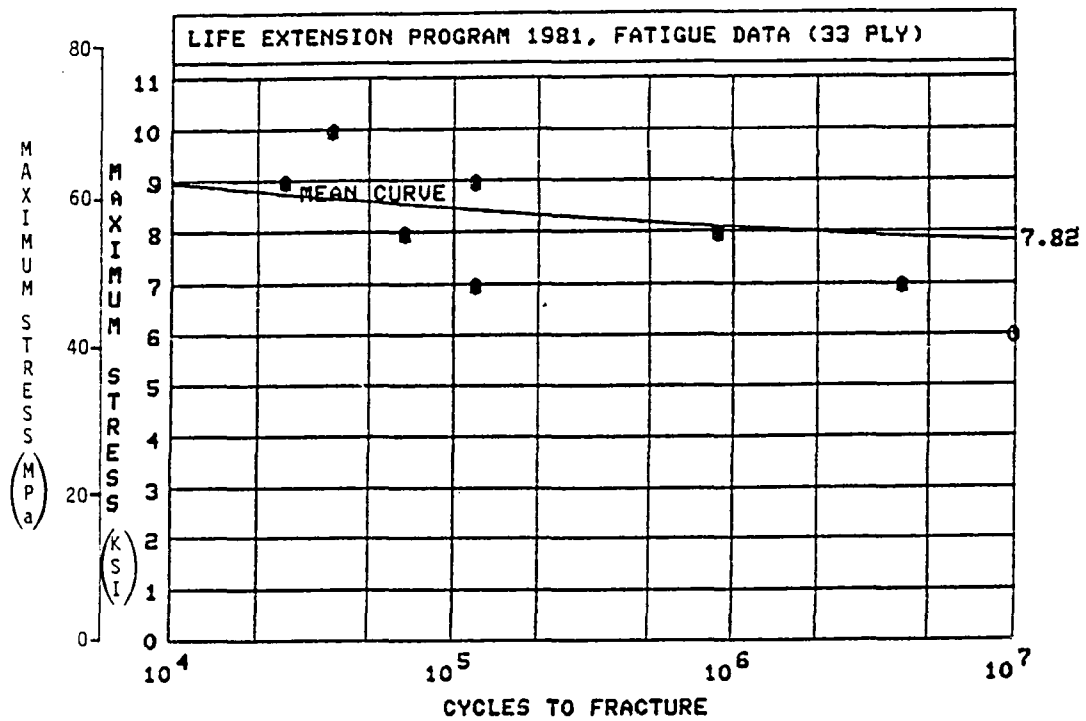

FIGURE 20. SBS FATIGUE STRENGTH, 33 PLY PANELS, EXPOSED 2 YEARS, WPB

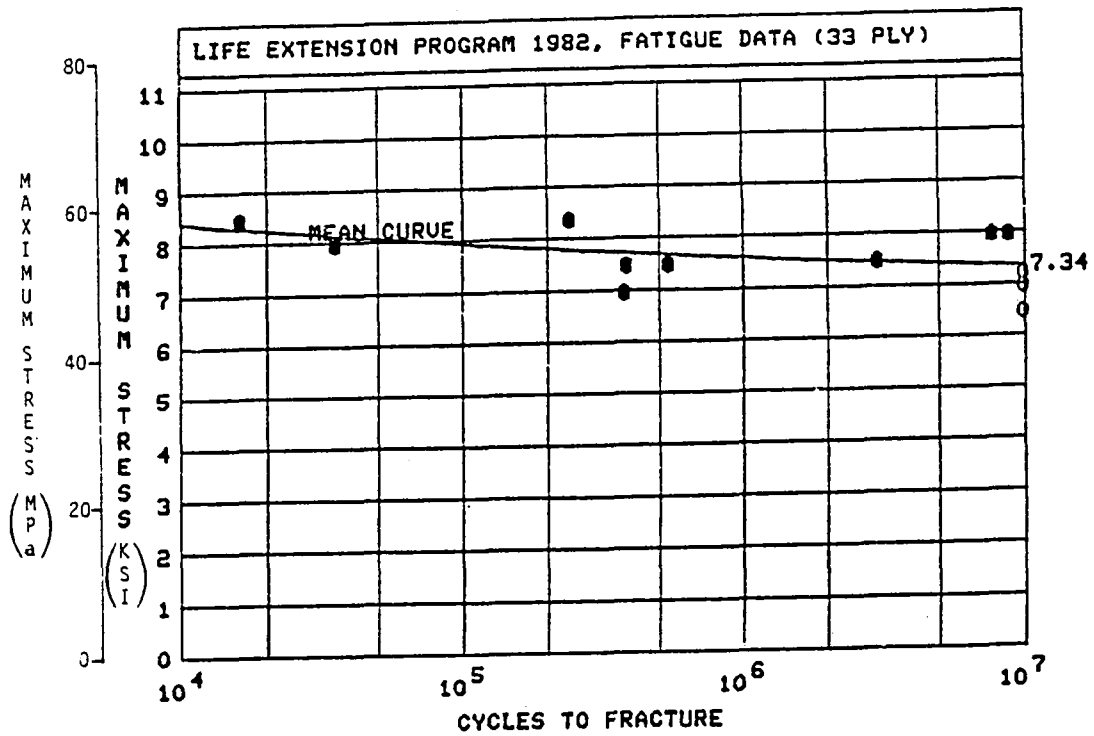

FIGURE 21. SBS FATIGUE STRENGTH, 33 PLY PANELS, EXPOSED 3 YEARS, WPB

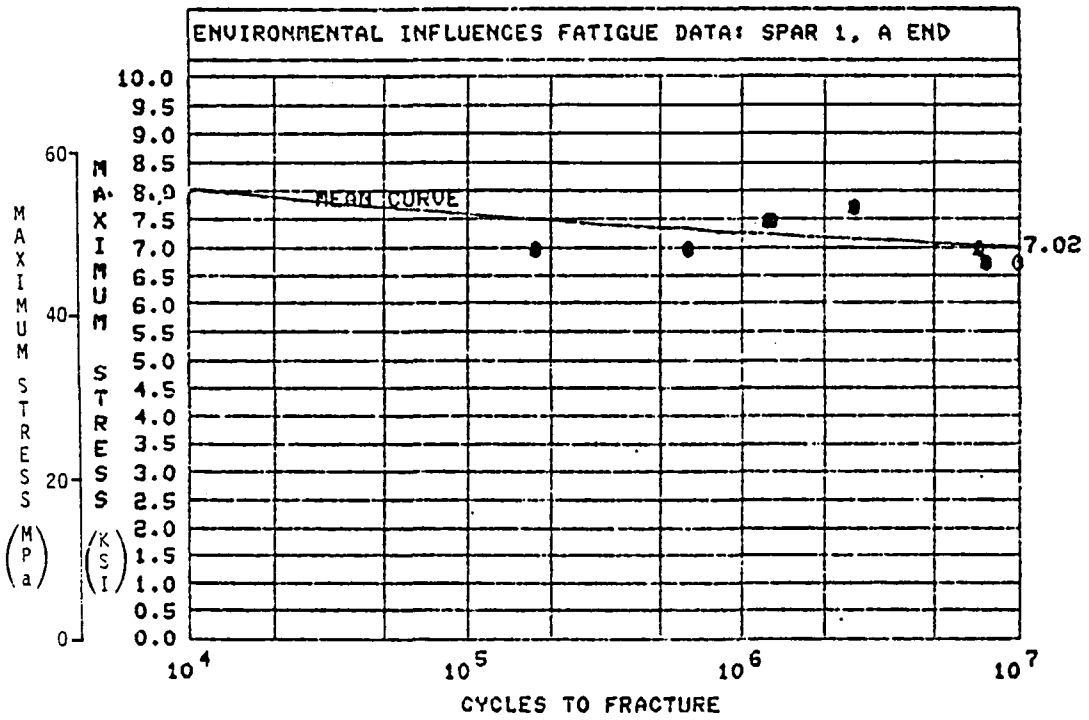

FIGURE 22. COUPON FATIGUE STRENGTH, SPAR A-116-00150, A END

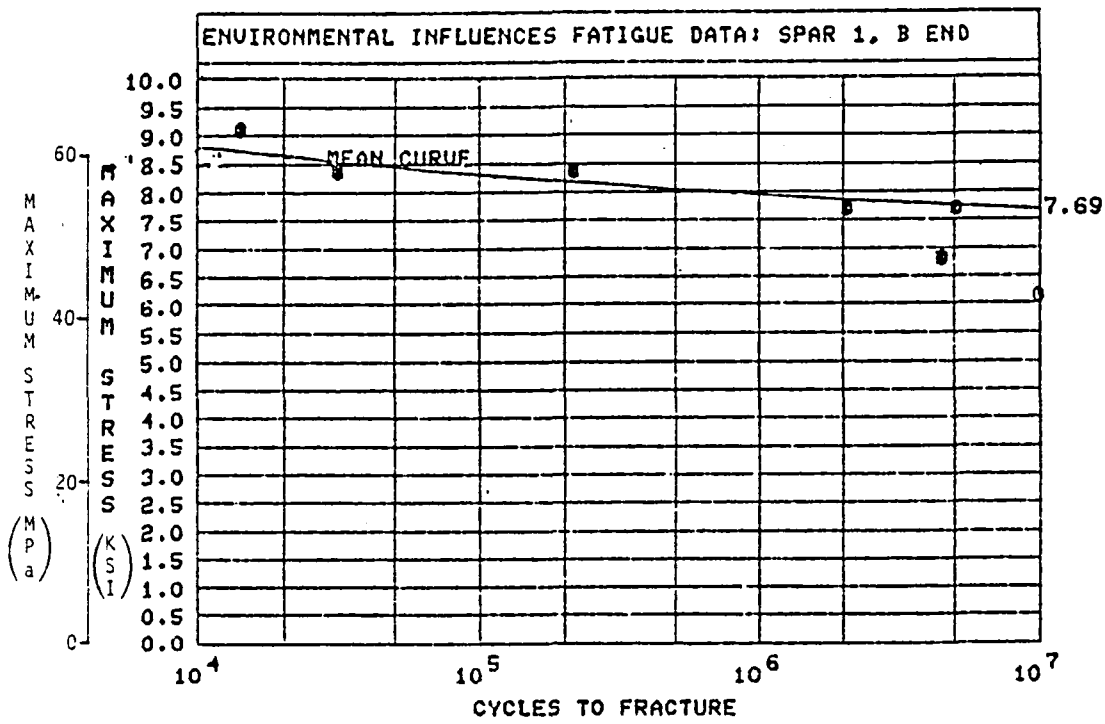

FIGURE 23. COUPON FATIGUE STRENGTH, SPAR A-116-00150, B END

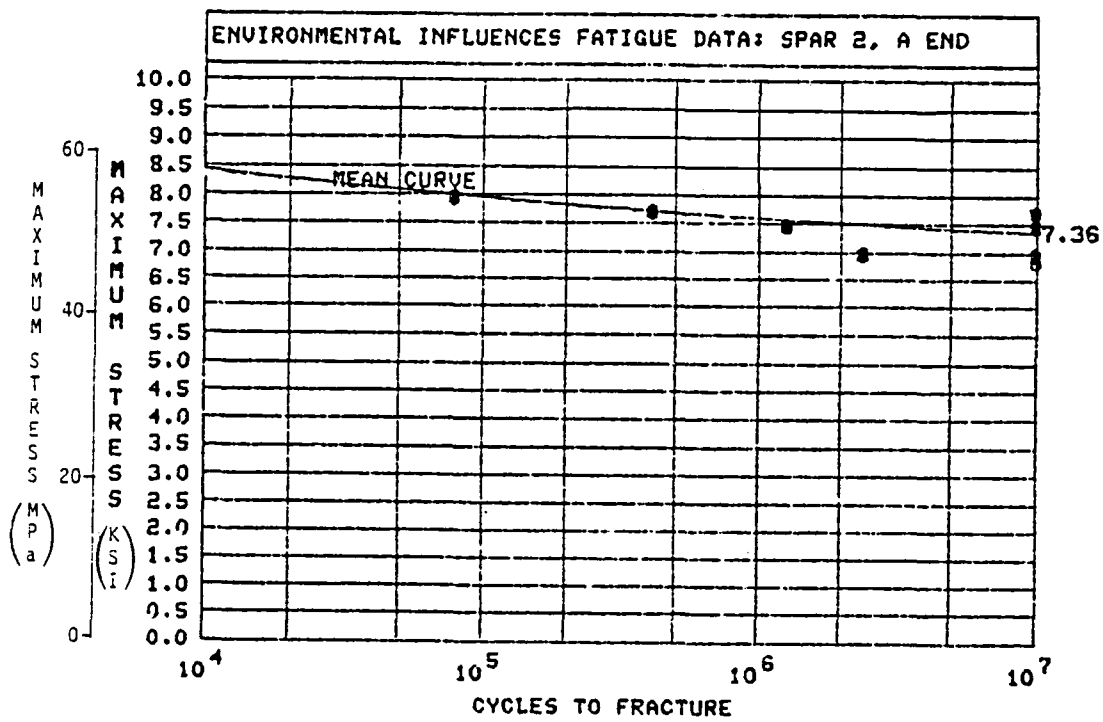

FIGURE 24. COUPON FATIGUE STRENGTH, SPAR A-116-00283, A END

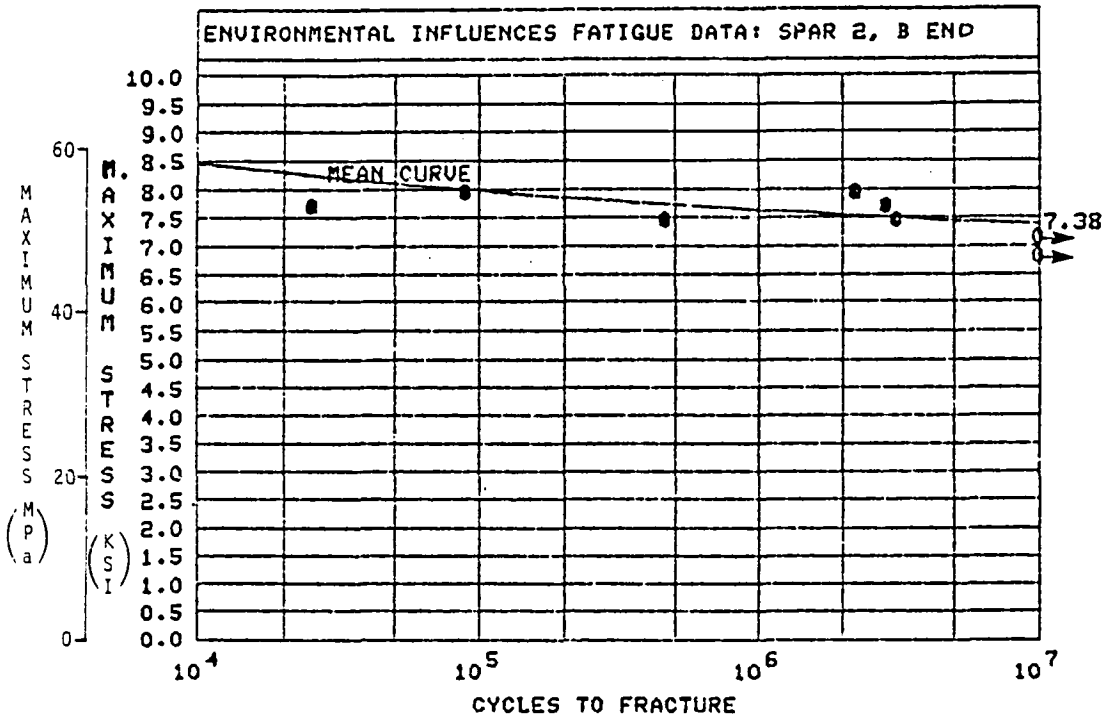

FIGURE 25. COUPON FATIGUE STRENGTH, SPAR A-116-00283, B END

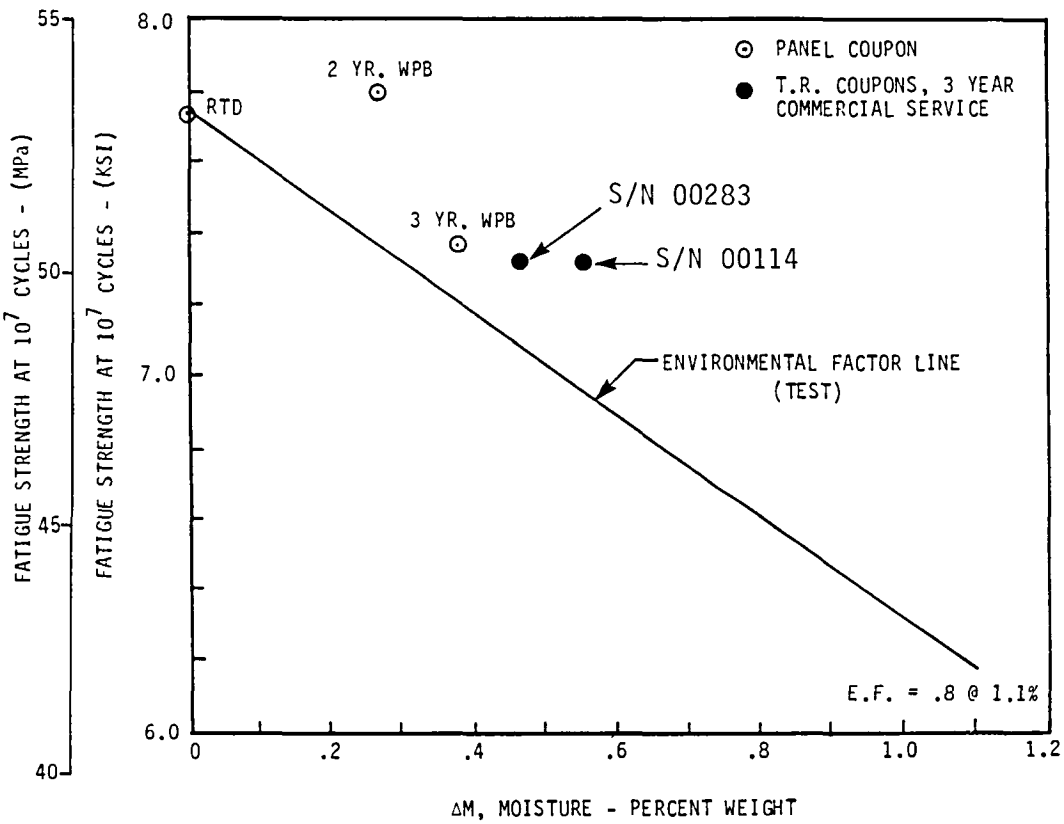

FIGURE 26. CORRELATION OF SBS FATIGUE ENVIRONMENTAL FACTOR

SECTION 5.0 ANALYSIS OF TEST RESULTS

The three year exposed panels at Stratford, Connecticut and West Palm Beach, Florida have provided real time moisture contents. Coupon tests from the exposed panels have been compared with RTD unexposed tests to determine environmental factors. The in-service components have provided measurements of moisture contents and strength tests for comparison with initial unexposed tested components. These data are assessed in the following paragraphs for their implications regarding environmental factors previously described.

The analysis of test results will be limited, at this time, due to the calendar life and service time of the in-service components. However, the available data will indicate trends. Future work in this program is expected to form a more quantitative relationship on the effects of environment on in-service components.

5.1 Exposed Panel Data

In general, the exposed panels appear to absorb moisture close to that predicted by an environmental analysis using ambient RH only, as shown in Figures 14, 15, and 16 for the West Palm Beach Region.

A comparison of environmental factors derived from lab conditions and field exposure is presented in Figure 27.

The environmental factor (EF) is defined as the ratio of conditioned (field or lab) strength to the RTD strength. Figure 27 compares the field exposed EF with those determined from accelerated lab conditioning.

5.2 In-Service Component Data

