NASA CR-178149
(SER-510237)

FLIGHT SERVICE EVALUATION OF COMPOSITE HELICOPTER COMPONENTS

Third Annual Report
OCTOBER 1983 through DECEMBER 1985

George H. Mardoian and Maureen B. Ezzo

SIKORSKY AIRCRAFT
DIVISION OF UNITED TECHNOLOGIES CORPORATION
Stratford, Connecticut 06602

CONTRACT NO. NASI-16542
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National Aeronautics and
Space Administration

Langley Research Center
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FOREWORD

This report was prepared by Sikorsky Aircraft, Division of United Technologies Corporation, Stratford, Connecticut 06602, under NASA Contract NAS1-16542 and covers the work performed during the period of October 1983 through December 1985. This program was jointly funded by the Materials Division of NASA-Langley Research Center and Aerostructures Directorate, U.S. Army Research and Technology Activity (AVSCOM). The contract is monitored by Mr. Donald J. Baker of the Applied Materials Branch.

The authors wish to acknowledge the contributions of the following Sikorsky personnel: W. G. Andrew and J. G. Byerley, component testing, E. Hansen component teardown, R. A. Pearsall, World Wide Customer Service and M. D. Rogers, graphical presentations.

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

by
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SUMMARY

This third annual report presents the environmental effects data for over four years service operation of an S-76 tail rotor spar, two horizontal stabilizers with four and a half and five and a half years of service operation and four and five year data for field exposed composite panels.

One S-76 tail rotor spar was returned with over four years (55 months) of commercial operation in the Louisiana Gulf Coast region. After the paddles were removed and the spar was nondestructively inspected it was cut up for small scale coupon testing. Both horizontal stabilizers passed the proof load and fatigue tests. The static small scale coupon test results compared favorably with those generated for the environmentally exposed panels.

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

1.0 INTRODUCTION

This third annual flight service report is submitted in accordance with the requirements of contract NAS1-16542 and covers the progress made for the period of October 1983 through December 1985. A primary objective of this program is to evaluate the effect of moisture on the mechanical properties of composite materials subjected to long term environmental exposure.

This effort is part of an eight year program to evaluate the effects of environmental exposure on composite helicopter structures. As part of this effort, full scale tests are conducted on composite components removed from Sikorsky S-76 helicopters in commercial service in the Gulf Coast Region of Louisiana. Tail rotor spars and horizontal stabilizers are periodically returned from the operating environment for full scale static, fatigue, and small scale coupon testing. Full scale test results are compared to initial FAA certification data. The amount of moisture absorbed is determined and compared with expected values. Environmental factors calculated from small scale coupon tests are compared with data generated in testing coupons removed from composite panels, having the same ply configurations as the components, exposed to the outdoor environment in two weathering locations.

Work on this contract was initiated in 1981. This is the third report published to document the results of the program. The first annual report, Reference (1), covered the reporting period from March 1981 to April 1982. The second report, Reference (2), documented results from May 1982 to September 1983.

During this reporting period, a horizontal stabilizer having 56 months and 3999 flight hours was returned for fatigue testing. A second horizontal stabilizer having 66 months and 4213 flight hours was returned for static testing. A tail rotor spar with 55 months and 3752 flight hours was returned for small scale testing. Panels having four and five years of environmental exposure were returned from their locations for coupon testing.

Full details of the testing are documented in the sections to follow.

2.0 IN-SERVICE COMPONENT SELECTION

The components selected for in-service evaluation were the tail rotor spar and the horizontal stabilizer. The tail rotor spar is constructed of uni-directional graphite/epoxy (Hercules AS1/Ciba Geigy 6350), ranging in thickness from 14 to 33 plies. The geometry is illustrated in Figure 1. The horizontal stabilizer is constructed of ±45° Kevlar/epoxy (285/American Cyanamid 5143) over Nomex honeycomb core with a torque box section fabricated of ±45° Kevlar/epoxy, aluminum honeycomb core and graphite/epoxy cap strip reinforcements. A schematic diagram of the stabilizer is shown in Figure 2.

Tail rotor spars and stabilizers are returned from the field for full scale static, full scale fatigue or small scale testing in accordance with the schedule detailed in Table I. A total of ten tail rotor spars and four stabilizers will be returned from the field for evaluation as required for this program.

The tail rotor spars and stabilizers to be evaluated are removed from S-76 aircraft owned and operated by Air Logistics in the Gulf Coast region of Louisiana. Every three months, the Air Logistics' aircraft logs are inspected to verify that each part being tracked is still installed on an operating aircraft. In addition to the components being tracked for testing, extra spars and stabilizers are tracked as spares, for use in the event that one of the components scheduled for testing becomes unavailable. The number of flight hours and months of in-service environmental exposure are recorded for each part and spare. An updated list of the tail rotor spars and horizontal stabilizers being tracked is presented in Table II.

During this reporting period, inspection of the aircraft logs revealed a tail rotor spar being tracked as a spare was no longer available for testing. The aircraft that tail rotor spar S/N A-116-00438 was installed on was sold by Air Logistics. Owing to the fact that two other tail rotor spars are available as spares, the spar will not be replaced.

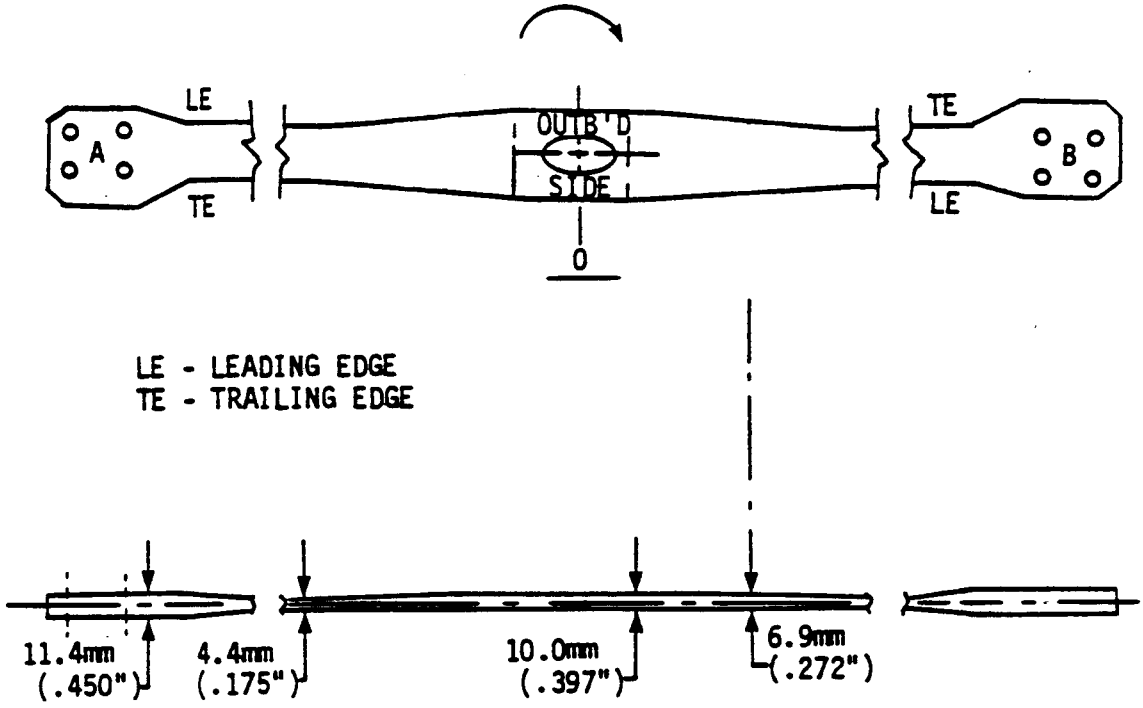
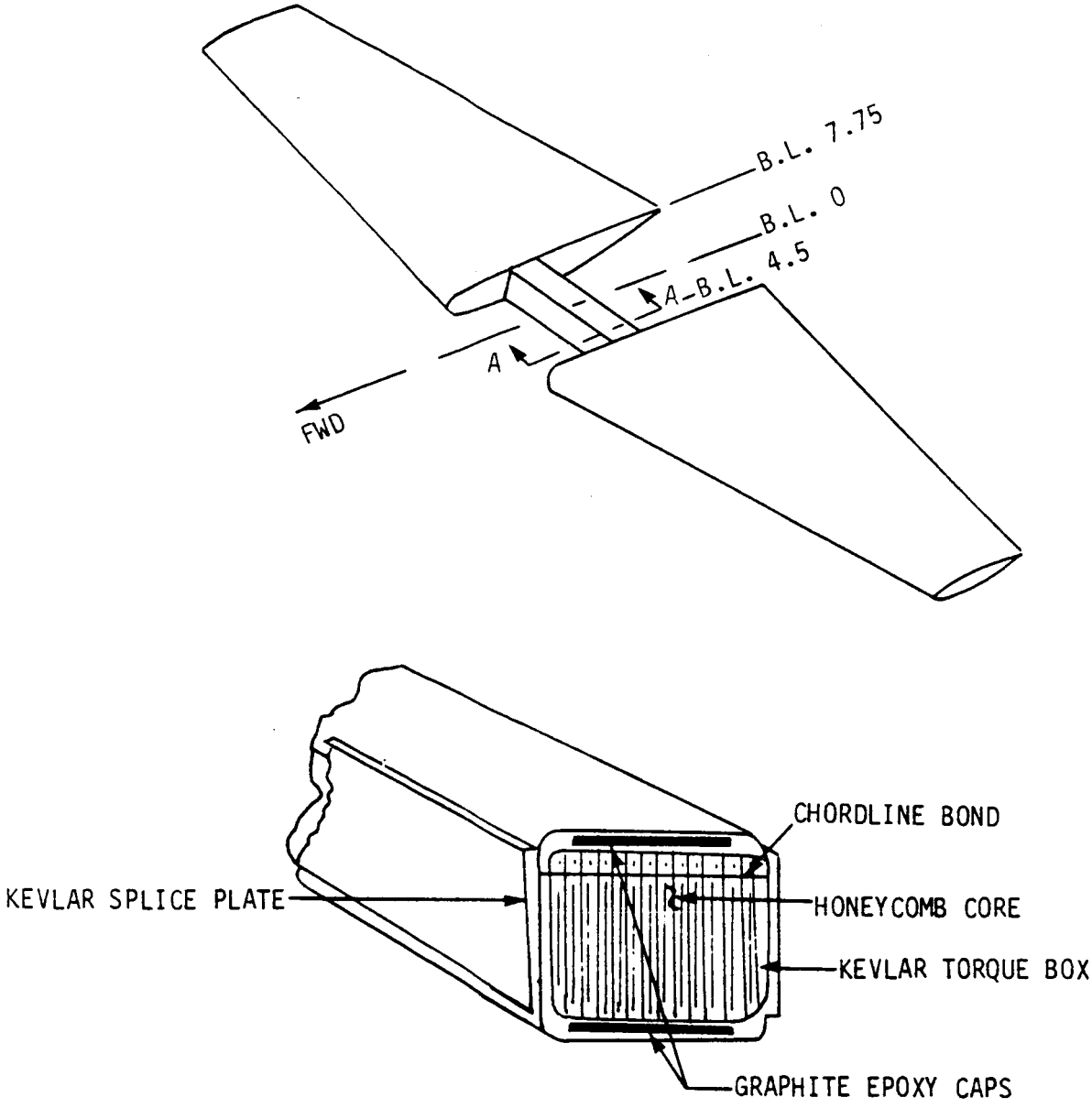


FIGURE 1. S-76 TAIL ROTOR SPAR



STABILIZER TORQUE BOX AT SECTION A-A

FIGURE 2. SCHEMATIC REPRESENTATION OF STABILIZER

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

S-76 HELICOPTER
NASA CONTRACT NAS1-16542

	CALENDAR YEAR							
	81	82	83	84	85	86	87	88
In-Service Component Selection								
Tracking	X	X	X	X	X	X	X	X
Selection:								
Horizontal Stabilizer	X		X		X		X	
Tail Rotor Spar	X	X	X	X	X	X	X	X
Tests of In-Service Components								
Horizontal Stabilizers:								
Fatigue Tests, Full Scale			X				X	
Static Tests, Full Scale	X		X		X		X	
Tail Rotor Spars:								
Fatigue Tests, Full Scale	X	X	X	X		X		X
Coupon Tests, Small Scale		XX		X		X		
Material Evaluation	X	X	X	X	X	X	X	X
Analysis of Test Results	X	X	X	X	X	X	X	X