The tail rotor spar fatigue test data for the three year in-service spar, S/N 00172, closely groups with previous two year field exposed components as illustrated in Figure 11. For spar S/N 00237, also a three year in-service spar, the fatigue test data is slightly above the mean of 20 RTD baseline spar tests as shown in Figure 11. The fatigue data for the four year in-service spar, S/N 00114, is also slightly above the mean baseline data.

The environmental factors for graphite/epoxy panels, exposed for three years, compares well with the environmental factors for two year exposed panels shown in Reference 1, Figure 31. The environmental factors for the Kevlar/epoxy panels, exposed for three years also compares well with the panels exposed for two years.

The strength graphite/epoxy panels exposed two and three years is groups close to the field exposed-lab environmental line. The Kevlar strength for two and three year exposures are grouped slightly above the line.

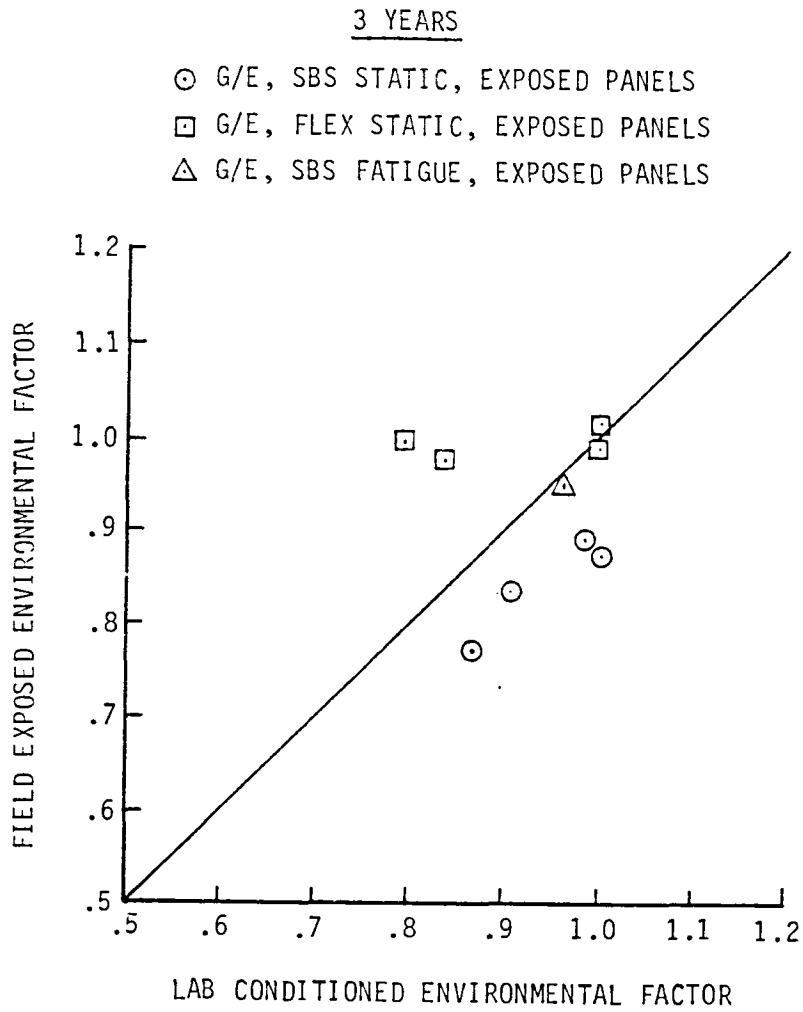

FIGURE 27. COMPARISON OF ENVIRONMENTAL FACTORS FOR FIELD EXPOSED AND LABORATORY CONDITIONED COUPONS.

SECTION 6.0 CONCLUSIONS

6.1 Conclusions

The following conclusions are based on the results of approximately three and four year in-service tail rotor spars and three year exposed panel.

1. The fatigue strength retention for the three year tail rotor spars (S/N 00172 and 00237) appears to be the same as the laboratory conditioned coupons. The fatigue strengths for the three year tail rotor (S/N 00237) and the four year tail rotor spar (S/N 00114) appear to be of equal fatigue strength and close to the baseline spar fatigue data.

2. From the three year exposed material evaluation tests, it is concluded that the moisture absorption (in the most humid region) is close to the predictions using ambient RH alone. The affect on strength varies. Graphite/epoxy fatigue strength retention appears to be the same for lab condition coupons. Graphite/epoxy static shear strength is a little less than expected and the flexure strength is slightly higher than expected. Kevlar/epoxy static strength is also slightly higher than expected.

SECTION 7.0 APPENDIX

Detailed data is contained in this appendix for future reference or analysis review.

7.1 Environmental Histories, Tail Rotor Spars

Table VIII	Spar A-116-00150
Table IX	Spar A-116-00283
Table X	Spar A-116-00237
Table XI	Spar A-116-00172

TABLE VIII

SPAR S/N A-116-00150 (PADDLE S/N A-137-00085)

SUMMARY OF ENVIRONMENTAL HISTORY

Total Hours 2385

DATE	AVERAGE TEMPERATURE °C	°F	AVERAGE RELATIVE HUMIDITY %	
10/01/79 - 10/30/79	20.4	68.9	79.0	installed 10/22/79
11/01/79 - 11/31/79	12.4	54.4	75.4	
12/01/79 - 12/31/79	10.3	50.5	78.1	
1/01/80 - 1/31/80	11.9	53.4	86.4	
2/01/80 - 2/29/80	10.3	50.6	80.5	
3/01/80 - 3/31/80	15.2	59.4	81.4	
4/01/80 - 4/30/80	18.4	65.1	76.5	
5/01/80 - 5/31/80	23.7	74.8	83.9	
6/01/80 - 6/30/80	27.0	80.8	80.3	
7/01/80 - 7/31/80	28.2	82.8	72.5	
8/01/80 - 8/31/80	27.4	81.3	74.0	
9/01/80 - 9/30/80	26.3	79.4	79.3	
10/01/80 - 10/30/80	18.0	64.4	69.8	
11/01/80 - 11/30/80	12.6	54.8	78.0	
12/01/80 - 12/31/80	10.7	51.3	75.0	

TABLE VIII (Cont'd)

SPAR S/N A-116-00150 (PADDLE S/N A-137-00085)

DATE	AVERAGE TEMPERATURE °C	°F	AVERAGE RELATIVE HUMIDITY %	
1/01/81 - 1/31/81	8.2	46.8	73.5	
2/01/81 - 2/28/81	11.1	52.0	74.0	
3/01/81 - 3/31/81	14.9	58.9	66.4	
4/01/81 - 4/30/81	21.4	70.5	76.1	
5/01/81 - 5/31/81	22.5	72.6	73.3	
6/01/81 - 6/31/81	26.8	80.3	82.1	
7/01/81 - 7/31/81	27.3	81.1	81.8	
8/01/81 - 8/31/81	26.9	80.5	79.3	
9/01/81 - 9/30/81	23.8	74.8	77.3	
10/01/81 - 10/31/81	20.0	68.1	79.1	
11/01/81 - 11/30/81	16.3	60.9	80.9	
12/01/81 - 12/31/81	11.4	52.5	73.4	
1/01/82 - 1/31/82	11.1	51.9	76.9	
2/01/82 - 2/28/82	10.8	51.4	78.4	
3/01/82 - 3/31/82	16.9	62.5	82.6	
4/01/82 - 4/30/82	18.9	66.1	80.1	
5/01/82 - 5/31/82	23.2	73.8	82.1	Removed 5/18/82.
6/01/82 - 6/30/82	26.4	79.6	82.4	Kept out-
7/01/82 - 7/31/82	27.2	80.9	80.8	side.
8/01/82 - 8/31/82	26.9	80.5	78.8	
9/01/82 - 9/30/82	24.2	75.6	75.5	
10/01/82 - 10/30/82	21.2	68.3	70.9	
11/01/82 - 11/30/82	16.4	61.5	74.3	Shipped 11/16/82

Shipped by Air Log to Sikorsky 11/16/82
Received at Sikorsky 12/6/82

TABLE IX

SPAR S/N A-116-00283 (PADDLE S/N A-137-00099)

SUMMARY OF ENVIRONMENTAL HISTORY

Total Hours 1884

DATE	AVERAGE TEMPERATURE °C	°F	AVERAGE RELATIVE HUMIDITY %	
10/01/79 - 10/30/79	20.4	68.9	79.0	Installed 10/23/79.
11/01/79 - 11/31/79	12.4	54.4	75.4	
12/01/79 - 12/31/79	10.3	50.5	78.1	
1/01/80 - 1/31/80	11.9	53.4	86.4	
2/01/80 - 2/29/80	10.3	50.6	80.5	
3/01/80 - 3/31/80	15.2	59.4	81.4	
4/01/80 - 4/30/80	18.4	65.1	76.5	
5/01/80 - 5/31/80	23.7	74.8	83.9	
6/01/80 - 6/30/80	27.0	80.8	80.3	
7/01/80 - 7/31/80	28.2	82.8	72.5	Removed for repair.
8/01/80 - 8/31/80	27.4	81.3	74.0	Shipped 8/22/80.
9/01/80 - 9/30/80	20.3	68.6	68.4	Held in Bpt. 9/23/80.
10/01/80 - 10/30/80 11/01/80 - 11/30/80 12/01/80 - 12/31/80	65-80°F, R.H. not to exceed 60%		In repair station.	

TABLE IX (Cont'd)

SPAR S/N A-116-00283 (PADDLE S/N A-137-00099)

DATE	AVERAGE TEMPERATURE °C	°F	AVERAGE RELATIVE HUMIDITY %	
1/01/81 - 1/31/81 2/01/81 - 2/28/81 3/01/81 - 3/31/81	Use blade shop conditions.		In blade repair station.	
4/01/81 - 4/30/81	21.4	70.5	76.1	Repair complete 4/10/81, shipped 4/25/81.
5/01/81 - 5/31/81	22.5	72.6	73.3	
6/01/81 - 6/31/81	26.8	80.3	82.1	
7/01/81 - 7/31/81	27.3	81.1	81.8	
8/01/81 - 8/31/81	26.9	80.5	79.3	
9/01/81 - 9/30/81	23.8	74.8	77.3	
10/01/81 - 10/31/81	20.0	68.1	79.1	
11/01/81 - 11/30/81	16.3	60.9	80.9	
12/01/81 - 12/31/81	11.4	52.5	73.4	
1/01/82 - 1/31/82	11.1	51.9	76.9	
2/01/82 - 2/28/82	10.8	51.4	78.4	
3/01/82 - 3/31/82	16.9	62.5	82.6	
4/01/82 - 4/30/82	18.9	66.1	80.1	
5/01/82 - 5/31/82	23.2	73.8	82.1	
6/01/82 - 6/30/82	26.4	79.6	82.4	
7/01/82 - 7/31/82	27.2	80.9	80.8	
8/01/82 - 8/31/82	26.9	80.5	78.8	
9/01/82 - 9/30/82	24.2	75.6	75.5	
10/01/82 - 10/30/82	21.2	68.3	70.9	
11/01/82 - 11/30/82	16.4	61.5	74.3	Shipped 11/16/82.

Shipped by Air Log to Sikorsky 11/16/82
Received at Sikorsky 12/6/82

TABLE X

SPAR S/N A-116-00237 (PADDLE S/N A-137-00068)

SUMMARY OF ENVIRONMENTAL HISTORY

Total Hours 1596. Sent as spare with A/C S/N 760003 3/79, and kept in non-conditioned hangar.

DATE	AVERAGE TEMPERATURE °C	AVERAGE TEMPERATURE °F	AVERAGE RELATIVE HUMIDITY %	
3/01/79 - 3/31/79	15.9	60.7	74.5	shipped as spare
4/01/79 - 4/30/79	20.0	68.1	80.5	
5/01/79 - 5/31/79	22.4	72.3	78.6	
6/01/79 - 6/30/79	26.0	78.9	78.4	
7/01/79 - 7/31/79	26.8	80.3	85.4	
8/01/79 - 8/31/79	26.6	80.0	83.8	
9/01/79 - 9/30/79	23.6	74.7	80.3	
10/01/79 - 10/30/79	20.4	68.9	79.0	
11/01/79 - 11/31/79	12.4	54.4	75.4	
12/01/79 - 12/31/79	10.3	50.5	78.1	
1/01/80 - 1/31/80	11.9	53.4	86.4	
2/01/80 - 2/29/80	10.3	50.6	80.5	
3/01/80 - 3/31/80	15.2	59.4	81.4	
4/01/80 - 4/30/80	18.4	65.1	76.5	
5/01/80 - 5/31/80	23.7	74.8	83.9	installed
6/01/80 - 6/30/80	27.0	80.8	80.3	
7/01/80 - 7/31/80	28.2	82.8	72.5	
8/01/80 - 8/31/80	27.4	81.3	74.0	
9/01/80 - 9/30/80	26.3	79.4	79.3	
10/01/80 - 10/30/80	18.0	64.4	69.8	
11/01/80 - 11/30/80	12.6	54.8	78.0	
12/01/80 - 12/31/80	10.7	51.3	75.0	

TABLE X - (Cont'd)

SPAR S/N A-116-00237 (PADDLE S/N A-137-00068)

SUMMARY OF ENVIRONMENTAL HISTORY

DATE	AVERAGE TEMPERATURE °C	AVERAGE TEMPERATURE °F	AVERAGE RELATIVE HUMIDITY %
1/01/81 - 1/31/81	8.2	46.8	73.5
2/01/81 - 2/28/81	11.1	52.0	74.0
3/01/81 - 3/31/81	14.9	58.9	66.4
4/01/81 - 4/30/81	21.4	70.5	76.1
5/01/81 - 5/31/81	22.5	72.6	73.3
6/01/81 - 6/31/81	26.8	80.3	82.1
7/01/81 - 7/31/81	27.3	81.1	81.8
8/01/81 - 8/31/81	26.9	80.5	79.3
9/01/81 - 9/30/81	23.8	74.8	77.3
10/01/81 - 10/31/81	20.0	68.1	79.1
11/01/81 - 11/30/81	16.3	60.9	80.9
12/01/81 - 12/31/81	11.4	52.5	73.4
1/01/82 - 1/31/82	11.1	51.9	76.9
2/01/82 - 2/28/82	10.8	51.4	78.4
3/01/82 - 3/31/82	16.9	62.5	82.6
4/01/82 - 4/30/82	18.9	66.1	80.1
5/01/82 - 5/31/82	23.2	73.8	82.1
6/01/82 - 6/30/82	26.4	79.6	82.4
7/01/82 - 7/31/82	27.2	80.9	80.8
8/01/82 - 8/31/82	26.9	80.5	78.8

Shipped to Sikorsky 8/29/82 - 39 months at Lake Charles
Lost at J. F. K. - 3 month, use warehouse conditions
Arrived at Sikorsky 12/1/82

TABLE XI

SPAR S/N A-116-00172 (PADDLE S/N A-137-00047)

SUMMARY OF ENVIRONMENTAL HISTORY

Total Hours 2533

DATE	AVERAGE TEMPERATURE °C	AVERAGE TEMPERATURE °F	AVERAGE RELATIVE HUMIDITY %
5/01/79 - 5/31/79	22.4	72.3	78.6
6/01/79 - 6/30/79	26.0	78.9	78.4
7/01/79 - 7/31/79	26.8	80.3	85.4
8/01/79 - 8/31/79	26.6	80.0	83.8
9/01/79 - 9/30/79	23.6	74.7	80.3
10/01/79 - 10/30/79	20.4	68.9	79.0
11/01/79 - 11/31/79	12.4	54.4	75.4
12/01/79 - 12/31/79	10.3	50.5	78.1
1/01/80 - 1/31/80	11.9	53.4	86.4
2/01/80 - 2/29/80	10.3	50.6	80.5
3/01/80 - 3/31/80	15.2	59.4	81.4
4/01/80 - 4/30/80	18.4	65.1	76.5
5/01/80 - 5/31/80	23.7	74.8	83.9
6/01/80 - 6/30/80	27.0	80.8	80.3
7/01/80 - 7/31/80	28.2	82.8	72.5
8/01/80 - 8/31/80	27.4	81.3	74.0
9/01/80 - 9/30/80	26.3	79.4	79.3
10/01/80 - 10/30/80	18.0	64.4	69.8
11/01/80 - 11/30/80	12.6	54.8	78.0
12/01/80 - 12/31/80	10.7	51.3	75.0

TABLE XI (Cont'd)

SPAR S/N A-116-00172 (PADDLE S/N A-137-00047)

SUMMARY OF ENVIRONMENTAL HISTORY

DATE	AVERAGE TEMPERATURE °C	AVERAGE TEMPERATURE °F	AVERAGE RELATIVE HUMIDITY %	
1/01/81 - 1/31/81	8.2	46.8	73.5	
2/01/81 - 2/28/81	11.1	52.0	74.0	
3/01/81 - 3/31/81	14.9	58.9	66.4	
4/01/81 - 4/30/81	21.4	70.5	76.1	
5/01/81 - 5/31/81	22.5	72.6	73.3	
6/01/81 - 6/31/81	26.8	80.3	82.1	
7/01/81 - 7/31/81	27.3	81.1	81.8	
8/01/81 - 8/31/81	26.9	80.5	79.3	
9/01/81 - 9/30/81	23.8	74.8	77.3	
10/01/81 - 10/31/81	20.0	68.1	79.1	
11/01/81 - 11/30/81	16.3	60.9	80.9	
12/01/81 - 12/31/81	11.4	52.5	73.4	
1/01/82 - 1/31/82	11.1	51.9	76.9	
2/01/82 - 2/28/82	10.8	51.4	78.4	
3/01/82 - 3/31/82	16.9	62.5	82.6	
4/01/82 - 4/30/82	18.9	66.1	80.1	
5/01/82 - 5/31/82	23.2	73.8	82.1	removed 5/28/82
6/01/82 - 6/30/82	26.4	79.6	82.4	
7/01/82 - 7/31/82	27.2	80.9	80.8	kept outside
8/01/82 - 8/31/82	26.9	80.5	78.8	

Shipped to Sikorsky 8/29/82 - 39 months at Lake Charles
Lost at J.F.K. - 3 months, use warehouse conditions
Arrived at Sikorsky 12/1/82

9/01/82 - 9/30/82	
10/01/82 - 10/30/82	Use Warehouse Conditions
11/01/82 - 11/30/82	

7.2 Test Data, Field Exposed Panels

Table XII	Moisture desorption measurements of twelve exposed panels, Stratford and West Palm Beach. Four coupons of each panel were absorbed at 65.5°C (150°F).
Table XIII	Average moisture values of coupons from values of Table XII.
Table XIV	WPB Weather Bureau Data
Table XV	Summary of Coupon Test Results