FOLDOUT FRAME

Table II. S-76 Components Available for Testing - Contract NAS1-16542

COMPONENT/SERIAL NO.	S/N OF AIRCRAFT CURRENTLY INSTALLED ON	FLIGHT HOURS AS OF DECEMBER 4, 1985	OPERATOR/LOCATION	FIELD EXPOSED TIME SINCE DELIVERY TO OPERATOR	REMARKS
Tail Rotor Paddle/Spar Paddle S/N-137-00031 Spar S/N-116-00114	--	3358 Removed May 1983	Air Logistics Lake Charles, LA	52 months	Tested mid 1983, full scale fatigue
-00034 -00094	--	2390 Removed Sept. 1981	Air Logistics Lake Charles, LA	29 months	Tested late 1981
-00067 -00178	--	3753 Removed June 1984	Air Logistics Lake Charles, LA	51 months	Tested mid 1984 coupon tests
-00068 -00237	--	2128 Removed Aug 1982	Air Logistics Lake Charles, LA	42 months	Tested 1983
-00085 -00150	--	2385 Removed May 1982	Air Logistics Lake Charles, LA	38 months	Tested 1983
-00099 -00283	--	1884 Removed Nov 1982	Air Logistics Lake Charles, LA	38 months	Tested 1983
-00107 -00069	760002	4638	Air Logistics Lake Charles, LA	Spare	Hold as a spare
-00151 -00411	760267	4813	Air Logistics Lake Charles, LA	63 months	Test mid 1986
-00152 -00415	760031	4819	Air Logistics Lake Charles, LA	62 months	Test mid 1986
-00231 -00493	760048	4094	Air Logistics Lake Charles, LA	60 months	Test mid 1987
-00232 -00502	760088	4991	Air Logistics Lake Charles, LA	Spare 60 months	Test mid 1988
Horizontal Stabilizer					
S/N-B-157-00009	--	3999	Air Logistics	56 months	Tested mid 1984
S/N-B-157-00010	760031	5951	Air Logistics	77 months	Hold as spare
S/N-B-157-00021	--	4051	Air Logistics	66 months	Tested late 1985
S/N-B-157-00027	760027	5099	Air Logistics	68 months	Hold as spare
S/N-B-157-00030	760030	5198	Air Logistics	68 months	Test mid 1987
S/N-B-157-00076	--	1600	Air Logistics	19 months	Tested late 1981

FOLDOUT FRAME 2

3.0 TESTS OF IN-SERVICE COMPONENTS

3.1 Horizontal Stabilizers

3.1.1 S/N B-157-00009

Horizontal stabilizer S/N B-157-00009 was returned from the field after 56 months of service. The stabilizer had accumulated 3999 flight hours. Table III details the environmental history of the stabilizer. Prior to full scale testing, the stabilizer was proof load tested in accordance with the same procedure required for production acceptance. A 2400 pound load was applied at Buttline 0, and the corresponding deflection measured. A deflection of 0.150 inches was recorded for stabilizer S/N B-157-00009. The production acceptance criteria is a maximum deflection of 4.14 mm (.163 in), indicating no loss of stiffness in the stabilizer after exposure.

The stabilizer was the loaded in fatigue in accordance with the values detailed in Figure 3. Loads were applied to the right and left ends of the stabilizer out of phase, so that shear forces were developed in the center torque box area of the stabilizer. Roll and yaw moments generated were ± 48000 in-lbs and ± 22700 in-lbs, respectively. When no fracture occurred after 5 X 10^5 cycles, the test was considered a runout. Loads were increased by 5 percent, producing a roll moment of ± 50240 in-lbs and a yaw moment of ± 23800 in-lbs. At 3 X 10^5 cycles, the test was stopped since a fracture in the torque box was noted.

Coupons were removed from Buttlines 4-9 of the failed stabilizer for desorption. The moisture desorbed from graphite/epoxy coupons between Buttlines 4 and 9 was 0.42 percent. Desorption data is contained in Tables IV and V. A typical desorption plot is shown in Figure 4.

TABLE III

STABILIZER S/N B-157-00009

SUMMARY OF ENVIRONMENTAL HISTORY

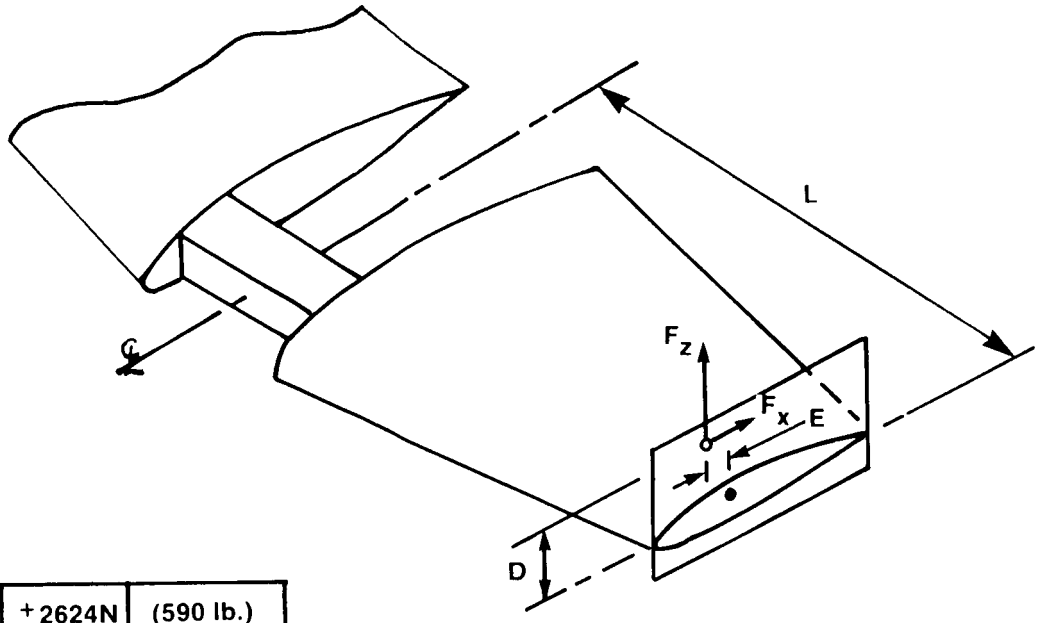
DATE	AVERAGE TEMPERATURE (°C)	(°F)	AVERAGE RELATIVE HUMIDITY (%)
1/10/79 - 1/31/79	6.4	43.6	72.6
2/01/79 - 2/28/79	9.8	49.7	82.1
3/01/79 - 3/31/79	15.9	60.7	74.5
4/01/79 - 4/30/79	20.1	68.1	80.5
5/01/79 - 5/31/79	22.4	72.3	78.6
6/01/79 - 6/30/79	26.1	78.9	78.4
7/01/79 - 7/31/79	26.8	80.3	85.4
8/01/79 - 8/31/79	26.7	80.0	83.8
9/01/79 - 9/30/79	23.7	74.7	80.3
10/01/79 - 10/31/79	20.5	68.9	79.0
11/01/79 - 11/30/79	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	23.8	74.8	83.9
6/01/80 - 6/30/80	27.1	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 - 10/31/80	18.0	64.4	69.8
11/01/80 - 11/30/80	12.7	54.8	78.0
12/01/80 - 12/31/80	10.7	51.3	75.0
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	22.6	72.6	73.3
6/01/81 - 6/30/81	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	20.1	68.1	79.1
11/01/81 - 11/30/81	16.1	60.9	80.9
12/01/81 - 12/31/81	11.4	52.5	73.4

TABLE III (Continued)

STABILIZER S/N B-157-00009

SUMMARY OF ENVIRONMENTAL HISTORY

DATE	AVERAGE TEMPERATURE (°C)	(°F)	AVERAGE RELATIVE HUMIDITY (%)
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 - 10/31/82	20.2	68.3	70.9
11/01/82 - 11/30/82	16.4	61.5	74.3
12/01/82 - 12/31/82	13.9	57.0	81.1
1/01/83 - 1/31/83	9.5	49.1	81.1
2/01/83 - 2/28/83	11.3	52.4	77.3
3/01/83 - 3/31/83	14.2	57.6	73.5
4/01/83 - 4/30/83	17.5	63.5	73.4
5/01/83 - 5/31/83	23.0	73.4	77.1
6/01/83 - 6/30/83	25.6	78.0	81.3
7/01/83 - 7/31/83	28.2	82.8	78.1
8/01/83 - 8/31/83	27.8	82.1	81.4



F_z	±2624N	(590 lb.)
F_x	±1214 N	(273 lb.)
D	193 mm	(7.6 in.)
E	112 mm	(4.4 in.)
L	1016mm	(4 0 in.)

FIGURE 3
S-76 STABILIZER LOCATION AND
MAGNITUDE OF FATIGUE TEST LOADS

TABLE IV MOISTURE DESORPTION OF HORIZONTAL STABILIZER
S/N B-157-00009, BUTTLINES 6-7

DATE OF WEIGHING	DAYS	SQRT OF TIME	% MOIST DESORBED COUP 67B	% MOIST DESORBED COUP 67T	WEIGHT OF COUP 67B	WEIGHT OF COUP 67T	AVERAGE % MOIST DESORBED
3/12/84	0	0	0	0	10.2752	9.9427	0
3/14/84	2	1.41	-0.11	-0.09	10.2644	9.9335	-0.10
3/16/84	4	2.00	-0.16	-0.11	10.2592	9.9315	-0.13
3/19/84	7	2.65	-0.17	-0.15	10.2573	9.9277	-0.16
3/21/84	9	3.00	-0.17	-0.15	10.258	9.9278	-0.16
3/23/84	11	3.32	-0.19	-0.19	10.2557	9.9241	-0.19
3/28/84	16	4.00	-0.25	-0.22	10.2496	9.9213	-0.23
3/30/84	18	4.24	-0.23	-0.19	10.2515	9.9234	-0.21
4/2/84	21	4.58	-0.24	-0.20	10.2503	9.9225	-0.22
4/4/84	23	4.80	-0.26	-0.22	10.2482	9.9206	-0.24
4/6/84	25	5.00	-0.27	-0.22	10.2479	9.9206	-0.24
4/9/84	28	5.29	-0.27	-0.23	10.2478	9.9195	-0.25
4/11/84	30	5.48	-0.30	-0.26	10.2443	9.9166	-0.28
4/13/84	32	5.66	-0.28	-0.24	10.2464	9.9193	-0.26
4/16/84	35	5.92	-0.29	-0.24	10.2458	9.9192	-0.26
4/23/84	42	6.48	-0.31	-0.27	10.243	9.9163	-0.29
4/27/84	46	6.78	-0.31	-0.27	10.2436	9.916	-0.29
4/30/84	49	7.00	-0.32	-0.27	10.2422	9.9158	-0.30
5/4/84	53	7.28	-0.32	-0.27	10.2428	9.9156	-0.29
5/7/84	56	7.48	-0.31	-0.27	10.2433	9.9154	-0.29
5/11/84	60	7.75	-0.34	-0.30	10.2403	9.9129	-0.32
5/14/84	63	7.94	-0.34	-0.30	10.2402	9.9126	-0.32
5/21/84	70	8.27	-0.34	-0.30	10.2398	9.913	-0.32
5/25/84	74	8.60	-0.34	-0.28	10.2403	9.9145	-0.31
6/18/84	98	9.90	-0.32	-0.28	10.2419	9.9153	-0.30
6/22/84	102	10.10	-0.33	-0.28	10.2409	9.9147	-0.31
6/26/84	106	10.30	-0.33	-0.28	10.2418	9.915	-0.30
6/28/84	108	10.39	-0.36	-0.31	10.2382	9.9121	-0.33
7/2/84	112	10.58	-0.37	-0.32	10.2374	9.9107	-0.34
7/9/84	119	10.91	-0.36	-0.31	10.2381	9.9118	-0.34
7/13/84	123	11.09	-0.36	-0.31	10.238	9.9116	-0.34
7/16/84	126	11.22	-0.36	-0.31	10.2381	9.9116	-0.34
7/18/84	128	11.31	-0.36	-0.31	10.2384	9.9114	-0.34
7/20/84	130	11.40	-0.37	-0.33	10.2372	9.9102	-0.35
7/23/84	133	11.53	-0.35	-0.31	10.2392	9.9121	-0.33
7/27/84	137	11.70	-0.36	-0.31	10.2384	9.9119	-0.33
7/30/84	140	11.83	-0.33	-0.28	10.2413	9.9148	-0.31
8/3/84	144	12.00	-0.35	-0.31	10.2388	9.9114	-0.33
8/6/84	147	12.12	-0.35	-0.31	10.2392	9.9118	-0.33
8/10/84	151	12.29	-0.36	-0.32	10.2386	9.9111	-0.34
8/13/84	154	12.41	-0.33	-0.29	10.2408	9.9138	-0.31
8/17/84	158	12.57	-0.36	-0.32	10.2382	9.9112	-0.34
8/20/84	161	12.69	-0.35	-0.30	10.2388	9.9127	-0.33

TABLE IV (cont'd) MOISTURE DESORPTION OF HORIZONTAL STABILIZER
S/N B-157-00009, BUTTLINES 6-7

DATE OF WEIGHING	DAYS	SQRT OF TIME	% MOIST DESORBED COUP 67B	% MOIST DESORBED COUP 67T	WEIGHT OF COUP 67B	WEIGHT OF COUP 67T	AVERAGE % MOIST DESORBED
8/24/84	165	12.85	-0.37	-0.33	10.2376	9.9103	-0.35
8/27/84	168	12.96	-0.36	-0.30	10.2387	9.9128	-0.33
8/31/84	172	13.11	-0.34	-0.30	10.2407	9.9127	-0.32
9/7/84	179	13.38	-0.37	-0.32	10.2374	9.9113	-0.34
9/10/84	182	13.49	-0.36	-0.31	10.2381	9.9114	-0.34
9/14/84	186	13.64	-0.35	-0.30	10.2396	9.9133	-0.32
9/17/84	189	13.75	-0.38	-0.32	10.2361	9.9109	-0.35
9/21/84	193	13.89	-0.38	-0.32	10.2359	9.9107	-0.35
9/24/84	196	14.00	-0.36	-0.30	10.2384	9.9131	-0.33
9/28/84	200	14.14	-0.37	-0.33	10.2373	9.9102	-0.35
10/1/84	203	14.25	-0.38	-0.32	10.2363	9.9106	-0.35
10/5/84	207	14.39	-0.38	-0.32	10.2366	9.9111	-0.35
10/8/84	210	14.49	-0.39	-0.33	10.2355	9.9096	-0.36
10/12/84	214	14.63	-0.40	-0.34	10.2346	9.9085	-0.37
10/15/84	217	14.73	-0.30	-0.34	10.2343	9.9084	-0.37
10/19/84	221	14.87	-0.39	-0.34	10.2348	9.9091	-0.37
10/22/84	224	14.97	-0.38	-0.33	10.2362	9.9095	-0.36
10/26/84	228	15.10	-0.37	-0.32	10.2372	9.9106	-0.35
10/29/84	231	15.20	-0.37	-0.32	10.2375	9.9106	-0.34
11/5/84	238	15.43	-0.37	-0.31	10.2374	9.9119	-0.34
11/9/84	242	15.56	-0.37	-0.32	10.237	9.9106	-0.35
11/12/84	245	15.65	-0.36	-0.31	10.2381	9.9119	-0.34
11/16/84	249	15.78	-0.37	-0.31	10.2371	9.9114	-0.34
11/19/84	252	15.87	-0.39	-0.33	10.2351	9.9096	-0.36
11/26/84	259	16.09	-0.39	-0.33	10.2354	9.9098	-0.36
11/30/84	263	16.22	-0.39	-0.33	10.2352	9.9095	-0.36
12/7/84	270	16.43	-0.41	-0.37	10.2326	9.9062	-0.39
12/10/84	273	16.52	0.41	-0.36	10.2335	9.9074	-0.38
12/14/84	277	16.64	-0.41	-0.34	10.2335	9.9084	-0.38
12/17/84	280	16.73	-0.40	-0.34	10.2337	9.9086	-0.37
1/4/85	298	17.26	-0.42	-0.36	10.232	9.9065	-0.39
1/7/85	301	17.35	-0.43	-0.38	10.2306	9.9053	-0.41
1/11/85	305	17.46	-0.43	-0.37	10.231	9.9057	-0.40
1/18/85	312	17.66	-0.43	-0.37	10.2307	9.9056	-0.40
1/21/85	315	17.75	-0.44	-0.39	10.2303	9.9036	-0.42
1/25/85	319	17.86	-0.44	-0.38	10.2295	9.9049	-0.41
1/28/85	322	17.94	-0.44	-0.39	10.2299	9.9044	-0.41
2/1/85	326	18.06	-0.42	-0.37	10.2318	9.9056	-0.40
2/4/85	329	18.14	-0.44	-0.39	10.2296	9.9044	-0.41
2/8/85	333	18.25	-0.44	-0.39	10.2299	9.9041	-0.41
2/11/85	336	18.33	-0.46	-0.40	10.228	9.9033	-0.43
2/15/85	340	18.44	-0.46	-0.40	10.2279	9.9029	-0.43

TABLE IV (cont'd) MOISTURE DESORPTION OF HORIZONTAL STABILIZER
S/N B-157-00009, BUTTLINES 6-7

DATE OF WEIGHING	DAYS	SQRT OF TIME	% MOIST DESORBED COUP 67B	% MOIST DESORBED COUP 67T	WEIGHT OF COUP 67B	WEIGHT OF COUP 67T	AVERAGE % MOIST DESORBED
2/18/85	343	18.52	-0.47	-0.41	10.2271	9.9018	-0.44
2/22/85	347	18.63	-0.46	-0.40	10.2279	9.903	-0.43
2/25/85	350	18.71	-0.46	-0.41	10.2278	9.9023	-0.43
3/1/85	354	18.81	-0.45	-0.39	10.2293	9.9037	-0.42
3/4/85	357	18.89	-0.46	-0.41	10.2277	9.9037	-0.42
3/8/85	260	18.97	-0.45	-0.40	10.2288	9.9028	-0.43
3/11/85	363	19.05	-0.47	-0.43	10.2269	9.9002	-0.45
3/15/85	367	19.16	-0.45	-0.40	10.2285	9.9026	-0.43
3/18/85	370	19.24	-0.47	-0.41	10.2274	9.9022	-0.44
3/22/85	374	19.34	-0.47	-0.40	10.227	9.9028	-0.44
3/25/85	377	19.42	-0.46	-0.41	10.2278	9.9018	-0.44
3/29/85	381	19.52	-0.43	-0.38	10.2312	9.9051	-0.40
4/1/85	384	19.60	-0.45	-0.39	10.2289	9.9036	-0.42
4/8/85	391	19.77	-0.44	-0.39	10.23	9.9044	-0.41
4/12/85	395	19.87	-0.46	-0.40	10.2284	9.9028	-0.43
4/15/85	398	19.95	-0.45	-0.41	10.2289	9.9018	-0.43
4/19/85	402	20.05	-0.45	-0.41	10.2291	9.9021	-0.43
4/22/85	405	20.12	-0.43	-0.38	10.2308	9.9054	-0.40
4/26/85	409	20.22	-0.45	-0.40	10.2287	9.903	-0.43
4/29/85	412	20.30	-0.44	-0.38	10.2297	9.9045	-0.41
5/3/85	416	20.40	-0.44	-0.39	10.2304	9.9039	-0.41
5/6/85	419	20.47	-0.44	-0.39	10.23	9.9039	-0.42
5/10/85	423	20.57	-0.44	-0.39	10.2299	9.9042	-0.41
5/13/85	426	20.64	-0.44	-0.40	10.2295	9.9031	-0.42
5/17/85	430	20.74	-0.44	-0.39	10.23	9.9039	-0.42
5/20/85	433	20.81	-0.38	-0.34	10.236	9.9088	-0.36
5/24/85	437	20.90	-0.40	-0.36	10.2341	9.9069	-0.38
5/31/85	444	21.07	-0.42	-0.37	10.2321	9.9064	-0.39
6/3/85	447	21.14	-0.43	-0.38	10.2313	9.905	-0.40
6/17/85	461	21.47	-0.41	-0.36	10.233	9.9072	-0.38

TABLE V MOISTURE DESORPTION OF HORIZONTAL STABILIZER
S/N B-157-00009, BUTTLINES 8-9

DATE OF WEIGHING	DAYS	SQRT OF TIME	% MOIST DESORBED COUP 89B	% MOIST DESORBED COUP 89T	WEIGHT OF COUP 89B	WEIGHT OF COUP 89T	AVERAGE % MOIST DESORBED
3/12/84	0	0	0	0	12.5117	8.0043	0
3/14/84	2	1.41	-0.11	-0.09	12.4978	7.9971	-0.10
3/16/84	4	2.00	-0.15	-0.12	12.4933	7.9943	-0.14
3/19/84	7	2.65	-0.19	-0.20	12.4883	7.9886	-0.19
3/21/84	9	3.00	-0.17	-0.14	12.4907	7.9927	-0.16
3/23/84	11	3.32	-0.20	-0.18	12.4863	7.99	-0.19
3/28/84	16	4.00	-0.25	-0.20	12.4801	7.988	-0.23
3/30/84	18	4.24	-0.24	-0.20	12.4818	7.988	-0.22
4/2/84	21	4.58	-0.24	-0.21	12.4816	7.9874	-0.23
4/4/84	23	4.80	-0.26	-0.23	12.4795	7.9862	-0.24
4/6/84	25	5.00	-0.25	-0.23	12.4798	7.9862	-0.24
4/9/84	28	5.29	-0.30	-0.24	12.4746	7.9853	-0.27
4/11/84	30	5.48	-0.30	-0.28	12.4745	7.9815	-0.29
4/13/84	32	5.66	-0.28	-0.25	12.4767	7.9845	-0.26
4/16/84	35	5.92	-0.29	-0.26	12.4759	7.9831	-0.28
4/23/84	42	6.48	-0.31	-0.27	12.4725	9.9827	-0.29
4/27/84	46	6.78	-0.31	-0.28	12.4732	7.9815	-0.30
4/30/84	49	7.00	-0.32	-0.29	12.4719	7.981	-0.30
5/4/84	53	7.28	-0.32	-0.29	12.4715	7.9813	-0.30
5/7/84	56	7.48	-0.31	-0.30	12.4723	7.9804	-0.31
5/11/84	60	7.75	-0.35	-0.32	12.4678	7.9788	-0.33
5/14/84	63	7.94	-0.33	-0.33	12.4701	7.9778	-0.33
5/21/84	70	8.37	-0.35	-0.34	12.4682	7.9768	-0.35
5/25/84	74	8.60	-0.33	-0.30	12.471	7.98	-0.31
6/18/84	98	9.90	-0.32	-0.30	12.4713	7.9806	-0.31
6/22/84	102	10.10	-0.33	-0.31	12.4704	7.9896	-0.32
6/26/84	106	10.30	-0.33	-0.30	12.4707	7.98	-0.32
6/28/84	108	10.39	-0.36	-0.32	12.4669	7.9783	-0.34
7/2/84	112	10.58	-0.37	-0.33	12.466	7.9779	-0.35
7/9/84	119	10.91	-0.36	-0.32	12.4669	7.9785	-0.34
7/13/84	123	11.09	-0.37	-0.34	12.4654	7.9771	-0.35
7/16/84	126	11.22	-0.36	-0.33	12.4665	7.9776	-0.35
7/18/84	128	11.31	-0.36	-0.33	12.4672	7.9776	-0.34
7/20/84	130	11.40	-0.36	-0.34	12.4664	7.9772	-0.35
7/23/84	133	11.53	-0.35	-0.33	12.4678	7.9778	-0.34
7/27/84	137	11.70	-0.35	-0.33	12.4676	7.9775	-0.34
7/30/84	140	11.83	-0.33	-0.32	12.4705	7.9787	-0.32
8/3/84	144	12.00	-0.35	-0.33	12.4676	7.9779	-0.34
8/6/84	147	12.12	-0.35	-0.33	12.4678	7.9782	-0.34
8/10/84	151	12.29	-0.35	-0.33	12.4683	7.9782	-0.34
8/13/84	154	12.41	-0.34	-0.31	12.4696	7.9793	-0.32
8/17/84	158	12.57	-0.36	-0.35	12.4666	7.9761	-0.36

TABLE V MOISTURE DESORPTION OF HORIZONTAL STABILIZER
S/N B-157-00009, BUTTLINES 8-9

DATE OF WEIGHING	DAYS	SQRT OF TIME	% MOIST DESORBED COUP 89B	% MOIST DESORBED COUP 89T	WEIGHT OF COUP 89B	WEIGHT OF COUP 89T	AVERAGE % MOIST DESORBED
8/20/84	161	12.69	-0.36	-0.33	12.4663	7.9775	-0.35
8/24/84	165	12.85	-0.36	-0.35	12.4669	7.9762	-0.35
8/27/84	168	12.96	-0.35	-0.33	12.4681	7.9778	-0.34
8/31/84	172	13.11	-0.36	-0.23	12.4671	7.9774	-0.35
9/7/84	179	13.38	-0.38	-0.35	12.4643	7.976	-0.37
9/10/84	182	13.49	-0.36	-0.35	12.4661	7.976	-0.36
9/14/84	186	13.64	-0.35	-0.33	12.4679	7.9778	-0.34
9/17/84	189	13.75	-0.38	-0.37	12.4642	7.9748	-0.37
9/21/84	193	13.89	-0.38	-0.37	12.4638	7.9739	-0.38
9/24/84	196	14.00	-0.36	-0.34	12.4667	7.9773	-0.35
9/28/84	200	14.14	-0.38	-0.36	12.464	7.9752	-0.37
10/1/84	203	14.25	-0.38	-0.36	12.4636	7.9751	-0.37
10/5/84	207	14.39	-0.38	-0.36	12.4639	7.9752	-0.37
10/8/84	210	14.49	-0.39	-0.37	12.4631	7.975	-0.38
10/12/84	214	14.63	-0.39	-0.39	12.4624	7.9732	-0.39
10/15/84	217	14.73	-0.30	-0.38	12.4618	7.974	-0.39
10/19/84	221	14.87	-0.39	-0.38	12.4629	7.9738	-0.39
10/22/84	224	14.97	-0.38	-0.38	12.4637	7.9738	-0.38
10/26/84	228	15.10	-0.37	-0.36	12.4654	7.9756	-0.36
10/29/84	231	15.20	-0.37	-0.36	12.4659	7.9754	-0.36
11/5/84	238	15.43	-0.37	-0.35	12.4654	7.9766	-0.36
11/9/84	242	15.56	-0.38	-0.36	12.4638	7.9751	-0.37
11/12/84	245	15.65	-0.36	-0.33	12.467	7.9775	-0.35
11/16/84	249	15.78	-0.38	-0.36	12.4643	7.9755	-0.37
11/19/84	252	15.87	-0.30	-0.38	12.4617	7.9737	-0.39
11/26/84	259	16.09	-0.39	-0.36	12.4629	7.9755	-0.37
11/30/84	263	16.22	-0.30	-0.37	12.4621	7.9745	-0.38
12/7/84	270	16.43	-0.42	-0.40	12.4591	7.9721	-0.41
12/10/84	273	16.52	-0.41	-0.40	12.4605	7.9722	-0.41
12/14/84	277	16.64	-0.40	-0.39	12.4618	7.973	-0.39
12/17/84	280	16.73	-0.39	-0.38	12.4623	7.9736	-0.39
1/4/85	298	17.26	-0.43	-0.41	12.5483	7.9712	-0.42
1/7/85	301	17.35	-0.43	-0.42	12.4581	7.9706	-0.42
1/11/85	305	17.46	-0.44	-0.39	12.4565	7.9728	-0.42
1/18/85	312	17.66	-0.45	-0.43	12.4552	7.9702	-0.44
1/21/85	315	17.75	-0.46	-0.42	12.4542	7.9706	-0.44
1/25/85	319	17.86	-0.43	-0.43	12.5673	7.9699	-0.43
1/28/85	322	17.94	-0.44	-0.41	12.4567	7.9715	-0.42
2/1/85	236	18.06	-0.43	-0.41	12.4574	7.9717	-0.42
2/4/85	239	18.14	-0.45	-0.41	12.4555	7.9711	-0.43
2/8/85	333	18.25	-0.44	-0.43	12.457	7.9696	-0.44
2/11/85	336	18.33	-0.45	-0.43	12.4551	7.9696	-0.44
2/15/85	340	18.44	-0.47	-0.43	12.4535	7.9702	-0.45