TABLE XII.
MOISTURE DESORPTION MEASUREMENTS OF TWELVE EXPOSED PANELS, STRATFORD AND WEST PALM BEACH

MOISTURE DESORBED FROM PANEL #79071A-5 82W1C 6 PLY GRAPHITE - WEST PALM BEACH WEATHERED 10-15-79 TO 9-14-82				
DATE	COUPON I	COUPON II	COUPON III	COUPON IV
10.5	0	0	0	0
10.6	.37122	.37354	.26392	.27579
10.7	.46591	.47666	.38461	.38662
10.8	.5294	.544	.45092	.46008
10.11	.73599	.7555	.65914	.67014
10.13	.79732	.81652	.72545	.732
10.15	.85435	.87124	.78116	.78483
10.18	.92752	.95121	.84614	.85571
10.20	.97056	.98909	.88328	.89824
10.22	1.0007	1.0238	.91245	.92402
10.25	1.0556	1.0806	.95489	.96526
10.27	1.0696	1.0943	.96948	.98201
10.29	1.0835	1.1101	.98275	.9949
11.1	1.0997	1.1238	.99203	1.0065
11.3	1.1018	1.128	.99601	1.0117
11.5	1.1104	1.1332	.99733	1.0104
11.8	1.1578	1.1806	1.0345	1.0439
11.10	1.1675	1.1922	1.0424	1.0542
11.12	1.1621	1.1911	1.0411	1.0542
11.15	1.1879	1.2143	1.0557	1.0735
11.19	1.2051	1.2343	1.069	1.0864
11.22	1.2041	1.2311	1.065	1.0812
11.29	1.2385	1.2648	1.0915	1.1057
12.3	1.2331	1.2542	1.0796	1.0941
12.6	1.2245	1.249	1.0703	1.0851
12.10	1.2718	1.2911	1.1048	1.1251
12.13	1.2923	1.3121	1.1233	1.1379
12.17	1.274	1.2984	1.1087	1.1289

TABLE XII. CONTINUED

MOISTURE DESORBED FROM PANEL #79071A-5 82W1C
6 PLY GRAPHITE - WEST PALM BEACH
WEATHERED 10-15-79 TO 9-14-82
(CONTINUED)

DATE	COUPON I	COUPON II	COUPON III	COUPON IV
1.10	1.3203	1.3384	1.1273	1.1483
1.14	1.3149	1.3384	1.1273	1.1457
1.17	1.3235	1.3426	1.1353	1.1521
1.21	1.3278	1.3626	1.1353	1.1483
1.24	1.3213	1.3395	1.1286	1.1444
1.28	1.3332	1.3521	1.1353	1.1534
1.31	1.3213	1.3395	1.13	1.1444
2.4	1.316	1.3363	1.1207	1.1392
2.7	1.3267	1.3405	1.1286	1.1444
2.11	1.345	1.3542	1.1392	1.1637
2.14	1.3418	1.3584	1.1419	1.1586

TABLE XII. CONTINUED

MOISTURE DESORBED FROM PANEL #79070B-6 82W1C-1
6 PLY GRAPHITE - WEST PALM BEACH
WEATHERED 10-15-79 TO 9-14-82

DATE	COUPON I	COUPON II	COUPON III	COUPON IV
10.5	0	0	0	0
10.6	.36309	.36524	.28518	.28546
10.7	.46222	.46535	.39457	.39965
10.8	.52125	.52915	.46749	.4762
10.11	.72841	.73377	.69407	.71236
10.13	.78522	.79318	.75007	.76556
10.15	.83868	.84268	.81388	.82914
10.18	.89882	.90759	.86727	.89142
10.20	.94115	.9505	.90763	.92905
10.22	.97456	.978	.93628	.9576
10.25	1.0236	1.033	.99228	1.0134
10.27	1.0314	1.044	1.0001	1.0225
10.29	1.0403	1.0561	1.0105	1.0342
11.1	1.0592	1.0671	1.0222	1.0497
11.3	1.0659	1.0737	1.0353	1.0549
11.5	1.0648	1.0737	1.0339	1.0549
11.8	1.106	1.1188	1.0626	1.0912
11.10	1.1227	1.1375	1.0717	1.099
11.12	1.1071	1.1243	1.0743	1.0912
11.15	1.1405	1.1551	1.0925	1.1159
11.19	1.1594	1.1683	1.103	1.1237
11.22	1.1606	1.165	1.1017	1.125
11.29	1.1884	1.2013	1.1251	1.1509
12.3	1.1695	1.1837	1.116	1.147
12.6	1.1639	1.1716	1.1043	1.1341
12.10	1.2029	1.2189	1.142	1.1652
12.13	1.2229	1.2398	1.1577	1.1886
12.17	1.2151	1.2255	1.1577	1.1834

TABLE XII. CONTINUED

MOISTURE DESORBED FROM PANEL #79070B-6 82W1C-1
6 PLY GRAPHITE - WEST PALM BEACH
WEATHERED 10-15-79 TO 9-14-82
(CONTINUED)

DATE	COUPON I	COUPON II	COUPON III	COUPON IV
1.10	1.2508	1.264	1.1798	1.1976
1.14	1.2452	1.2607	1.1668	1.1912
1.17	1.2497	1.2651	1.1694	1.1925
1.21	1.2486	1.2673	1.1694	1.1976
1.24	1.253	1.2684	1.1759	1.1976
1.28	1.2508	1.2717	1.1798	1.2041
1.31	1.2452	1.2563	1.1694	1.1899
2.4	1.243	1.2563	1.1629	1.195
2.7	1.2441	1.2596	1.1668	1.1925
2.11	1.2775	1.2695	1.1863	1.2132
2.14	1.2586	1.2794	1.1785	1.2041

TABLE XII. CONTINUED

MOISTURE DESORBED FROM PANEL #79068B-1 82SIC
6 PLY GRAPHITE - STRATFORD
WEATHERED 9-21-79 TO 9-24-82

DATE	COUPON I	COUPON II	COUPON III	COUPON IV
10.5	0	0	0	0
10.6	.28932	.27739	.19964	.19117
10.7	.36864	.36049	.28917	.28192
10.8	.41667	.40317	.34483	.33637
10.11	.57753	.56938	.51664	.50455
10.13	.61663	.60531	.56382	.55537
10.15	.65796	.64237	.6098	.60135
10.18	.72275	.70751	.67635	.66547
10.20	.75068	.73895	.71264	.70056
10.22	.78084	.76366	.74047	.72839
10.25	.81659	.79847	.77798	.7659
10.27	.83669	.81981	.80097	.7901
10.29	.84786	.83216	.81549	.80341
11.1	.84898	.83216	.82154	.80946
11.3	.84675	.82767	.82154	.8143
11.5	.85457	.8389	.83001	.81793
11.8	.89255	.87596	.8663	.85302
11.10	.9093	.88719	.87477	.86269
11.12	.89813	.88045	.8784	.86874
11.15	.92159	.89955	.8905	.88568
11.19	.93723	.91864	.91107	.90383
11.22	.92606	.91302	.91107	.89899
11.29	.95622	.93773	.93043	.9244
12.3	.94282	.93324	.92438	.92077
12.6	.93388	.9265	.9147	.91109
12.10	.97856	.95907	.951	.94134
12.13	.99755	.97816	.97157	.94981
12.17	.97521	.95907	.96068	.9486

TABLE XII. CONTINUED

MOISTURE DESORBED FROM PANEL #79068B-1 82SIC
6 PLY GRAPHITE - STRATFORD
WEATHERED 9-21-79 TO 9-24-82
(CONTINUED)

DATE	COUPON I	COUPON II	COUPON III	COUPON IV
1.10	1.0065	.98826	.98246	.97038
1.14	1.0054	.98826	.98488	.97764
1.17	1.0132	.99388	.98851	.97764
1.21	1.0177	.99163	.98367	.97401
1.24	1.0065	.98377	.98125	.97401
1.28	1.0188	.99837	.99456	.98974
1.31	1.002	.98377	.98367	.9728
2.4	.99979	.97894	.97399	.96796
2.7	1.0054	.98602	.98004	.97643
2.11	1.0367	.99051	.99577	.98611
2.14	1.0221	1.0017	.99698	.98732

TABLE XII. CONTINUED

MOISTURE DESORBED FROM PANEL #790698-6 82S1C
6 PLY GRAPHITE - STRATFORD
WEATHERED 9-28-79 TO 9-24-82

DATE	COUPON I	COUPON II	COUPON III	COUPON IV
10.5	0	0	0	0
10.6	.28419	.29488	.2097	.21266
10.7	.36663	.37402	.29513	.30308
10.8	.41978	.4304	.35467	.36293
10.11	.58032	.59193	.53589	.53993
10.13	.61828	.63747	.5799	.58705
10.15	.66709	.683	.6265	.63672
10.18	.7235	.74263	.68604	.69657
10.20	.76146	.77949	.72099	.71949
10.22	.78858	.80442	.74688	.75769
10.25	.83088	.85104	.78959	.79844
10.27	.84498	.86622	.80124	.8099
10.29	.85909	.87814	.8103	.82264
11.1	.86017	.87923	.81548	.82518
11.3	.86776	.88248	.81936	.829
11.5	.87319	.88899	.82325	.83028
11.8	.91224	.93452	.85043	.86339
11.10	.92417	.94753	.86596	.87867
11.12	.92308	.94211	.86985	.87485
11.15	.94478	.96271	.87632	.89522
11.19	.96647	.9833	.89444	.90668
11.22	.95888	.97788	.89185	.90159
11.29	.986	1.0082	.9048	.91942
12.3	.9784	.99306	.90091	.91432
12.6	.96864	.98764	.88926	.90286
12.10	1.0088	1.0267	.91774	.93088
12.13	1.0175	1.0397	.92162	.94616
12.17	1.0185	1.0332	.92292	.93597

TABLE XII. CONTINUED

MOISTURE DESORBED FROM PANEL #79069B-6 82S1C
6 PLY GRAPHITE - STRATFORD
WEATHERED 9-28-79 TO 9-24-82
(CONTINUED)

DATE	COUPON I	COUPON II	COUPON III	COUPON IV
1.10	1.0457	1.0646	.94363	.95889
1.14	1.0532	1.069	.94881	.95889
1.17	1.0511	1.069	.94622	.96017
1.21	1.0522	1.0733	.94881	.95253
1.24	1.0478	1.07	.94363	.9538
1.28	1.0598	1.0776	.95269	.96781
1.31	1.0446	1.0635	.93327	.94998
2.4	1.0435	1.0614	.93845	.95253
2.7	1.0532	1.0711	.93975	.94998
2.11	1.0565	1.0679	.96046	.97163
2.14	1.0673	1.0863	.95139	.96526

TABLE XII. CONTINUED

MOISTURE DESORBED FROM PANEL #78263A-5 82S1B-1
14 PLY GRAPHITE - STRATFORD
WEATHERED 11-6-79 TO 9-24-82

DATE	COUPON I	COUPON II	COUPON III	COUPON IV
10.5	0	0	0	0
10.6	.12357	.12632	.076721	.07459
10.7	.15519	.1602	.10444	.10144
10.8	.1727	.17762	.12127	.11835
10.11	.23789	.24344	.17869	.17305
10.13	.25006	.25796	.19254	.18896
10.15	.26903	.2749	.20739	.20388
10.18	.2953	.30297	.23511	.22924
10.20	.306	.31652	.24452	.24018
10.22	.32011	.32959	.25689	.25112
10.25	.34103	.35282	.27719	.27151
10.27	.34638	.35621	.28362	.27698
10.29	.35125	.36395	.28906	.28145
11.1	.35806	.36879	.295	.28742
11.3	.36098	.37218	.30144	.29389
11.5	.36536	.37508	.30243	.29488
11.8	.38579	.3988	.32223	.31427
11.10	.39649	.40945	.33213	.32472
11.12	.39357	.40654	.33064	.32223
11.15	.40525	.41913	.34153	.33317
11.19	.42082	.43268	.35539	.34511
11.22	.42228	.43316	.35935	.35157
11.29	.44028	.45204	.37371	.3635
12.3	.44222	.45397	.37717	.36897
12.6	.43736	.45155	.37667	.36649
12.10	.4646	.47866	.394	.38538
12.13	.47044	.48592	.40439	.39235
12.17	.4719	.48495	.40291	.39334

TABLE XII. CONTINUED

MOISTURE DESORBED FROM PANEL #78263A-5 82S1B-1
14 PLY GRAPHITE - STRATFORD
WEATHERED 11-6-79 TO 9-24-82
(CONTINUED)