TABLE V MOISTURE DESORPTION OF HORIZONTAL STABILIZER
S/N B-157-00009, BUTTLINES 8-9

DATE OF WEIGHING	DAYS	SQRT OF TIME	% MOIST DESORBED COUP 89B	% MOIST DESORBED COUP 89T	WEIGHT OF COUP 89B	WEIGHT OF COUP 89T	AVERAGE % MOIST DESORBED
2/18/85	343	18.52	-0.47	-0.45	12.4527	7.9683	-0.46
2/22/85	347	18.63	-0.46	-0.44	12.4543	7.9691	-0.45
2/25/85	350	18.71	-0.46	-0.43	12.4537	7.9701	-0.45
3/1/85	354	18.81	-0.45	-0.42	12.4554	7.971	-0.43
3/4/85	357	18.89	-0.47	-0.45	12.4529	7.9685	-0.46
3/8/85	360	18.97	-0.45	-0.43	12.455	7.97	-0.44
3/11/85	363	19.05	-0.48	-0.47	12.4519	7.967	-0.47
3/15/85	267	19.16	-0.45	-0.42	12.4554	7.9704	-0.44
3/18/85	270	19.24	-0.46	-0.45	12.4544	7.9679	-0.46
3/22/85	374	19.34	-0.46	-0.46	12.4537	7.9678	-0.46
3/25/85	377	19.42	-0.46	-0.44	12.4538	7.9694	-0.45
3/29/85	381	19.52	-0.42	-0.40	12.4587	7.89722	-0.41
4/1/85	384	19.60	-0.45	-0.42	12.4557	7.9708	-0.43
4/8/85	391	19.77	-0.47	-0.42	12.4533	7.9705	-0.44
4/12/85	395	19.87	-0.46	-0.43	12.4546	7.9699	-0.44
4/15/85	398	19.95	-0.46	-0.42	12.4544	7.9706	-0.44
4/19/85	402	20.05	-0.46	-0.43	12.4537	7.9701	-0.45
4/22/85	405	20.12	-0.43	-0.41	12.4577	7.9712	-0.42
4/26/85	409	20.22	-0.45	-0.44	12.4553	7.9693	-0.44
4/29/85	412	20.30	-0.44	-0.42	12.4572	7.9705	-0.43
5/3/85	416	20.40	-0.43	-0.41	12.4573	7.9717	-0.42
5/6/85	419	20.47	-0.44	-0.41	12.4571	7.9715	-0.42
5/10/85	423	20.57	-0.44	-0.42	12.4563	7.9808	-0.43
5/13/85	426	20.64	-0.43	-0.42	12.4583	7.9708	-0.42
5/17/85	430	20.74	-0.42	-0.41	12.4587	7.9715	-0.42
5/20/85	433	20.81	-0.39	-0.37	12.4624	7.9743	-0.38
5/24/85	437	20.90	-0.42	-0.39	12.4594	7.9732	-0.40
5/31/85	444	21.07	-0.42	-0.40	12.4597	7.9723	-0.41
6/3/85	447	21.14	-0.43	-0.41	12.4583	7.9713	-0.42
6/17/85	461	21.47	-0.43	-0.39	12.4584	7.9729	-0.41

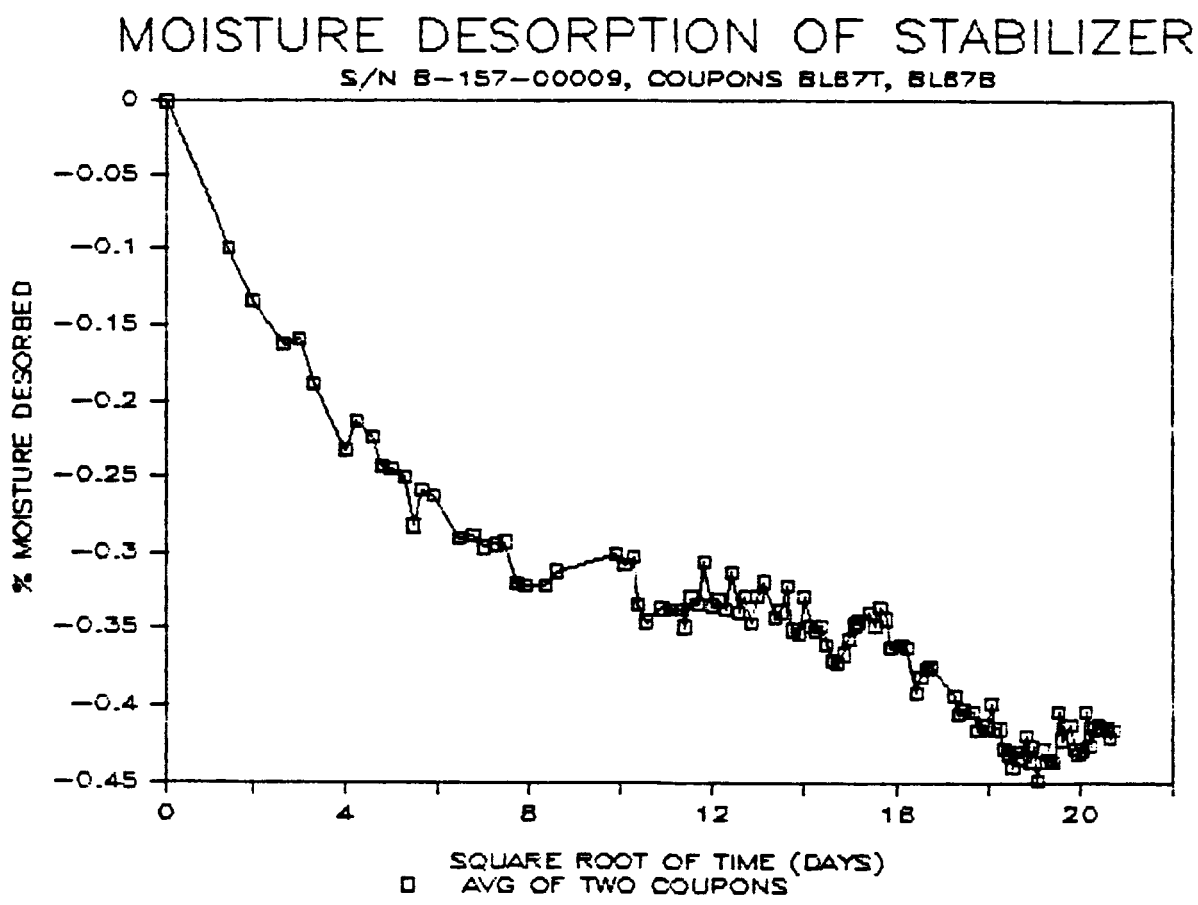


FIGURE 4
MOISTURE DESORPTION OF STABILIZER S/N B-157-00009
COUPONS BL67T, BL67B

3.1.2 S/N B-157-00021

Horizontal stabilizer S/N B-157-00021 was returned from the field for full scale static and small scale coupon testing. After 66 months of in-service environmental exposure, the stabilizer had accumulated 4213 flight hours. The environmental history of the stabilizer is detailed in Table VI.

The horizontal stabilizer was proof load deflection tested in accordance with the aforementioned procedure required for production acceptance. An acceptable deflection of 3.86 mm (.150 in), indicating no loss of stiffness after 66 months in service, was noted.

Visual inspection and coin tapping revealed two small areas of disbond in the torque box section. One disbond measured approximately 3/4 inch high by 1-1/2 inch wide and was located at left Buttline 3. The other disbond measured approximately 1 inch high by 3 inches wide, located at right Buttline 3. Damage was thought to have been sustained during removal of the stabilizer from the aircraft.

Although the stabilizer was scheduled for full scale static testing, concern over the disbond prompted S-76B engineers to verbally request permission from NASA representatives to test the stabilizer in fatigue. With the approval of the NASA technical monitor, the stabilizer was first static tested to the design limit load, then tested in fatigue.

The stabilizer was statically loaded as detailed in Figure 5. As the design limit load is asymmetrical, the loads shown in Figure 5 are designated L for left side and R for right side of the stabilizer. To allow for direct comparison with the baseline, the static test was conducted at 160°F.

When no fracture occurred, the stabilizer was to be fatigue tested with the loads detailed in Figure 3. Owing to an error in loading, the fatigue loads applied were 23 percent higher than the baseline loads of Figure 3. During fatigue testing, the stabilizer disbonded from the test fixture. Proof load deflection tests were run to insure that fracture did not occur in the stabilizer as well. The stabilizer was then rebonded into the test fixture, and the test continued. Testing was stopped at 59,980 cycles, when test engineers visually observed a fracture in the torque box. While a complete teardown analysis is in progress, preliminary results indicate that the fractured area was located between Buttline 3L and Buttline 3R, as anticipated.

Six graphite/epoxy coupons were removed from the failed stabilizer at Buttlines 4-9, for moisture desorption. Two Kevlar/epoxy coupons were also removed from Buttlines 4-5. Desorption of the coupons is in progress.

Previously in the program, stabilizer S/N B-157-00076 having 17 months and 1600 flight hours, was returned from the field for full scale static tests. Details of the testing were documented in the first annual report, Reference (1). For comparison purposes, a summary of proof load deflection testing, flight hours and moisture level (B-157-00021 in progress) for all three stabilizers is presented in Figure 6.

TABLE VI

STABILIZER S/N B-157-00021

SUMMARY OF ENVIRONMENTAL HISTORY

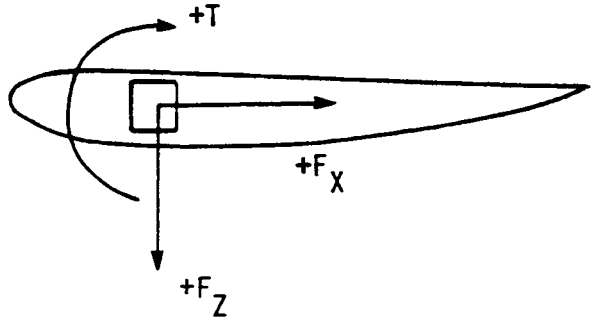
DATE	AVERAGE TEMPERATURE (°C)	(°F)	AVERAGE RELATIVE HUMIDITY (%)
10/23/79 - 10/31/79	20.5	68.9	79.0
11/01/79 - 11/30/79	12.4	54.5	75.4
12/01/79 - 12/31/79	10.3	50.5	78.1
1/01/80 - 1/31/80	11.9	53.4	86.4
2/01/80 - 2/29/80	10.3	50.6	80.5
3/01/80 - 3/31/80	15.2	59.4	81.4
4/01/80 - 4/30/80	18.4	65.1	76.5
5/01/80 - 5/31/80	23.8	74.8	83.9
6/01/80 - 6/30/80	27.1	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 - 10/31/80	18.0	64.4	69.8
11/01/80 - 11/30/80	12.7	54.8	78.0
12/01/80 - 12/31/80	10.7	51.3	75.0
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	22.6	72.6	73.3
6/01/81 - 6/30/81	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	20.1	68.1	79.1
11/01/81 - 11/30/81	16.1	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

TABLE VI (Continued)

STABILIZER S/N B-157-00021

SUMMARY OF ENVIRONMENTAL HISTORY

DATE	AVERAGE TEMPERATURE (°C)	(°F)	AVERAGE RELATIVE HUMIDITY (%)
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 - 10/31/82	20.2	68.3	70.9
11/01/82 - 11/30/82	16.4	61.5	74.3
12/01/82 - 12/31/82	13.9	57.0	81.1
1/01/83 - 1/31/83	9.5	49.1	81.1
2/01/83 - 2/28/83	11.3	52.4	77.3
3/01/83 - 3/31/83	14.2	57.6	73.5
4/01/83 - 4/30/83	17.5	63.5	73.4
5/01/83 - 5/31/83	23.0	73.4	77.1
6/01/83 - 6/30/83	25.6	78.0	81.3
7/01/83 - 7/31/83	28.2	82.8	78.1
8/01/83 - 8/31/83	27.9	82.1	81.4
9/01/83 - 9/30/83	24.2	75.6	77.9
10/01/83 - 10/31/83	21.1	69.9	73.3
11/01/83 - 11/30/83	16.7	62.1	75.8
12/01/83 - 12/31/83	9.1	48.3	73.3
1/01/84 - 1/31/84	8.9	48.1	74.3
2/01/84 - 2/29/84	13.3	55.9	68.1
3/01/84 - 3/31/84	16.9	62.4	72.5
4/01/84 - 4/30/84	21.1	69.9	66.9
5/01/84 - 5/31/84	23.9	75.0	72.3
6/01/84 - 6/30/84	26.4	79.5	79.0



F_{XL} •	F_{ZL}	T_L	F_{XR}	F_{ZR}	T_R
511N (115 LB)	4257N (957 LB)	107N-m (950 IN-LB)	-476N (-107 LB)	196N (44 LB)	106N-m (935 IN-LB)

L, R - LEFT OR RIGHT SIDE LOADS, RESPECTIVELY

FIGURE 5. S-76 STABILIZER LOCATION AND MAGNITUDE OF STATIC TEST LOADS

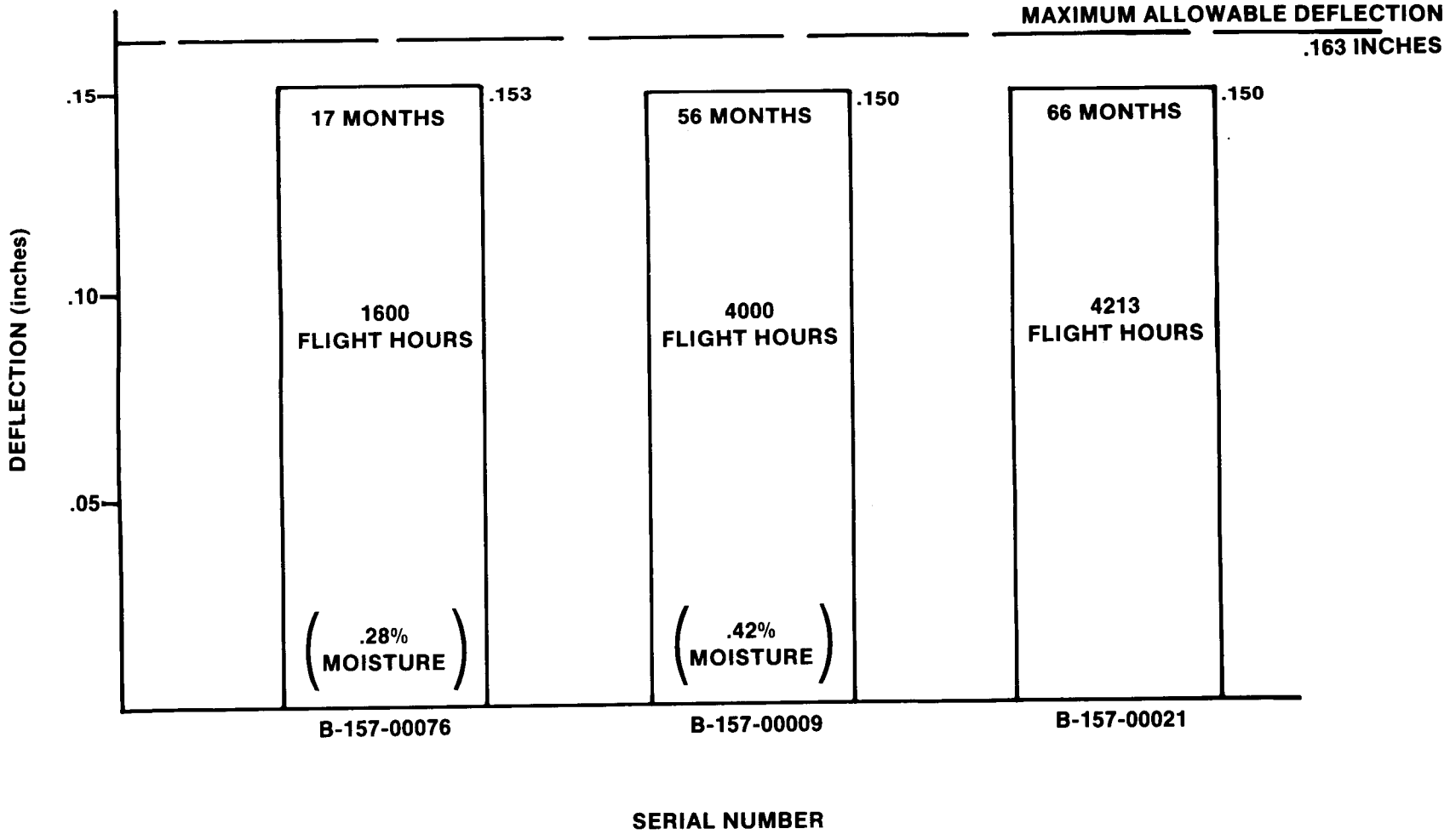


FIGURE 6. SUMMARY OF S-76 STABILIZER DEFLECTION AND MOISTURE DATA

3.2 Tail Rotor Spars

To date, nine tail rotor spars have been returned from the field for evaluation. The tail rotor blade consists of two separable tail rotor paddles attached to one tail rotor spar. After the paddles were removed, the tail rotor spar was non-destructively inspected. No abnormalities were found. Table VII presents the service time, location, fatigue data and measured moisture content of the spars evaluated. As can be seen in Table VII, six of the tail rotor spars returned from the field were full scale fatigue tested. Three of the tail rotor spars were returned for small scale (coupon) testing. During this reporting period, spar S/N A-116-00178 was returned from the field for small scale testing. The environmental history of the spar is summarized in Table VIII. Spar S/N A-116-00178 had accumulated 3753 flight hours after 55 months of in-service exposure.

Coupons were removed from Buttlines 11-12 Right and Buttlines 11-12 Left from S/N A-116-00178 tail rotor spar for static and fatigue testing. As shown in Figure 7, twelve coupons were removed from each side of the spar, six for short beam shear static and six for short beam shear fatigue testing. Of the six static specimens removed from each end, three were tested at room temperature and three at 170°F, in accordance with ASTM D 2344, Reference (3). Data is compiled in Tables IX and X. Although specimens were marked A or B to designate the end of the spar from which they were removed, application of the t distribution test in accordance with Freund, Reference (4), and as detailed in Figure 8, showed that the data could be combined. At room temperature, the average interlaminar shear strength generated was 12.6 ksi. The average interlaminar shear strength at 170°F was 10.2 ksi.

For comparison, coupon data generated for tail rotor spar S/N A-116-00178 is presented in Tables XI and XII with coupon data from the two tail rotor spars previously returned from the field for coupon testing. Tail rotor spars S/N A-116-00150 and S/N A-116-00283 were both returned from the field after 38 months of in-service exposure. Inspection shows values from spar S/N A-116-00178 to appear high compared to results from the other two spars, however, when compared to 14 ply graphite/epoxy panel data, results are shown to be compatable to expected values.

All coupon fatigue testing was conducted at room temperature. The maximum stress versus cycles to fracture plot generated for spar S/N A-116-00178 is presented in Figure 9. As in the static properties, data compiled in Table XIII shows fatigue properties of tail rotor spar S/N A-116-00178 to be somewhat higher (14 percent) than the properties of the two previously returned spars S/N A-116-00150 and S/N A-116-00283.

Moisture desorption coupons were removed from Buttlines 5-7 Right and Buttlines 5-7 Left for moisture analysis. An average of 0.60 percent moisture was desorbed from the eight coupons removed. The desorption-time plot for coupon 5-7-1 removed from the right side of the spar is typical and shown in Figure 10. Full results of the spar coupon moisture desorption tests are detailed in Tables XIV and XV.

A moisture-time profile was developed for the tail rotor blades operating in the Louisiana Gulf coast region. Weather data from Lake Charles, Louisiana was used in predicting the expected moisture absorbed. Measured moisture values are shown in Figure 11 on a plot of predicted moisture versus calendar time. The effects of solar radiation are not included in the moisture prediction, as discussed in the earlier reports, References (1) and (2). As can be seen in the Figure, the measured moisture values plotted on the curve of predicted moisture versus calendar time fall within an acceptable range of scatter. In addition, Figure 12 presents the measured versus analysis moisture contents of in-service S-76 spars as a one-to-one correlation. Inspection of the plot shows the prediction analysis has been generally accurate, with most variation being conservative.

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

TAIL ROTOR SPAR S/N	IN-SERVICE TIME MONTHS/FLT HRS	CYCLIC SHEAR STRESS, PSI	CYCLES TO CRACK	MOISTURE CONTENT (%)
00046	25 Months *1 150 flight hours	(a) 3980 (b) 3980	$.25 \times 10^6$ $.38 \times 10^6$	.29
00064	25 Months *1 150 flight hours	(a) 4320 (b) 4320	$.035 \times 10^6$ $.071 \times 10^6$	.32
00094	29 Months *2 2390 flight hours	(a) 3890 (b) 3920	$.286 \times 10^6$ $.174 \times 10^6$	.26
00283	37 Months *2 1884 flight hours	(coupon tests)	(coupon tests)	.36
00150	37 Months *2 2385 flight hours	(coupon tests)	(coupon tests)	.40
00237	39 Months *2 1596 flight hours	4520	$.267 \times 10^6$	.47
00172	39 Months *2 2533 flight hours	4270	$.218 \times 10^6$	.49
00114	49 Months *2 3350 flight hours	4416	$.839 \times 10^6$	.56
00178	55 Months *2 3753 flight hours	(coupon tests)	(coupon tests)	.60

*1 In-service location: West Palm Beach, Florida
*2 In-service location: Gulf Coast Region, Louisiana

TABLE VIII

SPAR S/N A-116-00178 (PADDLE S/N A-137-00067)

SUMMARY OF ENVIRONMENTAL HISTORY

DATE	AVERAGE TEMPERATURE (°C)	(°F)	AVERAGE RELATIVE HUMIDITY (%)
11/08/79 - 11/30/79	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	33.4	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	23.9	74.8	83.9
6/01/80 - 6/30/80	27.1	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 - 10/31/80	18.0	64.4	69.8
11/01/80 - 11/30/80	12.7	54.8	78.0
12/01/80 - 12/31/80	10.7	51.3	75.0
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	22.6	72.6	73.3
6/01/81 - 6/30/81	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	20.1	68.1	79.1
11/01/81 - 11/30/81	16.1	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

TABLE VIII (Continued)

SPAR S/N A-116-00178 (PADDLE S/N A-137-00067)

SUMMARY OF ENVIRONMENTAL HISTORY

DATE	AVERAGE TEMPERATURE (°C)	(°F)	AVERAGE RELATIVE HUMIDITY (%)
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 - 10/31/82	20.2	68.3	70.9
11/01/82 - 11/30/82	16.4	61.5	74.3
12/01/82 - 12/31/82	13.9	57.0	81.1
1/01/83 - 1/31/83	9.5	49.1	81.1
2/01/83 - 2/28/83	11.3	52.4	77.3
3/01/83 - 3/31/83	14.2	57.6	73.5
4/01/83 - 4/30/83	17.5	63.5	73.4
5/01/83 - 5/31/83	23.0	73.4	77.1
6/01/83 - 6/30/83	25.6	78.0	81.3
7/01/83 - 7/31/83	28.2	92.8	78.1
8/01/83 - 8/31/83	27.8	82.1	81.4
9/01/83 - 9/30/83	24.2	75.6	77.9
10/01/83 - 10/31/83	21.1	69.9	73.3
11/01/83 - 11/30/83	16.7	62.1	75.8
12/01/83 - 12/31/83	9.1	48.3	73.3
1/01/84 - 1/31/84	8.9	48.1	74.3
2/01/84 - 2/29/84	13.3	55.9	68.1
3/01/84 - 3/31/84	16.9	62.4	72.5
4/01/84 - 4/30/84	21.1	69.9	66.9
5/01/84 - 5/31/84	23.9	75.0	72.3
6/01/84 - 6/18/84	26.4	79.5	79.0

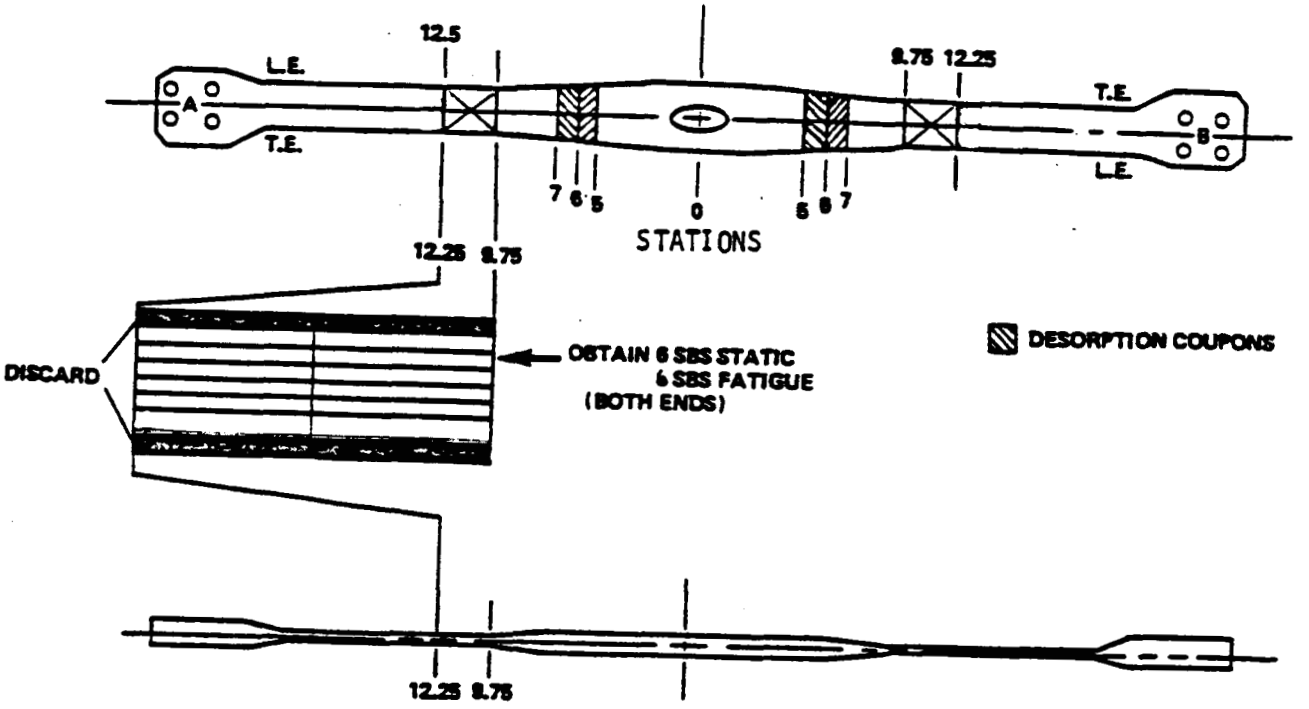


FIGURE 7. S-76 TAIL ROTOR SPAR - SKETCH OF COUPON LOCATIONS

TABLE IX. SHORT BEAM SHEAR STRENGTH AT ROOM TEMPERATURE, S/N A-116-00178 TAIL ROTOR SPAR

SPECIMEN NUMBER	WIDTH (in)	THICKNESS (in)	LOAD (lb)	SBS STRENGTH (ksi)
A1	.295	.177	870	12.5
A2	.290	.179	830	13.4
A3	.290	.176	855	12.6
B1	.283	.180	890	13.1
B2	.278	.181	885	13.2
B3	.220	.179	690	13.1
$\bar{X}$				13.0