DATE	COUPON I	COUPON II	COUPON III	COUPON IV
1.10	.52007	.52028	.4336	.42566
1.14	.53418	.52367	.43558	.42914
1.17	.53077	.52512	.43954	.43163
1.21	.52493	.52802	.44102	.43212
1.24	.53028	.5256	.44152	.4356
1.28	.53077	.53335	.44696	.43909
1.31	.52834	.52851	.4435	.4356
2.4	.52931	.53189	.44597	.43809
2.7	.53028	.53577	.45043	.43909
2.11	.53418	.55125	.46132	.4545
2.14	.53418	.54496	.45785	.44853
2.18	.52883	.53964	.45587	.44754
2.21	.53807	.54496	.45785	.45052
2.25	.53174	.54738	.46132	.45351
3.4	.5371	.5469	.45983	.45251
3.7	.5405	.54787	.45934	.45251
3.11	.5332	.54545	.45934	.45052
3.14	.53612	.54883	.4633	.45301
3.18	.54001	.54835	.46231	.4545
3.21	.52883	.54351	.45637	.45052
3.25	.53807	.55319	.46429	.4545
3.28	.53174	.54787	.46231	.45251
4.4	.5371	.55174	.46429	.45599
4.8	.5405	.55513	.46924	.46047
4.11	.5332	.54835	.46082	.45351
4.15	.53612	.55125	.46478	.455

TABLE XII. CONTINUED

MOISTURE DESORBED FROM PANEL #78263A-5 82S1B-1
14 PLY GRAPHITE - STRATFORD
WEATHERED 11-6-79 TO 9-24-82
(CONTINUED)

DATE	COUPON I	COUPON II	COUPON III	COUPON IV
4.18	.54001	.55609	.46726	.45947
4.22	.53661	.55319	.46429	.45649
4.25	.53126	.54448	.46033	.45251
4.29	.53174	.54448	.45934	.45152

TABLE XII. CONTINUED

% MOISTURE DESORBED FROM PANEL #78261B-5 82S1B
14 PLY GRAPHITE - STRATFORD
WEATHERED 11-6-79 TO 9-24-82

DATE	COUPON I	COUPON II	COUPON III	COUPON IV
10.5	0	0	0	0
10.6	.11553	.12085	.071899	.07074
10.7	.1448	.14832	.099513	.094833
10.8	.16397	.1678	.11619	.11124
10.11	.22602	.22623	.16672	.1625
10.13	.23813	.23871	.18131	.17429
10.15	.25579	.25719	.19382	.18967
10.18	.28051	.27966	.21935	.21273
10.20	.29111	.28865	.2282	.22145
10.22	.30422	.30263	.2381	.23119
10.25	.32592	.32311	.25894	.25118
10.27	.32995	.3266	.26311	.25528
10.29	.3355	.3306	.26936	.25989
11.1	.33903	.33559	.27197	.26502
11.3	.34206	.33759	.27718	.26912
11.5	.3466	.34308	.2803	.2722
11.8	.3683	.36306	.29489	.28757
11.10	.37738	.37005	.3074	.29629
11.12	.37284	.36606	.30531	.29731
11.15	.38747	.38353	.31677	.30654
11.19	.39806	.39202	.32615	.31782
11.22	.39756	.39402	.33136	.31884
11.29	.41572	.4115	.34178	.33268
12.3	.41976	.4145	.34491	.33473
12.6	.4137	.4095	.3423	.33217
12.10	.4359	.43347	.36054	.34909
12.13	.44296	.44046	.36783	.35831
12.17	.44599	.43747	.36627	.35678

TABLE XII. CONTINUED

% MOISTURE DESORBED FROM PANEL #78261B-5 8251B
14 PLY GRAPHITE - STRATFORD
WEATHERED 11-6-79 TO 9-24-82
(CONTINUED)

DATE	COUPON I	COUPON II	COUPON III	COUPON IV
1.10	.47424	.46694	.39077	.38241
1.14	.47727	.46944	.39165	.38497
1.17	.47929	.47243	.39389	.38753
1.21	.48484	.47443	.3965	.38753
1.24	.4808	.47343	.39598	.38805
1.28	.49039	.47893	.40431	.39471
1.31	.48282	.47393	.39598	.38958
2.4	.48383	.47843	.40119	.39112
2.7	.48837	.47992	.40119	.3942
2.11	.49342	.49491	.41578	.40291
2.14	.49644	.48791	.40796	.39984
2.18	.49241	.48542	.40484	.39984
2.21	.49745	.48941	.409	.40086
2.25	.49745	.49041	.41213	.40342
3.4	.49897	.48692	.409	.40189
3.7	.49695	.48791	.40952	.4024
3.11	.49796	.48941	.41005	.40086
3.14	.50149	.49341	.41265	.40342
3.18	.49947	.48941	.41109	.40291
3.21	.49745	.48791	.40796	.40137
3.25	.50603	.4994	.41369	.40701
3.28	.49947	.48991	.41161	.40342
4.4	.50149	.49391	.41369	.40394
4.8	.50552	.4959	.41578	.40753
4.11	.49796	.48791	.409	.40189
4.15	.50149	.49141	.41213	.40445

TABLE XII. CONTINUED

% MOISTURE DESORBED FROM PANEL #78261B-5 82S1B
14 PLY GRAPHITE - STRATFORD
WEATHERED 11-6-79 TO 9-24-82
(CONTINUED)

DATE	COUPON I	COUPON II	COUPON III	COUPON IV
4.18	.50552	.49491	.41265	.4065
4.22	.50149	.49391	.41109	.40496
4.25	.49443	.48642	.40588	.39984
4.29	.49392	.48692	.40744	.39984

TABLE XII. CONTINUED

MOISTURE DESORBED FROM PANEL #79033A-6 82W1A
33 PLY GRAPHITE - WEST PALM BEACH
WEATHERED 10-15-79 TO 9-14-82

DATE	COUPON I	COUPON II	COUPON III	COUPON IV
10.5	0	0	0	0
10.6	.088966	.089317	.058714	.061517
10.7	.11375	.11565	.077426	.083058
10.8	.12921	.13185	.091405	.09735
10.11	.17687	.18269	.1327	.1396
10.13	.18789	.19362	.1413	.15037
10.15	.1989	.20537	.15033	.16114
10.18	.22051	.22805	.16776	.18082
10.20	.22962	.23798	.17593	.1889
10.22	.23873	.2479	.18367	.19698
10.25	.25504	.26431	.19701	.21148
10.27	.25948	.26896	.20066	.21521
10.29	.26414	.27443	.20453	.21997
11.1	.26753	.27788	.20819	.22308
11.3	.2688	.28031	.20969	.2237
11.5	.2705	.28193	.21034	.2268
11.8	.2866	.29853	.22346	.24006
11.10	.29549	.30704	.22991	.24752
11.12	.29232	.30461	.22841	.24586
11.15	.30079	.31433	.23529	.25373
11.19	.31159	.32547	.24432	.26347
11.22	.31075	.32527	.24432	.2645
11.29	.32367	.33823	.25421	.27444
12.3	.32473	.34005	.25572	.2761
12.6	.32303	.33843	.25357	.27362
12.10	.34061	.35646	.26733	.28791
12.13	.34506	.36213	.2712	.2935
12.17	.34485	.36213	.27207	.29329

TABLE XII. CONTINUED

MOISTURE DESORBED FROM PANEL #79033A-6 82W1A
33 PLY GRAPHITE - WEST PALM BEACH
WEATHERED 10-15-79 TO 9-14-82
(CONTINUED)

DATE	COUPON I	COUPON II	COUPON III	COUPON IV
1.10	.37048	.38786	.29164	.31463
1.14	.37281	.39089	.29357	.31794
1.17	.37366	.39251	.29465	.31857
1.21	.37895	.3992	.29981	.32209
1.24	.37641	.39535	.29981	.32188
1.28	.38255	.40163	.30282	.3254
1.31	.38001	.39839	.30003	.32519
2.4	.37916	.39879	.29981	.32312
2.7	.38171	.40244	.29981	.32602
2.11	.39802	.41621	.3168	.34031
2.14	.39463	.415	.31228	.33431
2.18	.39103	.41155	.30798	.33182
2.21	.39632	.41419	.3125	.33596
2.25	.39293	.41378	.31099	.33493
3.4	.39399	.41419	.3125	.33721
3.7	.39442	.41621	.31379	.337
3.11	.39463	.4154	.31228	.33638
3.14	.39844	.41925	.3153	.33928
3.18	.39802	.41905	.31551	.33949
3.21	.39611	.41722	.31401	.337
3.25	.40162	.42391	.31831	.34238
3.28	.39802	.42087	.31487	.34011
4.4	.40374	.42492	.31745	.34404
4.8	.40458	.42451	.31938	.34363
4.11	.40458	.4233	.31659	.34156
4.15	.40374	.42614	.31981	.34487

TABLE XII. CONTINUED

MOISTURE DESORBED FROM PANEL #79033A-6 82W1A
33 PLY GRAPHITE - WEST PALM BEACH
WEATHERED 10-15-79 TO 9-14-82
(CONTINUED)

DATE	COUPON I	COUPON II	COUPON III	COUPON IV
4.18	.4067	.42978	.32218	.34694
4.22	.40607	.42877	.32089	.3457
4.25	.40077	.42269	.3168	.34176
4.29	.40458	.42593	.31917	.34508

TABLE XII. CONTINUED

MOISTURE DESORBED FROM PANEL #79030B-6 82S1A
33 PLY GRAPHITE - STRATFORD
WEATHERED 9-14-79 TO 9-24-82

DATE	COUPON I	COUPON II	COUPON III	COUPON IV
10.5	0	0	0	0
10.6	.065625	.062336	.048247	.04444
10.7	.085498	.081206	.066394	.063267
10.8	.094607	.09096	.056573	.070272
10.11	.12152	.11874	.10567	.10026
10.13	.13021	.12382	.11187	.10661
10.15	.13373	.12934	.11784	.11165
10.18	.1503	.14312	.13193	.12675
10.20	.15526	.14736	.1362	.13201
10.22	.15837	.15287	.14047	.13507
10.25	.16706	.16072	.14944	.14448
10.27	.16996	.16347	.15328	.14711
10.29	.17307	.16665	.15478	.1377
11.1	.1741	.16793	.1567	.15061
11.3	.17286	.16581	.15627	.14864
11.5	.17286	.16644	.15584	.1504
11.8	.18425	.17768	.16566	.16025
11.10	.18756	.1798	.16759	.16244
11.12	.18652	.17959	.16929	.16266
11.15	.19253	.1851	.17399	.16747
11.19	.20039	.19273	.1821	.17404
11.22	.19563	.18743	.17826	.17163
11.29	.20619	.19931	.18701	.18104
12.3	.20702	.19888	.18829	.1828
12.6	.20371	.19591	.18573	.17885
12.10	.21509	.20545	.19512	.18717
12.13	.21675	.20779	.19726	.19111
12.17	.21737	.20842	.19705	.19024

TABLE XII. CONTINUED

MOISTURE DESORBED FROM PANEL #79030B-6 82S1A
33 PLY GRAPHITE - STRATFORD
WEATHERED 9-14-79 TO 9-24-82
(CONTINUED)

DATE	COUPON I	COUPON II	COUPON III	COUPON IV
1.10	.23207	.22263	.21199	.20294
1.14	.23704	.22411	.21391	.20469
1.17	.23497	.22178	.21114	.20272
1.21	.23517	.22369	.21263	.20513
1.24	.23103	.22072	.21135	.2025
1.28	.23621	.22496	.21412	.20469
1.31	.23434	.22369	.21306	.20425
2.4	.23103	.2203	.21049	.20141
2.7	.23455	.22432	.21434	.20425
2.11	.2418	.23047	.22501	.21126
2.14	.23993	.22856	.21733	.20972
2.18	.23393	.22475	.21412	.20447
2.21	.23807	.22708	.21775	.20797
2.25	.23828	.22644	.21626	.20775
3.4	.23766	.22644	.2169	.20688
3.7	.2389	.22814	.21733	.20797
3.11	.23683	.22602	.21583	.20556
3.14	.24014	.22899	.21754	.20819
3.18	.23807	.22772	.21605	.20754
3.21	.23662	.22602	.21476	.20535
3.25	.24076	.22962	.21754	.20929
3.28	.23621	.22602	.21562	.20666
4.4	.23931	.22835	.21775	.20863
4.8	.23807	.22814	.21711	.21082
4.11	.23683	.22729	.21583	.206
4.15	.23745	.22708	.21605	.20732

TABLE XII. CONTINUED

MOISTURE DESORBED FROM PANEL #79030B-6 82S1A
33 PLY GRAPHITE - STRATFORD
WEATHERED 9-14-79 TO 9-24-82
(CONTINUED)

DATE	COUPON I	COUPON II	COUPON III	COUPON IV
4.18	.24097	.22899	.21861	.20972
4.22	.2389	.22856	.21775	.20841
4.25	.23414	.22284	.21348	.20381
4.29	.23579	.24129	.21348	.20403