TABLE X. SHORT BEAM SHEAR STRENGTH AT 170°F, S/N A-116-00178 TAIL ROTOR SPAR

SPECIMEN NUMBER	WIDTH (in)	THICKNESS (in)	LOAD (lb)	SBS STRENGTH (ksi)
A4	.260	.177	660	10.8
A5	.255	.177	605	10.1
A6	.280	.176	675	10.3
B4	.283	.184	695	10.0
B5	.281	.180	670	9.9
B6	.209	.181	510	10.1
$\bar{X}$				10.2

FOR ROOM TEMPERATURE TEST DATA

X_1	X_2
12.5	13.1
13.4	13.2
12.6	13.1

$n_1 = 3$ $\quad n_2 = 3$

$\bar{X}_1 = 12.8$ $\quad \bar{X}_2 = 13.1$

$\Sigma' X_1^2 = 0.49$ $\quad \Sigma' X_2^2 = 0.01$

$$\bar{S}(X) = \sqrt{\frac{.49 + .01}{3 + 3 - 2}}$$

$\bar{S}(X) = .3536$

$$t = \frac{|12.8 - 13.1|}{.3536\sqrt{\frac{1}{3} + \frac{1}{3}}}$$

$t = 1.04 < t_{.05,4} = 2.776$

FOR 170°F DATA

X_1	X_2
10.8	10.0
10.1	9.93
10.3	10.1

$n_1 = 3$ $\quad n_2 = 3$

$\bar{X}_1 = 10.4$ $\quad \bar{X}_2 = 10.0$

$\Sigma' X_1^2 = 0.26$ $\quad \Sigma' X_2^2 = 0.0146$

$$\bar{S}(X) = \sqrt{\frac{.26 + .0146}{3 + 3 - 2}}$$

$\bar{S}(X) = .262$

$$t = \frac{|10.4 - 10.0|}{.262\sqrt{\frac{1}{3} + \frac{1}{3}}}$$

$t = 1.82 < t_{.05,4} = 2.776$

FIGURE 8. T-TEST CALCULATIONS TO DETERMINE IF TEST RESULTS FROM A AND B ENDS OF TAIL ROTOR SPAR S/N A-116-00178 ARE FROM THE SAME POPULATION

TABLE XI COMPILATION OF SPAR COUPON STATIC TESTING
WITH COMPARISON TO PANEL TEST RESULTS
ROOM TEMPERATURE DATA

SPAR S/N	EXPOSURE TIME (MONTHS)	FLIGHT HOURS	COUPON SBS STRENGTH (KSI)	PANEL SBS STRENGTH (KSI)
00150	37	2385	12.2	13.3 1/
00283	37	1884	12.3	13.3 1/
00178	55	3753	13.0	13.0 2/

NOTES: 1/ Panel exposure time (months) = 34.5

2/ Panel exposure time (months) = 48

TABLE XII COMPILATION OF SPAR COUPON STATIC TESTING
WITH COMPARISON TO PANEL TEST RESULTS
170°F DATA

SPAR S/N	EXPOSURE TIME (MONTHS)	FLIGHT HOURS	COUPON SBS STRENGTH (KSI)	PANEL SBS STRENGTH (KSI)
00150	37	2385	8.5	7.8 1/
00283	37	1884	9.5	7.8 1/
00178	55	3753	10.2	9.8 2/

NOTES: 1/ Panel exposure time (months) = 34.5

2/ Panel exposure time (months) = 48

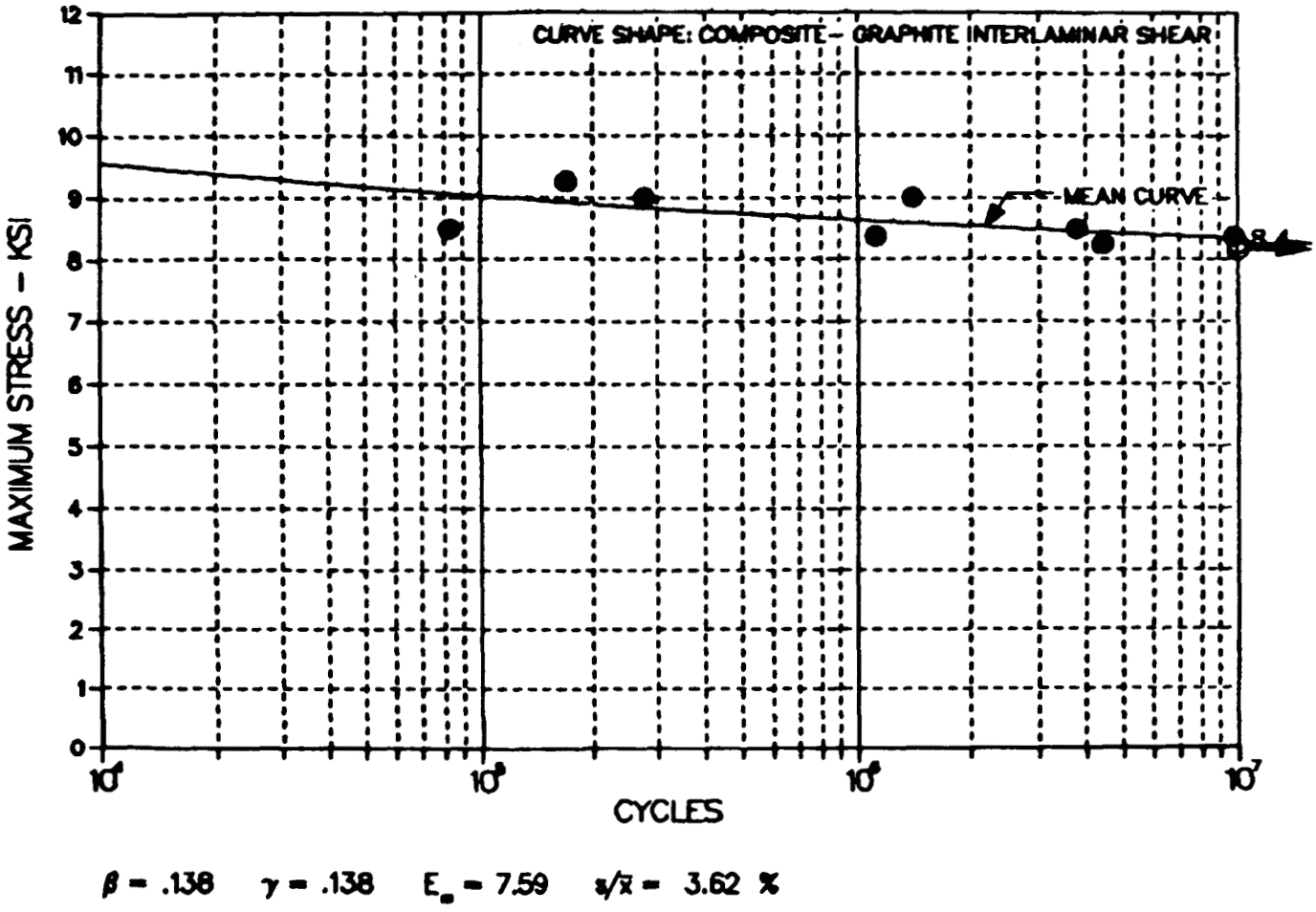


FIGURE 9. SPAR S/N A-116-00178
INTERLAMINAR SHEAR FATIGUE
COUPON TESTING - MAXIMUM
STRESS VERSUS CYCLES TO
FRACTURE

TABLE XIII. COMPILATION OF SPAR COUPON FATIGUE TESTING - ROOM TEMPERATURE DATA

Spar S/N	Exposure Time (Months)	Flight Hours	Max. Stress (KSI) at 10^7 Cycles
00150	38	2,385	7.4
00283	38	1,884	7.4
00178	55	3,753	8.4

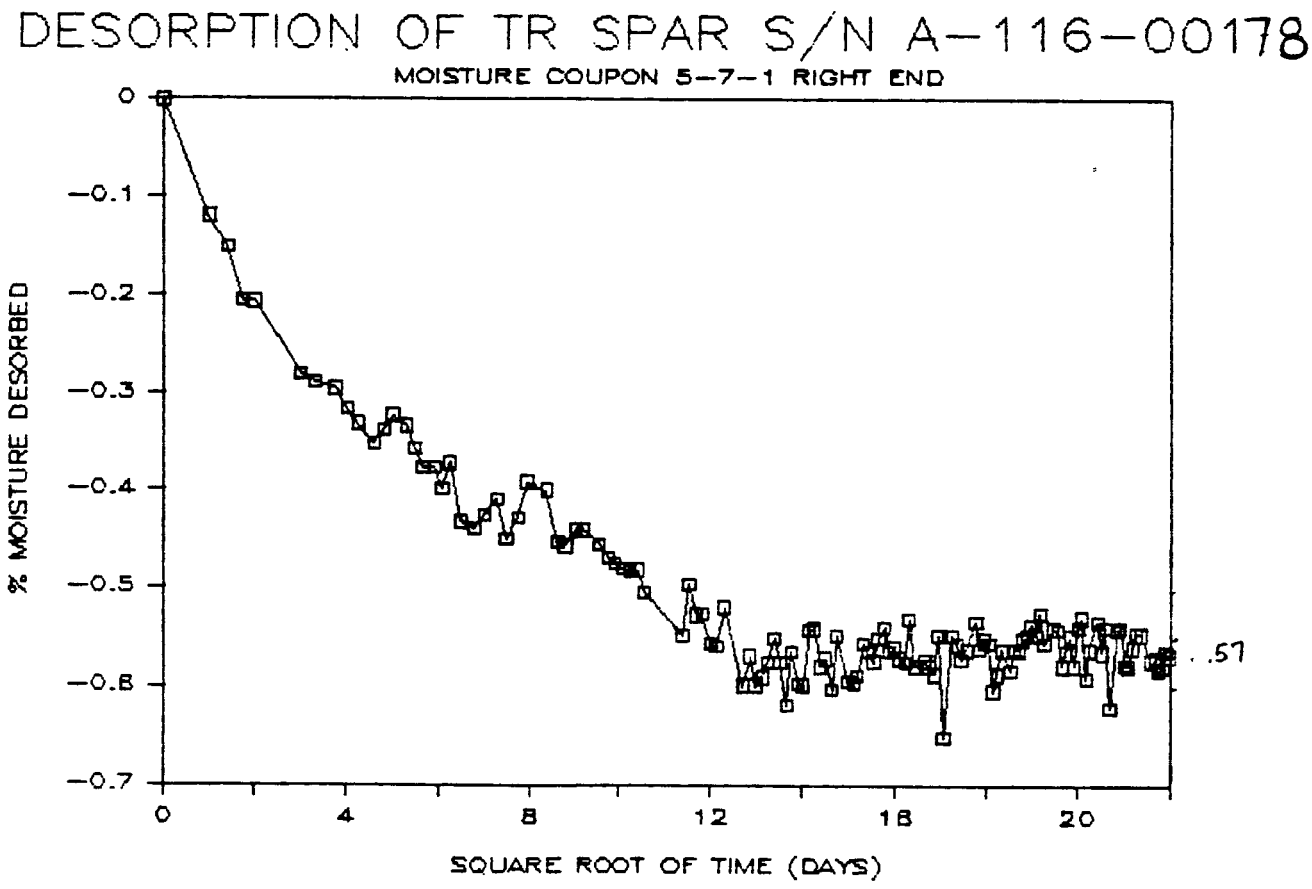


FIGURE 10. MOISTURE DESORPTION OF TAIL ROTOR SPAR S/N A-116-00178, COUPON 5-7-1, RIGHT

TABLE XIV MOISTURE DESORPTION OF TAIL ROTOR SPAR
S/N A-116-00178, BUTTLINES 5-7, A END

DATE OF WEIGHING	DAYS	SQ RT OF TIME	% MOIST DESORBED COUPON 5-7-1	% MOIST DESORBED COUPON 5-7-2	% MOIST DESORBED COUPON 5-7-3	% MOIST DESORBED COUPON 5-7-4	AVERAGE % MOIST DESORBED
8/27/84	0	0.00	.00	.00	.00	.00	.00
8/28/84	1	1.00	-0.12	-0.13	-0.13	-0.15	-0.13
8/29/84	2	1.41	-0.15	-0.17	-0.16	-0.18	-0.16
8/30/84	3	1.73	-0.20	-0.19	-0.20	-0.21	-0.20
8/31/84	4	2.00	-0.21	-0.22	-0.21	-0.22	-0.21
9/05/84	9	3.00	-0.28	-0.30	-0.28	-0.31	-0.29
9/07/84	11	3.32	-0.29	-0.28	-0.28	-0.34	-0.30
9/10/84	14	3.74	-0.30	-0.30	-0.28	-0.36	-0.31
9/12/84	16	4.00	-0.32	-0.33	-0.29	-0.38	-0.33
9/14/84	18	4.24	-0.33	-0.33	-0.30	-0.37	-0.33
9/17/84	21	4.58	-0.35	-0.38	-0.36	-0.42	-0.38
9/19/84	23	4.80	-0.34	-0.33	-0.31	-0.38	-0.34
9/21/84	25	5.00	-0.32	-0.35	-0.31	-0.42	-0.35
9/24/84	28	5.29	-0.33	-0.34	-0.33	-0.41	-0.35
9/26/84	30	5.48	-0.36	-0.34	-0.32	-0.42	-0.36
9/28/84	32	5.66	-0.38	-0.40	-0.36	-0.46	-0.40
10/01/84	35	5.92	-0.38	-0.37	-0.39	-0.48	-0.40
10/03/84	37	6.08	-0.40	-0.41	-0.36	-0.44	-0.40
10/05/84	39	6.24	-0.37	-0.38	-0.36	-0.47	-0.40
10/08/84	42	6.48	-0.43	-0.41	-0.40	-0.51	-0.44
10/12/84	46	6.78	-0.44	-0.45	-0.41	-0.49	-0.45
10/15/84	49	7.00	-0.43	-0.43	-0.38	-0.53	-0.44
10/19/84	53	7.28	-0.41	-0.41	-0.38	-0.50	-0.43
10/22/84	56	7.48	-0.45	-0.45	-0.42	-0.52	-0.46
10/26/84	60	7.75	-0.43	-0.43	-0.41	-0.53	-0.45
10/29/84	63	7.94	-0.39	-0.39	-0.36	-0.49	-0.41
11/05/84	70	8.37	-0.40	-0.40	-0.38	-0.50	-0.42
11/09/84	74	8.60	-0.45	-0.45	-0.40	-0.54	-0.46
11/12/84	77	8.77	-0.46	-0.45	-0.39	-0.53	-0.46
11/16/84	81	9.00	-0.44	-0.44	-0.41	-0.52	-0.45
11/19/84	84	9.17	-0.44	-0.44	-0.44	-0.56	-0.47
11/26/84	91	9.54	-0.46	-0.46	-0.44	-0.56	-0.48
11/30/84	95	9.75	-0.47	-0.48	-0.43	-0.56	-0.49
12/03/84	98	9.90	-0.48	-0.50	-0.44	-0.60	-0.51
12/07/84	102	10.10	-0.48	-0.48	-0.45	-0.58	-0.50
12/10/84	105	10.25	-0.48	-0.50	-0.46	-0.57	-0.50
12/14/84	109	10.44	-0.48	-0.48	-0.45	-0.60	-0.50
12/17/84	112	10.58	-0.51	-0.51	-0.48	-0.60	-0.53

TABLE XIV (cont'd) MOISTURE DESORPTION OF TAIL ROTOR SPAR
S/N A-116-00178, BUTTLINES 5-7, A END

DATE OF WEIGHING	DAYS	SQ RT OF TIME	% MOIST DESORBED COUPON 5-7-1	% MOIST DESORBED COUPON 5-7-2	% MOIST DESORBED COUPON 5-7-3	% MOIST DESORBED COUPON 5-7-4	AVERAGE % MOIST DESORBED
1/04/85	130	11.40	-0.55	-0.55	-0.48	-0.62	-0.55
1/07/85	133	11.53	-0.50	-0.52	-0.48	-0.62	-0.53
1/11/85	137	11.70	-0.53	-0.54	-0.49	-0.62	-0.54
1/14/85	140	11.83	-0.53	-0.52	-0.48	-0.61	-0.54
1/18/85	144	12.00	-0.56	-0.56	-0.52	-0.63	-0.57
1/21/85	147	12.12	-0.56	-0.55	-0.53	-0.64	-0.57
1/25/85	151	12.29	-0.52	-0.54	-0.49	-0.62	-0.54
2/04/85	161	12.69	-0.60	-0.60	-0.56	-0.70	-0.62
2/08/85	165	12.83	-0.57	-0.58	-0.55	-0.66	-0.59
2/11/85	168	12.96	-0.60	-0.62	-0.56	-0.70	-0.62
2/15/85	172	13.11	-0.59	-0.59	-0.57	-0.67	-0.61
2/18/85	175	13.23	-0.58	-0.59	-0.52	-0.68	-0.59
2/22/85	179	13.38	-0.55	-0.57	-0.54	-0.68	-0.58
2/25/85	182	13.49	-0.58	-0.57	-0.53	-0.67	-0.59
3/01/85	186	13.64	-0.62	-0.58	-0.56	-0.71	-0.62
3/04/85	189	13.75	-0.56	-0.59	-0.53	-0.67	-0.59
3/08/85	193	13.89	-0.60	-0.59	-0.54	-0.71	-0.61
3/11/85	196	14.00	-0.60	-0.62	-0.57	-0.71	-0.62
3/15/85	200	14.14	-0.54	-0.57	-0.52	-0.65	-0.57
3/18/85	203	14.25	-0.54	-0.55	-0.54	-0.69	-0.58
3/22/85	207	14.39	-0.58	-0.59	-0.54	-0.70	-0.60
3/25/85	210	14.49	-0.57	-0.59	-0.57	-0.69	-0.60
3/29/85	214	14.63	-0.60	-0.61	-0.56	-0.70	-0.62
4/01/85	217	14.73	-0.55	-0.60	-0.54	-0.72	-0.60
4/08/85	224	14.97	-0.59	-0.62	-0.59	-0.75	-0.64
4/12/85	228	15.10	-0.60	-0.61	-0.56	-0.72	-0.62
4/15/85	231	15.20	-0.59	-0.60	-0.52	-0.70	-0.60
4/19/85	235	15.33	-0.56	-0.60	-0.51	-0.67	-0.58
4/22/85	238	15.43	-0.56	-0.59	-0.51	-0.66	-0.58
4/26/85	242	15.56	-0.57	-0.62	-0.54	-0.69	-0.61
4/29/85	245	15.65	-0.55	-0.58	-0.52	-0.68	-0.58
5/03/85	249	15.78	-0.54	-0.56	-0.50	-0.67	-0.57
5/06/85	252	15.87	-0.57	-0.58	-0.54	-0.70	-0.60
5/10/85	256	16.00	-0.56	-0.59	-0.52	-0.69	-0.59
5/13/85	259	16.09	-0.57	-0.58	-0.51	-0.71	-0.59
5/17/85	263	16.22	-0.58	-0.60	-0.52	-0.66	-0.59
5/20/85	266	16.31	-0.53	-0.55	-0.48	-0.65	-0.55
5/24/85	270	16.43	-0.58	-0.62	-0.55	-0.72	-0.62

TABLE XIV (cont'd) MOISTURE DESORPTION OF TAIL ROTOR SPAR
S/N A-116-00178, BUTTLINES 5-7, A END

DATE OF WEIGHING	DAYS	SQ RT OF TIME	% MOIST DESORBED COUPON 5-7-1	% MOIST DESORBED COUPON 5-7-2	% MOIST DESORBED COUPON 5-7-3	% MOIST DESORBED COUPON 5-7-4	AVERAGE % MOIST DESORBED
5/31/85	277	16.64	-0.57	-0.60	-0.51	-0.68	-0.59
6/03/85	280	16.73	-0.58	-0.56	-0.51	-0.66	-0.58
6/07/85	284	16.85	-0.59	-0.63	-0.54	-0.70	-0.61
6/10/85	287	16.94	-0.55	-0.56	-0.49	-0.65	-0.56
6/14/85	291	17.06	-0.65	-0.67	-0.62	-0.77	-0.68
6/17/85	297	17.23	-0.55	-0.57	-0.52	-0.66	-0.57
6/21/85	301	17.35	-0.56	-0.57	-0.53	-0.67	-0.58
6/24/85	304	17.44	-0.57	-0.59	-0.52	-0.66	-0.59
6/28/85	308	17.55	-0.56	-0.57	-0.52	-0.67	-0.58
7/05/85	315	17.75	-0.53	-0.55	-0.48	-0.64	-0.55
7/08/85	318	17.83	-0.56	-0.57	-0.52	-0.66	-0.58
7/12/85	322	17.94	-0.55	-0.57	-0.54	-0.67	-0.58
7/15/85	325	18.03	-0.56	-0.58	-0.53	-0.67	-0.58
7/19/85	329	18.14	-0.60	-0.61	-0.56	-0.72	-0.62
7/22/85	332	18.22	-0.59	-0.60	-0.55	-0.70	-0.61
7/26/85	336	18.33	-0.56	-0.57	-0.52	-0.66	-0.58
8/02/85	343	18.52	-0.58	-0.58	-0.55	-0.68	-0.60
8/05/85	346	18.60	-0.56	-0.56	-0.52	-0.68	-0.58
8/09/85	350	18.71	-0.56	-0.59	-0.53	-0.70	-0.60
8/12/85	353	18.79	-0.55	-0.58	-0.50	-0.66	-0.57
8/16/85	357	18.89	-0.55	-0.56	-0.52	-0.68	-0.58
8/19/85	360	18.97	-0.54	-0.58	-0.54	-0.69	-0.59
8/23/85	364	19.08	-0.55	-0.59	-0.52	-0.69	-0.59
8/26/85	367	19.16	-0.53	-0.55	-0.50	-0.66	-0.56
8/30/85	371	19.26	-0.56	-0.58	-0.51	-0.68	-0.58
9/06/85	378	19.44	-0.54	-0.55	-0.50	-0.65	-0.56
9/09/85	382	19.54	-0.54	-0.57	-0.49	-0.66	-0.57
9/13/85	386	19.65	-0.58	-0.58	-0.50	-0.68	-0.59
9/16/85	389	19.72	-0.57	-0.56	-0.49	-0.68	-0.57
9/20/85	393	19.82	-0.55	-0.56	-0.49	-0.65	-0.56
9/23/85	396	19.90	-0.58	-0.57	-0.44	-0.68	-0.57
9/27/85	400	20.00	-0.54	-0.59	-0.52	-0.68	-0.58
9/30/85	403	20.07	-0.53	-0.56	-0.48	-0.64	-0.55
10/04/85	407	20.17	-0.59	-0.62	-0.56	-0.72	-0.62
10/07/85	410	20.25	-0.56	-0.37	-0.49	-0.67	-0.57
10/14/85	417	20.42	-0.54	-0.54	-0.48	-0.64	-0.55

TABLE XIV (cont'd) MOISTURE DESORPTION OF TAIL ROTOR SPAR
S/N A-116-00178, BUTTLINES 5-7, A END

DATE OF WEIGHING	DAYS	SQ RT OF TIME	% MOIST DESORBED COUPON 5-7-1	% MOIST DESORBED COUPON 5-7-2	% MOIST DESORBED COUPON 5-7-3	% MOIST DESORBED COUPON 5-7-4	AVERAGE % MOIST DESORBED
10/18/85	421	20.52	-0.57	-0.56	-0.52	-0.67	-0.58
10/21/85	424	20.59	-0.54	-0.55	-0.50	-0.64	-0.56
10/25/85	428	20.69	-0.62	-0.62	-0.57	-0.73	-0.64
11/01/85	435	20.86	-0.54	-0.55	-0.50	-0.66	-0.56
11/04/85	438	20.93	-0.54	-0.55	-0.51	-0.66	-0.56
11/08/85	442	21.02	-0.58	-0.57	-0.53	-0.67	-0.59
11/11/85	445	21.10	-0.58	-0.57	-0.54	-0.69	-0.59
11/15/85	449	21.19	-0.56	-0.57	-0.50	-0.68	-0.58
11/18/85	452	21.26	-0.55	-0.56	-0.50	-0.68	-0.57
11/22/85	456	21.35	-0.55	-0.59	-0.49	-0.67	-0.58
12/02/85	466	21.59	-0.57	-0.53	-0.53	-0.67	-0.58
12/06/85	470	21.68	-0.57	-0.57	-0.51	-0.70	-0.59
12/09/85	473	21.75	-0.58	-0.61	-0.54	-0.70	-0.61
12/13/85	477	21.84	-0.58	-0.58	-0.54	-0.68	-0.59
12/16/85	480	21.91	-0.56	-0.57	-0.52	-0.67	-0.58
12/20/85	484	22.00	-0.57	-0.58	-0.53	-0.66	-0.59