TABLE XII. CONTINUED

MOISTURE DESORBED FROM PANEL #78241-68 82W3D
5 PLY KEVLAR - WEST PALM BEACH
WEATHERED 10-15-79 TO 9-14-83

DATE	COUPON I	COUPON II	COUPON III	COUPON IV
10.5	5.7832	5.7661	4.3605	4.4555
10.6	5.7486	5.7316	4.335	4.4298
10.7	5.7337	5.7171	4.3215	4.4164
10.8	5.7261	5.7092	4.3143	4.4088
10.11	5.7029	5.6862	4.2941	4.3885
10.13	5.6962	5.6793	4.2891	4.3831
10.15	5.6917	5.6746	4.2852	4.3795
10.18	5.6843	5.667	4.2799	4.3741
10.20	5.6815	5.6641	4.2785	4.3724
10.22	5.6792	5.6618	4.2774	4.3712
10.25	5.6754	5.6581	4.2757	4.3692
10.27	5.6747	5.6575	4.2752	4.3686
10.29	5.6734	5.6563	4.2748	4.368
11.1	5.6743	5.6569	4.2758	4.3692
11.3	5.6757	5.6584	4.2773	4.3699
11.5	5.6759	5.6581	4.2777	4.3709
11.8	5.672	5.6545	4.2749	4.368
11.10	5.6713	5.6539	4.2741	4.3671
11.12	5.6721	5.6552	4.2749	4.3685
11.15	5.6704	5.6532	4.2739	4.367
11.19	5.6695	5.6527	4.2732	4.3666
11.22	5.6703	5.6532	4.2743	4.3674
11.29	5.6683	5.6516	4.273	4.3664
12.3	5.6693	5.6529	4.275	4.3679
12.6	5.671	5.6538	4.2758	4.3681
12.10	5.6674	5.6497	4.2724	4.3651
12.13	5.6663	5.6492	4.2727	4.3647
12.17	5.6666	5.6498	4.2721	4.3649

TABLE XII. CONTINUED

MOISTURE DESORBED FROM PANEL #78241-68 82W3D
5 PLY KEVLAR - WEST PALM BEACH
WEATHERED 10-15-79 TO 9-14-83
(CONTINUED)

DATE	COUPON I	COUPON II	COUPON III	COUPON IV
1.10	5.6638	5.6473	4.2715	4.364
1.14	5.6644	5.6481	4.2718	4.3649
1.17	5.6648	5.648	4.2722	4.3648
1.21	5.665	5.6483	4.2722	4.3654
1.24	5.6653	5.6489	4.2727	4.3654
1.28	5.6641	5.6482	4.2725	4.365
1.31	5.6657	5.6494	4.2734	4.366
2.4	5.6668	5.65	4.2746	4.3674

TABLE XII. CONTINUED

MOISTURE DESORBED FROM PANEL #78241-97 82W3D-1
5 PLY KEVLAR - WEST PALM BEACH
WEATHERED 10-15-79 TO 9-14-83

DATE	COUPON I	COUPON II	COUPON III	COUPON IV
10.5	5.5119	5.1901	4.1416	3.6987
10.6	5.4753	5.1549	4.1158	3.6746
10.7	5.4628	5.1419	4.1032	3.6631
10.8	5.454	5.1343	4.0959	3.6563
10.11	5.4328	5.1145	4.0771	3.6396
10.13	5.4267	5.108	4.071	3.6342
10.15	5.4221	5.1037	4.0679	3.6314
10.18	5.4153	5.0971	4.0623	3.6271
10.20	5.4129	5.096	4.06	3.6242
10.22	5.4107	5.0925	4.059	3.6239
10.25	5.407	5.0894	4.0565	3.6216
10.27	5.4058	5.0889	4.056	3.6214
10.29	5.4046	5.0874	4.0555	3.6208
11.1	5.4058	5.088	4.056	3.6214
11.3	5.4064	5.0898	4.0576	3.6224
11.5	5.4064	5.089	4.0579	3.6231
11.8	5.4034	5.0859	4.0553	3.6206
11.10	5.4022	5.085	4.0545	3.6197
11.12	5.4034	5.0864	4.0554	3.6209
11.15	5.4017	5.0845	4.0539	3.6193
11.19	5.401	5.084	4.0534	3.6188
11.22	5.402	5.0848	4.0543	3.6201
11.29	5.4003	5.0827	4.0536	3.6188
12.3	5.4021	5.084	4.0547	3.6198
12.6	5.403	5.0856	4.0558	3.6214
12.10	5.3984	5.0814	4.052	3.6176
12.13	5.3974	5.0804	4.052	3.6173
12.17	5.3979	5.0808	4.052	3.6178

TABLE XII. CONTINUED

MOISTURE DESORBED FROM PANEL #78241-97 82W3D-1.
5 PLY KEVLAR - WEST PALM BEACH
WEATHERED 10-15-79 TO 9-14-83
(CONTINUED)

DATE	COUPON I	COUPON II	COUPON III	COUPON IV
1.10	5.3953	5.0785	4.051	3.6164
1.14	5.3964	5.0793	4.0518	3.6173
1.17	5.3962	5.0796	4.0515	3.6175
1.21	5.3961	5.0794	4.0535	3.6183
1.24	5.397	5.0799	4.0525	3.6181
1.28	5.3962	5.0792	4.0521	3.6174
1.31	5.3974	5.0804	4.0529	3.6183
2.4	5.3989	5.0816	4.0542	3.6194
2.7	5.3973	5.0802	4.0531	3.6185
2.11	5.3954	5.0786	4.0509	3.6162
2.14	5.3959	5.0792	4.0524	3.6177

TABLE XII. CONTINUED

MOISTURE DESORBED FROM PANEL #78241-58 82S3D
5 PLY KEVLAR - STRATFORD
WEATHERED 8-29-79 TO 9-24-82

DATE	COUPON I	COUPON II	COUPON III	COUPON IV
10.5	5.7333	5.7302	4.6811	4.7217
10.6	5.7033	5.7001	4.6584	4.6987
10.7	5.6905	5.6875	4.6469	4.6878
10.8	5.6841	5.6811	4.6407	4.6817
10.11	5.6647	5.6618	4.6239	4.6641
10.13	5.6594	5.6562	4.6188	4.6595
10.15	5.6557	5.653	4.616	4.6567
10.18	5.6491	5.6465	4.6112	4.6513
10.20	5.6472	5.6443	4.609	4.6489
10.22	5.6454	5.6425	4.6081	4.6482
10.25	5.6431	5.6406	4.6065	4.6466
10.27	5.6424	5.6396	4.6061	4.6459
10.29	5.6414	5.6386	4.6057	4.6454
11.1	5.6421	5.6395	4.6067	4.6465
11.3	5.644	5.6408	4.6081	4.6477
11.5	5.6434	5.6404	4.6082	4.648
11.8	5.6406	5.6373	4.6056	4.6457
11.10	5.6393	5.6367	4.6053	4.6448
11.12	5.641	5.6382	4.6062	4.646
11.15	5.6386	5.636	4.6049	4.6446
11.19	5.638	5.6347	4.6041	4.6439
11.22	5.6392	5.6358	4.6056	4.6452
11.29	5.6378	5.6341	4.6046	4.6445
12.3	5.6388	5.6358	4.6057	4.6457
12.6	5.6404	5.6369	4.6075	4.6467
12.10	5.6357	5.6323	4.6033	4.6433
12.13	5.635	5.6314	4.603	4.6428
12.17	5.6353	5.6317	4.6034	4.643

TABLE XII. CONTINUED

MOISTURE DESORBED FROM PANEL #78241-58 82S3D
5 PLY KEVLAR - STRATFORD
WEATHERED 8-29-79 TO 9-24-82
(CONTINUED)

DATE	COUPON I	COUPON II	COUPON III	COUPON IV
1.10	5.6333	5.629	4.6023	4.642
1.14	5.634	5.63	4.6037	4.6435
1.17	5.6342	5.63	4.6032	4.643
1.21	5.6338	5.6295	4.6032	4.6427
1.24	5.6347	5.6299	4.6037	4.6433
1.28	5.6338	5.6298	4.6034	4.6427
1.31	5.6353	5.6308	4.6046	4.644
2.4	5.6367	5.6321	4.606	4.6452
2.7	5.6354	5.631	4.605	4.6443
2.11	5.6332	5.6286	4.6032	4.6429
2.14	5.634	5.6299	4.6036	4.643

TABLE XII. CONTINUED

MOISTURE DESORBED FROM PANEL #78241-88 82S3D
5 PLY KEVLAR - STRATFORD
WEATHERED 8-29-79 TO 9-24-82

DATE	COUPON I	COUPON II	COUPON III	COUPON IV
10.5	5.91	5.9578	4.5443	4.6485
10.6	5.8761	5.9233	4.5216	4.6249
10.7	5.8634	5.9117	4.5105	4.6145
10.8	5.8573	5.9049	4.5048	4.6083
10.11	5.8371	5.8843	4.4873	4.591
10.13	5.8316	5.879	4.483	4.586
10.15	5.8276	5.875	4.4801	4.5829
10.18	5.8212	5.8681	4.4748	4.5781
10.20	5.8187	5.8656	4.473	4.5759
10.22	5.8164	5.8636	4.4717	4.5745
10.25	5.8141	5.8609	4.4703	4.5731
10.27	5.8135	5.8605	4.4698	4.5726
10.29	5.8126	5.86	4.4696	4.572
11.1	5.8133	5.8605	4.4706	4.573
11.3	5.8147	5.8617	4.4718	4.5741
11.5	5.8145	5.8617	4.4718	4.5742
11.8	5.8109	5.858	4.4693	4.5718
11.10	5.8098	5.8569	4.4686	4.5713
11.12	5.8114	5.8587	4.47	4.5725
11.15	5.8096	5.8569	4.4686	4.5712
11.19	5.8082	5.8557	4.4679	4.5702
11.22	5.8096	5.8571	4.469	4.5716
11.29	5.8078	5.8552	4.4685	4.5709
12.3	5.8091	5.8565	4.4695	4.572
12.6	5.8108	5.8581	4.4712	4.5731
12.10	5.8055	5.853	4.4673	4.5694
12.13	5.8047	5.8522	4.4665	4.5687
12.17	5.8051	5.8529	4.4671	4.5698

TABLE XII. CONCLUDED

MOISTURE DESORBED FROM PANEL #78241-88 82S3D
5 PLY KEVLAR - STRATFORD
WEATHERED 8-29-79 TO 9-24-82
(CONTINUED)

DATE	COUPON I	COUPON II	COUPON III	COUPON IV
1.10	5.803	5.8503	4.4665	4.5684
1.14	5.8035	5.8512	4.4673	4.569
1.17	5.8034	5.851	4.467	4.5694
1.21	5.8027	5.8505	4.467	4.5694
1.24	5.8037	5.8511	4.4674	4.5699
1.28	5.8029	5.85	4.4672	4.5696
1.31	5.8042	5.8516	4.4681	4.5705
2.4	5.8058	5.8531	4.4696	4.572
2.7	5.8044	5.8518	4.469	4.5709
2.11	5.8022	5.8501	4.4682	4.569
2.14	5.8029	5.8504	4.4674	4.5697

TABLE XIII.
AVERAGE MOISTURE VALUE OF DESORPTION COUPONS

MOISTURE DESORBED FROM PANEL #79071A-5 82W1C
6 PLY GRAPHITE - WEST PALM BEACH
AVERAGE OF DATA FROM FOUR COUPONS

DATE	% WT. CHANGE	DATE	% WT. CHANGE	DATE	% WT. CHANGE
10.5	0	11.1	1.0555	12.13	1.2164
10.6	.32112	11.3	1.0594	12.17	1.2025
10.7	.42845	11.5	1.0628	1.10	1.2336
10.8	.4961	11.8	1.1042	1.14	1.2316
10.11	.70519	11.10	1.1141	1.17	1.2384
10.13	.76782	11.12	1.1121	1.21	1.2435
10.15	.8229	11.15	1.1328	1.24	1.2335
10.18	.89515	11.19	1.1487	1.28	1.2435
10.20	.93529	11.22	1.1453	1.31	1.2338
10.22	.96524	11.29	1.1751	2.4	1.228
10.25	1.0141	12.3	1.1653	2.7	1.2351
10.27	1.0288	12.6	1.1572	2.11	1.2505
10.29	1.0428	12.10	1.1982	2.14	1.2502

TABLE XIII. CONTINUED

MOISTURE DESORBED FROM PANEL #79070B-6 82W1C-1
6 PLY GRAPHITE - WEST PALM BEACH
AVERAGE OF DATA FROM FOUR COUPONS

DATE	% WT. CHANGE	DATE	% WT. CHANGE	DATE	% WT. CHANGE
10.5	0	11.1	1.0496	12.13	1.2022
10.6	.32474	11.3	1.0574	12.17	1.1954
10.7	.43045	11.5	1.0568	1.10	1.2231
10.8	.49852	11.8	1.0947	1.14	1.216
10.11	.71715	11.10	1.1077	1.17	1.2192
10.13	.77351	11.12	1.0992	1.21	1.2207
10.15	.83109	11.15	1.126	1.24	1.2237
10.18	.89128	11.19	1.1386	1.28	1.2266
10.20	.93208	11.22	1.1381	1.31	1.2152
10.22	.96161	11.29	1.1664	2.4	1.2143
10.25	1.0156	12.3	1.1541	2.7	1.2157
10.27	1.0245	12.6	1.1435	2.11	1.2366
10.29	1.0353	12.10	1.1823	2.14	1.2302

TABLE XIII. CONTINUED

MOISTURE DESORBED FROM PANEL #79068B-1 82S1C
6 PLY GRAPHITE - STRATFORD
AVERAGE OF DATA FROM FOUR COUPONS

DATE	% WT. CHANGE	DATE	% WT. CHANGE	DATE	% WT. CHANGE
10.5	0	11.1	.82803	12.13	.97427
10.6	.23938	11.3	.82756	12.17	.96089
10.7	.32505	11.5	.83535	1.10	.9869
10.8	.37526	11.8	.87196	1.14	.98904
10.11	.54202	11.10	.88349	1.17	.9933
10.13	.58528	11.12	.88143	1.21	.99174
10.15	.62787	11.15	.89933	1.24	.98638
10.18	.69302	11.19	.91769	1.28	1.0004
10.20	.72571	11.22	.91229	1.31	.98557
10.22	.75334	11.29	.9372	2.4	.98017
10.25	.78973	12.3	.9303	2.7	.98696
10.27	.81189	12.6	.92154	2.11	1.0023
10.29	.82473	12.10	.95749	2.14	1.002

TABLE XIII. CONTINUED

MOISTURE DESORBED FROM PANEL #79069B-6 82S1C
6 PLY GRAPHITE - STRATFORD
AVERAGE OF DATA FROM FOUR COUPONS

DATE	% WT. CHANGE	DATE	% WT. CHANGE	DATE	% WT. CHANGE
10.5	0	11.1	.84502	12.13	.98123
10.6	.25036	11.3	.84965	12.17	.97765
10.7	.33471	11.5	.85392	1.10	1.0032
10.8	.39194	11.8	.89014	1.14	1.0075
10.11	.56202	11.10	.90408	1.17	1.0066
10.13	.60567	11.12	.90247	1.21	1.0067
10.15	.65333	11.15	.91976	1.24	1.0038
10.18	.71218	11.19	.93772	1.28	1.0145
10.20	.74536	11.22	.93255	1.31	.99784
10.22	.77439	11.29	.95461	2.4	.99896
10.25	.81749	12.3	.94668	2.7	1.0035
10.27	.83059	12.6	.9371	2.11	1.0141
10.29	.84254	12.10	.97102	2.14	1.0176

TABLE XIII. CONTINUED

MOISTURE DESORBED FROM PANEL #78263A-5 82S1B-1
14 PLY GRAPHITE - STRATFORD
AVERAGE OF DATA FROM FOUR COUPONS

DATE	% WT. CHANGE	DATE	% WT. CHANGE	DATE	% WT. CHANGE
10.5	0	11.19	.3885	2.18	.49297
10.6	.1003	11.22	.39159	2.21	.49785
10.7	.13032	11.29	.40738	2.25	.49849
10.8	.14749	12.3	.41058	3.4	.49908
10.11	.20827	12.6	.40802	3.7	.50005
10.13	.22238	12.10	.43066	3.11	.49713
10.15	.2388	12.13	.43827	3.14	.50032
10.18	.26566	12.17	.43827	3.18	.50129
10.20	.27681	1.10	.4749	3.21	.49481
10.22	.28943	1.14	.48064	3.25	.50251
10.25	.31064	1.17	.48176	3.28	.49861
10.27	.3158	1.21	.48153	4.4	.50228
10.29	.32143	1.24	.48325	4.8	.50633
11.1	.32732	1.28	.48754	4.11	.49897
11.3	.33212	1.31	.48399	4.15	.50179
11.5	.33444	2.4	.48632	4.18	.50571
11.8	.35527	2.7	.48889	4.22	.50264
11.10	.3657	2.11	.50031	4.25	.49714
11.12	.36325	2.14	.49638	4.29	.49677
11.15	.37477				

TABLE XIII. CONTINUED

% MOISTURE DESORBED FROM PANEL #78261B-5 82S1B
14 PLY GRAPHITE - STRATFORD
AVERAGE OF DATA FROM FOUR COUPONS

DATE	% WT. CHANGE	DATE	% WT. CHANGE	DATE	% WT. CHANGE
10.5	0	11.19	.35851	2.18	.44562
10.6	.094757	11.22	.36045	2.21	.44918
10.7	.12187	11.29	.37542	2.25	.45085
10.8	.1398	12.3	.37847	3.4	.44919
10.11	.19537	12.6	.37442	3.7	.4492
10.13	.20811	12.10	.39475	3.11	.44957
10.15	.22411	12.13	.40239	3.14	.45274
10.18	.24806	12.17	.40163	3.18	.45072
10.20	.25735	1.10	.42859	3.21	.44868
10.22	.26904	1.14	.43083	3.25	.45653
10.25	.28979	1.17	.43329	3.28	.4511
10.27	.29374	1.21	.43583	4.4	.45326
10.29	.29884	1.24	.43456	4.8	.45618
11.1	.3029	1.28	.44208	4.11	.44919
11.3	.30649	1.31	.43558	4.15	.45237
11.5	.31055	2.4	.43864	4.18	.4549
11.8	.32846	2.7	.44092	4.22	.45286
11.10	.33778	2.11	.45175	4.25	.44664
11.12	.33538	2.14	.44804	4.29	.44703
11.15	.34858				

TABLE XIII. CONTINUED

MOISTURE DESORBED FROM PANEL #79033A-6 82W1A
33 PLY GRAPHITE - WEST PALM BEACH
AVERAGE OF DATA FROM FOUR COUPON

DATE	% WT. CHANGE	DATE	% WT. CHANGE	DATE	% WT. CHANGE
10.5	0	11.19	.28621	2.18	.3606
10.6	.074629	11.22	.28621	2.21	.36474
10.7	.09747	11.29	.29764	2.25	.36316
10.8	.11245	12.3	.29915	3.4	.36447
10.11	.15797	12.6	.29716	3.7	.36535
10.13	.1683	12.10	.31308	3.11	.36467
10.15	.17894	12.13	.31797	3.14	.36807
10.18	.19928	12.17	.31808	3.18	.36801
10.20	.20811	1.10	.34115	3.21	.36608
10.22	.21682	1.14	.34381	3.25	.37155
10.25	.23196	1.17	.34485	3.28	.36846
10.27	.23608	1.21	.35001	4.4	.37254
10.29	.24077	1.24	.34836	4.8	.37303
11.1	.24417	1.28	.3531	4.11	.37151
11.3	.24563	1.31	.3509	4.15	.37364
11.5	.24739	2.4	.35022	4.18	.3764
11.8	.26216	2.7	.35249	4.22	.37536
11.10	.26999	2.11	.36784	4.25	.37051
11.12	.2678	2.14	.36405	4.29	.37369
11.15	.27604				

TABLE XIII. CONTINUED

MOISTURE DESORBED FROM PANEL #79030B-6 82S1A
33 PLY GRAPHITE - STRATFORD
AVERAGE OF DATA FROM FOUR COUPON

DATE	% WT. CHANGE	DATE	% WT. CHANGE	DATE	% WT. CHANGE
10.5	0	11.19	.18732	2.18	.21932
10.6	.055162	11.22	.18324	2.21	.22272
10.7	.074091	11.29	.19339	2.25	.22218
10.8	.078103	12.3	.19425	3.4	.22197
10.11	.11155	12.6	.19105	3.7	.22308
10.13	.11813	12.10	.20071	3.11	.22106
10.15	.12314	12.13	.20323	3.14	.22372
10.18	.13802	12.17	.20327	3.18	.22234
10.20	.14271	1.10	.21741	3.21	.22069
10.22	.1467	1.14	.21994	3.25	.2243
10.25	.15543	1.17	.21765	3.28	.22113
10.27	.15846	1.21	.21915	4.4	.22351
10.29	.15805	1.24	.2164	4.8	.22354
11.1	.16233	1.28	.22	4.11	.22149
11.3	.16089	1.31	.21883	4.15	.22197
11.5	.16139	2.4	.21581	4.18	.22457
11.8	.17196	2.7	.21937	4.22	.22341
11.10	.17434	2.11	.22713	4.25	.21857
11.12	.17451	2.14	.22389	4.29	.22365
11.15	.17977				

TABLE XIII. CONTINUED

MOISTURE DESORBED FROM PANEL #78241-68 82W3D
5 PLY KEVLAR - WEST PALM BEACH
AVERAGE OF DATA FROM FOUR COUPONS

DATE	% WT. CHANGE	DATE	% WT. CHANGE	DATE	% WT. CHANGE
10.5	0	10.29	1.933	12.6	1.9479
10.6	.58955	11.1	1.9141	12.10	2.0176
10.7	.86942	11.3	1.889	12.13	2.0251
10.8	1.0204	11.5	1.8815	12.17	2.0235
10.11	1.4502	11.8	1.9463	1.10	2.0549
10.13	1.568	11.10	1.9616	1.14	2.0421
10.15	1.6504	11.12	1.94	1.17	2.039
10.18	1.776	11.15	1.9702	1.21	2.0335
10.20	1.8183	11.19	1.9825	1.24	2.0267
10.22	1.8512	11.22	1.9661	1.28	2.0384
10.25	1.9047	11.29	1.9947	1.31	2.0155
10.27	1.9165	12.3	1.9649	2.4	1.9934

TABLE XIII. CONTINUED

MOISTURE DESORBED FROM PANEL #78241-97 82W3D-1
5 PLY KEVLAR - WEST PALM BEACH
AVERAGE OF DATA FROM FOUR COUPONS

DATE	% WT. CHANGE	DATE	% WT. CHANGE	DATE	% WT. CHANGE
10.5	0	11.1	2.0122	12.13	2.1388
10.6	.65419	11.3	1.9844	12.17	2.1312
10.7	.92729	11.5	1.9817	1.10	2.1696
10.8	1.0938	11.8	2.0429	1.14	2.1498
10.11	1.5117	11.10	2.0635	1.17	2.1498
10.13	1.644	11.12	2.0378	1.21	2.1337
10.15	1.7232	11.15	2.0745	1.24	2.1346
10.18	1.8487	11.19	2.0865	1.28	2.1487
10.20	1.8984	11.22	2.0639	1.31	2.1266
10.22	1.9333	11.29	2.0948	2.4	2.0987
10.25	1.9957	12.3	2.0669	2.7	2.1255
10.27	2.0079	12.6	2.0377	2.11	2.1706
10.29	2.0276	12.10	2.1274	2.14	2.1463

TABLE XIII. CONTINUED

MOISTURE DESORBED FROM PANEL #78241-58 82S3D
5 PLY KEVLAR - STRATFORD
AVERAGE OF DATA FROM FOUR COUPONS

DATE	% WT. CHANGE	DATE	% WT. CHANGE	DATE	% WT. CHANGE
10.5	0	11.1	1.5889	12.13	1.6945
10.6	.50515	11.3	1.5611	12.17	1.6887
10.7	.73506	11.5	1.5633	1.10	1.7204
10.8	.8563	11.8	1.6151	1.14	1.6976
10.11	1.208	11.10	1.6298	1.17	1.702
10.13	1.3071	11.12	1.6047	1.21	1.7075
10.15	1.367	11.15	1.6391	1.24	1.696
10.18	1.4784	11.19	1.6554	1.28	1.7051
10.20	1.5207	11.22	1.6304	1.31	1.681
10.22	1.5449	11.29	1.653	2.4	1.6553
10.25	1.5803	12.3	1.629	2.7	1.6759
10.27	1.5935	12.6	1.6023	2.11	1.713
10.29	1.607	12.10	1.6833	2.14	1.7012

TABLE XIII. CONCLUDED

MOISTURE DESORBED FROM PANEL #78241-88 82S3D
5 PLY KEVLAR - STRATFORD
AVERAGE OF DATA FROM FOUR COUPONS

DATE	% WT. CHANGE	DATE	% WT. CHANGE	DATE	% WT. CHANGE
10.5	0	11.1	1.6288	12.13	1.7457
10.6	.53997	11.3	1.6054	12.17	1.7319
10.7	.75937	11.5	1.6057	1.10	1.7625
10.8	.87841	11.8	1.6631	1.14	1.749
10.11	1.2396	11.10	1.6789	1.17	1.7497
10.13	1.3357	11.12	1.6504	1.21	1.7548
10.15	1.402	11.15	1.6803	1.24	1.7432
10.18	1.513	11.19	1.7005	1.28	1.7539
10.20	1.5558	11.22	1.6751	1.31	1.7319
10.22	1.5886	11.29	1.6972	2.4	1.7025
10.25	1.6249	12.3	1.6748	2.7	1.7231
10.27	1.6345	12.6	1.6456	2.11	1.7541
10.29	1.6448	12.10	1.7308	2.14	1.7506

TABLE XIV

WEATHER BUREAU DATA, WEST PALM BEACH, FLORIDA

DATE	AVERAGE TEMPERATURE °C	AVERAGE TEMPERATURE °F	AVERAGE RELATIVE HUMIDITY %
4/01/78 - 4/30/78	22.9	73.2	67.9
5/01/78 - 5/31/78	26.0	78.9	77.5
6/01/78 - 6/30/78	27.5	81.6	78.3
7/01/78 - 7/31/78	27.8	82.1	76.3
8/01/78 - 8/31/78	27.9	82.2	73.3
9/01/78 - 9/30/78	27.0	80.7	76.4
10/01/78 - 10/31/78	24.9	77.0	74.9
11/01/78 - 11/30/78	23.1	73.7	79.4
12/01/78 - 12/31/78	20.2	68.4	80.1
1/01/79 - 1/31/79	17.0	62.7	66.8
2/01/79 - 2/28/79	17.6	63.7	79.3
3/01/79 - 3/31/79	20.0	68.0	66.8
4/01/79 - 4/30/79	23.5	74.4	68.6
5/01/79 - 5/31/79	24.4	76.0	79.3
6/01/79 - 6/30/79	26.8	80.2	75.4
7/01/79 - 7/31/79	28.1	82.7	75.9
8/01/79 - 8/31/79	28.0	82.5	73.0
9/01/79 - 9/30/79	27.4	81.3	83.5
10/01/79 - 10/31/79	25.3	77.5	77.4
11/01/79 - 11/30/79	22.9	73.2	80.1
12/01/79 - 12/31/79	19.5	67.1	80.3
1/01/80 - 1/31/80	17.8	64.1	80.5
2/01/80 - 2/29/80	16.0	60.9	76.0
3/01/80 - 3/31/80	21.2	70.2	77.3
4/01/80 - 4/30/80	22.1	71.8	77.1
5/01/80 - 5/31/80	24.8	76.6	77.1
6/01/80 - 6/30/80	27.4	81.3	70.9
7/01/80 - 7/31/80	28.0	82.4	75.1
8/01/80 - 8/31/80	22.4	72.4	78.9
9/01/80 - 9/30/80	26.7	80.1	80.3
10/01/80 - 10/31/80	25.3	77.5	76.4
11/01/80 - 11/30/80	17.6	63.8	68.1
12/01/80 - 12/31/80	18.3	64.9	61.4

TABLE XIV. CONCLUDED

DATE	AVERAGE TEMPERATURE °C	AVERAGE TEMPERATURE °F	AVERAGE RELATIVE HUMIDITY %
1/01/81 - 1/31/81	14.4	58.0	56.3
2/01/81 - 2/29/81	19.3	66.8	67.9
3/01/81 - 3/31/81	15.4	59.8	63.5
4/01/81 - 4/30/81	23.9	75.1	65.6
5/01/81 - 5/31/81	25.5	77.9	60.1
6/01/81 - 6/30/81	28.1	82.6	72.8
7/01/81 - 7/31/81	28.7	83.7	72.1
8/01/81 - 8/31/81	27.5	81.5	77.9
9/01/81 - 9/30/81	26.5	79.8	77.9
10/01/81 - 10/31/81	25.2	77.4	75.4
11/01/81 - 11/30/81	19.7	67.5	74.4
12/01/81 - 12/31/81	18.3	65.0	73.0
1/01/82 - 1/31/82	18.8	65.8	67.0
2/01/82 - 2/28/82	22.6	72.6	72.8
3/01/82 - 3/31/82	22.7	72.9	75.8
4/01/82 - 4/30/82	24.2	75.6	74.0
5/01/82 - 5/31/82	24.5	76.3	70.9
6/01/82 - 6/30/82	26.8	80.3	80.8
7/01/82 - 7/31/82	28.1	82.5	71.6
8/01/82 - 8/31/82	27.7	81.9	74.8
9/01/82 - 9/30/82	27.2	80.9	75.4
10/01/82 - 10/31/82	26.5	78.0	67.1
11/01/82 - 11/30/82	24.1	75.3	72.8
12/01/82 - 12/31/82	21.4	70.6	71.9
1/01/83 - 1/31/83	17.9	64.3	77.0
2/01/83 - 2/28/83	18.8	66.0	71.8
3/01/83 - 3/31/83	19.3	66.8	69.3
4/01/83 - 4/30/83	22.4	72.4	67.5
5/01/83 - 5/31/83	25.0	77.0	70.3
6/01/83 - 6/30/83	26.9	80.5	81.3
7/01/83 - 7/31/83	28.7	83.8	73.0

TABLE XV. SUMMARY OF COUPON TEST RESULTS

Material	Test	Ply Orientation	Number of Tests	Test Temperature °C	(°F)	Strength MPa	(KSI)	Coefficient of Variation	Exposure
Graphite/	SBS, Static	0_8	23	23.8	(75)	110.3	(16.0)	4.6	Qualification baseline, RTD
	SBS, Static	0_8	3	23.8		110.3	(16.1)	2.1	1½ Years, Gulf Coast, Stabilizer
Epoxy	SBS, Static	0_6	19	23.8		113.1	(16.4)	5.7	Panel Coupons, Baseline RTD
AS/6350	SBS, Static	0_6	18	23.8		100.7	(14.6)	5.0	2 Years, Stratford
	SBS, Static	0_6	18	23.8		96.5	(14.0)	3.4	2 Years, West Palm Beach
	SBS, Static	0_6	19	23.8	(75)	90.9	(13.2)	3.0	2 Years, West Palm Beach
	SBS, Static	0_{14}	18	23.8	(75)	102.0	(14.8)	4.1	2 Years, Stratford
	SBS, Static	0_{14}	13	76.6	(170)	73.8	(10.7)	2.7	2 Years, Stratford
	SBS, Static	$(0_{12}/-20/0/+20/0_{1.5})_S$	17	23.8	(75)	86.9	(12.6)	3.6	Panel Coupon, Baseline RTD
	SBS, Static	$(0_{12}/-20/0/+20/0_{1.5})_S$	15	23.8		83.4	(12.1)	5.3	2 Years, Stratford
	SBS, Static	$(0_{12}/-20/0/+20/0_{1.5})_S$	15	23.8		84.1	(12.2)	5.0	2 Years, West Palm Beach
	SBS, Static	0_6	18	23.8		91.0	(13.2)	3.7	3 Years, Stratford
	SBS, Static	0_6	18	23.8		95.9	(13.9)	2.5	3 Years, Stratford
	SBS, Static	0_6	18	23.8		89.0	(12.9)	3.1	3 Years, West Palm Beach
	SBS, Static	0_6	18	23.8		88.3	(12.8)	3.6	3 Years, West Palm Beach
	SBS, Static	0_{14}	18	23.8	(75)	91.7	(13.3)	7.0	3 Years, Stratford
	SBS, Static	0_{14}	18	76.6	(170)	53.8	(7.8)	4.2	3 Years, Stratford
	SBS, Static	$(0_{12}/-20/0/+20/0_{1.5})_S$	15	23.8	(75)	75.9	(11.0)	4.6	3 Years, Stratford
	SBS, Static	$(0_{12}/-20/0/+20/0_{1.5})_S$	15	23.8	(75)	77.9	(11.3)	2.6	3 Years, West Palm Beach
	Tension,Static	$(0/90)_5$	18	23.8	(75)	631.5	(91.6)	6.0	Panel Coupon, Baseline RTD
Kevlar/		$(0/90)_5$	9	23.8	(75)	666.7	(96.7)	8.7	2 Years, Stratford
Epoxy		$(0/90)_5$	10	23.8	(75)	632.2	(91.7)	6.5	2 Years, West Palm Beach
285/5143		$(0/90)_5$	10	23.8	(170)	677.7	(98.3)	6.6	2 Years, Stratford
		$(0/90)_5$	7	23.8	(75)	667.3	(96.8)	6.5	3 Years, Stratford
		$(0/90)_5$	7	23.8	(75)	646.6	(93.8)	12.9	3 Years, West Palm Beach
		$(0/90)_5$	7	76.6	(170)	592.2	(85.9)	11.7	3 Years, Stratford
		$(0/90)_5$	7	76.6	(170)	588.0	(85.3)	6.6	3 Years, West Palm Beach
	Tension,Static	$(0/90)_6$	14	23.8	(75)	590.2	(85.6)	4.4	Qualification Baseline RTD
	SBS, Fatigue	$(0/90)_6$	5	23.8	(75)	10.3	(1.5)[1]		1½ Yrs, Gulf Coast, Stabilizer

TABLE XV. CONCLUDED

Material	Test	Ply Orientation	Number of Tests	Test Temperature °C	(°F)	Strength MPa	(KSI)	Coefficient of Variation	Exposure
Grahpite/ Epoxy AS/6350	Flex,Static	0_6	20	23.8	(75)	1696.5	(246.0)	5.9	Panel Coupon Baseline RTD
	Flex,Static	0_6	18	23.8	(75)	1782.3	(258.5)	4.4	2 Years, West Palm Beach
	Flex,Static	0_6	15	23.8	(75)	2011.2	(291.7)	5.8	2 Years, West Palm Beach
	Flex,Static	0_6	12	23.8	(75)	1876.7	(272.2)	7.5	2 Years, Stratford
	Flex,Static	0_{14}	18	23.8	(75)	1449.9	(210.3)	5.6	Panel Coupon Baseline RTD
	Flex,Static	0_{14}	18	23.8	(75)	1375.5	(199.5)	3.2	2 Years, Stratford
	Flex,Static	$(0_{12}/-20/0/+20/0_{1.5})_S$	13	23.8	(75)	1209.3	(175.4)	5.5	Panel Coupon Baseline RTD
	Flex,Static	$(0_{12}/-20/0/+20/0_{1.5})_S$	18	23.8	(75)	1260.3	(182.8)	6.7	2 Years, Stratford
	Flex,Static	$(0_{12}/-20/0/+20/0_{1.5})_S$	18	23.8	(75)	1246.6	(180.8)	5.9	2 Years, West Palm Beach
	Flex,Static	0_6	18	23.8	(75)	1625.5	(235.7)	6.7	3 Years, West Palm Beach
	Flex,Static	0_6	18	23.8	(75)	1771.0	(256.8)	3.4	3 Years, West Palm Beach
	Flex,Static	0_6	18	23.8	(75)	1704.1	(247.1)	3.7	3 Years, Stratford
	Flex,Static	0_6	18	23.8	(75)	1660.7	(240.8)	4.2	3 Years, Stratford
	Flex,Static	0_{14}	18	23.8	(75)	1433.1	(207.8)	6.2	3 Years, Stratford
	Flex,Static	0_{14}	18	23.8	(75)	1550.3	(224.8)	8.6	3 Years, Stratford
	Flex,Static	$(0_{12}/-20/0/+20/0_{1.5})_S$	12	23.8	(75)	1185.5	(171.9)	6.4	3 Years, West Palm Beach
	Flex,Static	$(0_{12}/-20/0/+20/0_{1.5})_S$	12	23.8	(75)	1235.2	(179.1)	6.0	3 Years, Stratford
Graphite/ Epoxy AS/6350	SBS,Fatigue	0_8	10	23.8	(75)	64.1	(9.3)[1]		Qualification Baseline RTD
	SBS,Fatigue	0_8	4	23.8	(75)	58.6	(8.5)[1]		2 Years, Stratford
	SBS,Fatigue	0_{14}	10	23.8	(75)	53.8	(7.8)[1]		1½ Yrs, Gulf Coast, Stabilizer
	SBS,Fatigue	$(0_{12}/-20/0/+20/0_{1.5})_S$	9	23.8	(75)	53.4	(7.7)[1]		Panel Coupon Baseline RTD
	SBS,Fatigue	$(0_{12}/-20/0/+20/0_{1.5})_S$	12	23.8	(75)	43.4	(6.3)[1]		2 Years, Stratford
	SBS,Fatigue	$(0_{12}/-20/0/+20/0_{1.5})_S$	10	23.8	(75)	42.1	(6.1)[1]		2 Years, West Palm Beach
	SBS,Fatigue	$(0_{12}/-20/0/+20/0_{1.5})_S$	14	23.8	(75)	50.6	(7.3)[1]		3 Years, West Palm Beach

Note:

1. Maximum stress in cycle, R = 0.1, at 10^7 cycles.

SECTION 8.0 REFERENCES

(1) Rich, M. and Lowry, D. "Flight Service Evaluation of Composite Helicopter Components", First Annual Report March 1981 through April 1982, NASA CR-165952, June 1982.

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15. Supplementary Notes

LANGLEY TECHNICAL MONITOR: DONALD BAKER
FINAL REPORT

16. Abstract

This report presents an assessment of composite helicopter structures, exposed to environmental effects, after four years of commercial service. This assessment is supported by test results of helicopter components and test panels which have been exposed to environmental effects since late 1979. Full scale static and fatigue tests are being conducted on composite components obtained from S-76 helicopters in commercial operations in the Gulf Coast region of Louisiana. Small scale tests are being conducted on coupons obtained from panels being exposed to outdoor conditions in Stratford, Connecticut and West Palm Beach, Florida. The panel layups represent S-76 components. Moisture evaluations and strength tests are being conducted, on the S-76 components and panels, over a period of eight years. Results are discussed for components and panels with up to four years of exposure.

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