TABLE XV MOISTURE DESORPTION OF TAIL ROTOR SPAR
S/N A-116-00178, BUTTLINES 5-7, B END

DATE OF WEIGHING	DAYS	SQ RT OF TIME	% MOIST DESORBED COUPON 5-7-1	% MOIST DESORBED COUPON 5-7-2	% MOIST DESORBED COUPON 5-7-3	% MOIST DESORBED COUPON 5-7-4	AVERAGE % MOIST DESORBED
8/27/84	0	0.00	0.00	0.00	0.00	.00	.00
8/28/84	1	1.00	-0.12	-0.12	-0.13	-0.17	-0.14
8/29/84	2	1.41	-0.17	-0.18	-0.17	-0.22	-0.19
8/30/84	3	1.73	-0.19	-0.23	-0.18	-0.26	-0.22
8/31/84	4	2.00	-0.19	-0.20	-0.22	-0.27	-0.22
9/05/84	9	3.00	-0.27	-0.31	-0.29	-0.36	-0.31
9/07/84	11	3.32	-0.29	-0.32	-0.32	-0.36	-0.32
9/10/84	14	3.74	-0.30	-0.31	-0.30	-0.40	-0.33
9/12/84	16	4.00	-0.32	-0.35	-0.34	-0.40	-0.35
9/14/84	18	4.24	-0.33	-0.32	-0.33	-0.43	-0.35
9/17/84	21	4.58	-0.38	-0.40	-0.39	-0.48	-0.41
9/19/84	23	4.80	-0.33	-0.35	-0.34	-0.44	-0.37
9/21/84	25	5.00	-0.35	-0.35	-0.34	-0.44	-0.37
9/24/84	29	5.29	-0.35	-0.37	-0.35	-0.45	-0.38
9/26/84	30	5.48	-0.36	-0.41	-0.35	-0.47	-0.40
9/28/84	32	5.66	-0.39	-0.42	-0.42	-0.47	-0.43
10/01/84	35	5.92	-0.42	-0.42	-0.37	-0.51	-0.43
10/03/84	37	6.08	-0.39	-0.43	-0.38	-0.50	-0.43
10/05/84	39	6.24	-0.39	-0.41	-0.40	-0.50	-0.43
10/08/84	42	6.48	-0.41	-0.46	-0.41	-0.55	-0.46
10/12/84	46	6.78	-0.46	-0.46	-0.42	-0.53	-0.47
10/15/84	49	7.00	-0.44	-0.45	-0.43	-0.55	-0.46
10/19/84	53	7.28	-0.43	-0.45	-0.41	-0.56	-0.46
10/22/84	56	7.48	-0.46	-0.49	-0.46	-0.59	-0.50
10/26/84	60	7.75	-0.44	-0.44	-0.44	-0.54	-0.46
10/29/84	63	7.94	-0.41	-0.42	-0.39	-0.54	-0.44
11/05/84	70	8.37	-0.41	-0.43	-0.46	-0.54	-0.46
11/09/84	74	8.60	-0.45	-0.50	-0.45	-0.57	-0.49
11/12/84	77	8.77	-0.43	-0.46	-0.45	-0.57	-0.48
11/16/84	81	9.00	-0.46	-0.47	-0.42	-0.57	-0.48
11/19/84	84	9.17	-0.48	-0.49	-0.42	-0.59	-0.50
11/26/84	91	9.54	-0.47	-0.51	-0.48	-0.61	-0.52
11/30/84	95	9.75	-0.49	-0.50	-0.38	-0.61	-0.52
12/03/84	98	9.90	-0.51	-0.53	-0.49	-0.65	-0.54
12/07/84	102	10.10	-0.50	-0.52	-0.48	-0.61	-0.53
12/10/84	105	10.25	-0.50	-0.53	-0.48	-0.65	-0.54
12/14/84	109	10.44	-0.49	-0.50	-0.48	-0.64	-0.53
12/17/84	112	10.58	-0.50	-0.51	-0.52	-0.68	-0.55

TABLE XV (cont'd) MOISTURE DESORPTION OF TAIL ROTOR SPAR
S/N A-116-00178, BUTTLINES 5-7, B END

DATE OF WEIGHING	DAYS	SQ RT OF TIME	% MOIST DESORBED COUPON 5-7-1	% MOIST DESORBED COUPON 5-7-2	% MOIST DESORBED COUPON 5-7-3	% MOIST DESORBED COUPON 5-7-4	AVERAGE % MOIST DESORBED
1/04/85	130	11.40	-0.55	-0.54	-0.54	-0.71	-0.59
1/07/85	133	11.53	-0.53	-0.54	-0.51	-0.65	-0.56
1/11/85	137	11.70	-0.54	-0.55	-0.53	-0.69	-0.58
1/14/85	140	11.83	-0.55	-0.56	-0.51	-0.67	-0.57
1/18/85	144	12.00	-0.55	-0.59	-0.53	-0.68	-0.59
1/21/85	147	12.12	-0.57	-0.60	-0.55	-0.74	-0.62
1/25/85	151	12.29	-0.52	-0.55	-0.50	-0.68	-0.56
2/04/85	161	12.69	-0.58	-0.61	-0.57	-0.73	-0.62
2/08/85	165	12.85	-0.58	-0.56	-0.53	-0.73	-0.60
2/11/85	168	12.96	-0.58	-0.59	-0.56	-0.73	-0.62
2/15/85	172	13.11	-0.58	-0.59	-0.58	-0.73	-0.62
2/18/85	175	13.23	-0.57	-0.59	-0.59	-0.72	-0.62
2/22/85	179	13.38	-0.58	-0.60	-0.59	-0.75	-0.63
2/25/85	182	13.49	-0.57	-0.58	-0.57	-0.74	-0.62
3/01/85	186	13.64	-0.60	-0.63	-0.61	-0.78	-0.66
3/04/85	189	13.75	-0.59	-0.61	-0.58	-0.74	-0.63
3/08/85	193	13.89	-0.59	-0.59	-0.58	-0.75	-0.62
3/11/85	196	14.00	-0.57	-0.64	-0.55	-0.72	-0.62
3/15/85	200	14.14	-0.57	-0.58	-0.54	-0.72	-0.60
3/18/85	203	14.25	-0.56	-0.64	-0.54	-0.76	-0.62
3/22/85	207	14.39	-0.58	-0.60	-0.61	-0.77	-0.64
3/25/85	210	14.49	-0.58	-0.64	-0.59	-0.78	-0.65
3/29/85	214	14.63	-0.60	-0.62	-0.58	-0.74	-0.64
4/01/85	217	14.73	-0.61	-0.62	-0.56	-0.74	-0.63
4/08/85	224	14.97	-0.63	-0.61	-0.65	-0.81	-0.67
4/12/85	228	15.10	-0.60	-0.61	-0.57	-0.75	-0.63
4/15/85	231	15.20	-0.58	-0.60	-0.56	-0.76	-0.63
4/19/85	235	15.33	-0.62	-0.65	-0.59	-0.72	-0.64
4/22/85	238	15.43	-0.57	-0.59	-0.54	-0.72	-0.61
4/26/85	242	15.56	-0.61	-0.63	-0.55	-0.74	-0.63
4/29/85	245	15.65	-0.57	-0.60	-0.56	-0.74	-0.62
5/03/85	249	15.78	-0.56	-0.58	-0.54	-0.72	-0.60
5/06/85	252	15.87	-0.57	-0.60	-0.60	-0.78	-0.64
5/10/85	256	16.00	-0.57	-0.58	-0.55	-0.74	-0.61
5/13/85	259	16.09	-0.58	-0.59	-0.56	-0.71	-0.61
5/17/85	263	16.22	-0.56	-0.60	-0.57	-0.73	-0.62
5/20/85	266	16.31	-0.55	-0.56	-0.53	-0.71	-0.59

TABLE XV (cont'd) MOISTURE DESORPTION OF TAIL ROTOR SPAR
S/N A-116-00178, BUTTLINES 5-7, B END

DATE OF WEIGHING	DAYS	SQ RT OF TIME	% MOIST DESORBED COUPON 5-7-1	% MOIST DESORBED COUPON 5-7-2	% MOIST DESORBED COUPON 5-7-3	% MOIST DESORBED COUPON 5-7-4	AVERAGE % MOIST DESORBED
5/24/85	270	16.43	-0.59	-0.64	-0.58	-0.78	-0.65
5/31/85	277	16.64	-0.58	-0.61	-0.57	-0.74	-0.62
6/03/85	280	16.73	-0.60	-0.60	-0.55	-0.75	-0.62
6/07/85	284	16.85	-0.60	-0.64	-0.59	-0.78	-0.65
6/10/85	287	16.94	-0.56	-0.58	-0.56	-0.73	-0.61
6/14/85	291	17.06	-0.66	-0.69	-0.65	-0.85	-0.71
6/17/85	297	17.23	-0.56	-0.58	-0.52	-0.70	-0.59
6/21/85	301	17.35	-0.58	-0.60	-0.53	-0.74	-0.61
6/24/85	304	17.44	-0.58	-0.59	-0.54	-0.74	-0.61
6/28/85	308	17.55	-0.56	-0.57	-0.54	-0.72	-0.60
7/05/85	315	17.75	-0.55	-0.56	-0.52	-0.70	-0.58
7/08/85	318	17.83	-0.57	-0.59	-0.55	-0.73	-0.61
7/12/85	322	17.94	-0.60	-0.60	-0.58	-0.74	-0.63
7/15/85	325	18.03	-0.66	-0.59	-0.54	-0.70	-0.62
7/19/85	329	18.14	-0.59	-0.60	-0.56	-0.74	-0.62
7/22/85	332	18.22	-0.57	-0.58	-0.54	-0.73	-0.61
7/26/85	336	18.33	-0.57	-0.61	-0.54	-0.71	-0.61
8/02/85	343	18.52	-0.59	-0.61	-0.58	-0.76	-0.63
8/05/85	346	18.60	-0.59	-0.61	-0.58	-0.76	-0.64
8/09/85	350	18.71	-0.58	-0.59	-0.54	-0.72	-0.61
8/12/85	353	18.79	-0.56	-0.58	-0.55	-0/71	-0.60
8/16/85	357	18.89	-0.59	-0.60	-0.55	-0.74	-0.62
8/19/85	360	18.97	-0.59	-0160	-0.57	-0.77	-0.63
8/23/85	364	19.08	-0.58	-0.61	-0.56	-0.74	-0.62
8/26/85	367	19.16	-0.55	-0.58	-0.53	-0.70	-0.59
8/30/85	371	19.26	-0.56	-0.57	-0.53	-0.73	-0.60
9/06/85	378	19.44	-0.54	-0.57	-0.53	-0.72	-0.59
9/09/85	382	19.54	-0.56	-0.55	-0.51	-0.68	-0.57
9/13/85	386	19.65	-0.58	-0.61	-0.56	-0.76	-0.63
9/16/85	389	19.72	-0.58	-0.58	-0.54	-0.75	-0.61
9/20/85	393	19.82	-0.57	-0.57	-0.52	-0.71	-0.59
9/23/85	396	19.90	-0.59	-0.61	-0.54	-0.76	-0.63
9/27/85	400	20.00	-0.58	-0.60	-0.54	-0.73	-0.61
9/30/85	403	20.07	-0.55	-0.58	-0.53	-0.70	-0.59
10/04/85	407	20.17	-0.59	-0.63	-0.58	-0.75	-0.64
10/07/85	410	20.25	-0.55	-0.58	-0.54	-0.75	-0.60
10/14/85	417	20.42	-0.54	-0.57	-0.51	-0.69	-0.58

TABLE XV (cont'd) MOISTURE DESORPTION OF TAIL ROTOR SPAR
S/N A-116-00178, BUTTLINES 5-7, B END

DATE OF WEIGHING	DAYS	SQ RT OF TIME	% MOIST DESORBED COUPON 5-7-1	% MOIST DESORBED COUPON 5-7-2	% MOIST DESORBED COUPON 5-7-3	% MOIST DESORBED COUPON 5-7-4	AVERAGE % MOIST DESORBED
10/18/85	421	20.52	-0.58	-0.63	-0.57	-0.74	-0.63
10/21/85	424	20.59	-0.55	-0.57	-0.52	-0.71	-0.59
10/25/85	428	20.69	-0.61	-0.64	-0.59	-0.75	-0.65
11/01/85	435	20.86	-0.57	-0.56	-0.52	-0.71	-0.59
11/04/85	438	20.93	-0.56	-0.58	-0.54	-0.71	-0.60
11/08/85	442	21.02	-0.58	-0.58	-0.56	-0.77	-0.62
11/11/85	445	21.10	-0.59	-0.57	-0.55	-0.71	-0.61
11/15/85	449	21.19	-0.57	-0.59	-0.53	-0.71	-0.60
11/18/85	452	21.26	-0.57	-0.56	-0.52	-0.71	-0.59
11/22/85	456	21.35	-0.57	-0.60	-0.55	-0.74	-0.62
12/02/85	466	21.59	-0.58	-0.59	-0.52	-0.74	-0.61
12/06/85	470	21.68	-0.57	-0.60	-0.55	-0.73	-0.61
12/09/85	473	21.75	-0.59	-0.60	-0.56	-0.74	-0.62
12/13/85	477	21.84	-0.58	-0.59	-0.59	-0.76	-0.63
12/16/85	480	21.91	-0.57	-0.59	-0.54	-0.74	-0.61
12/20/85	484	22.00	-0.57	-0.61	-0.52	-0.72	-0.61

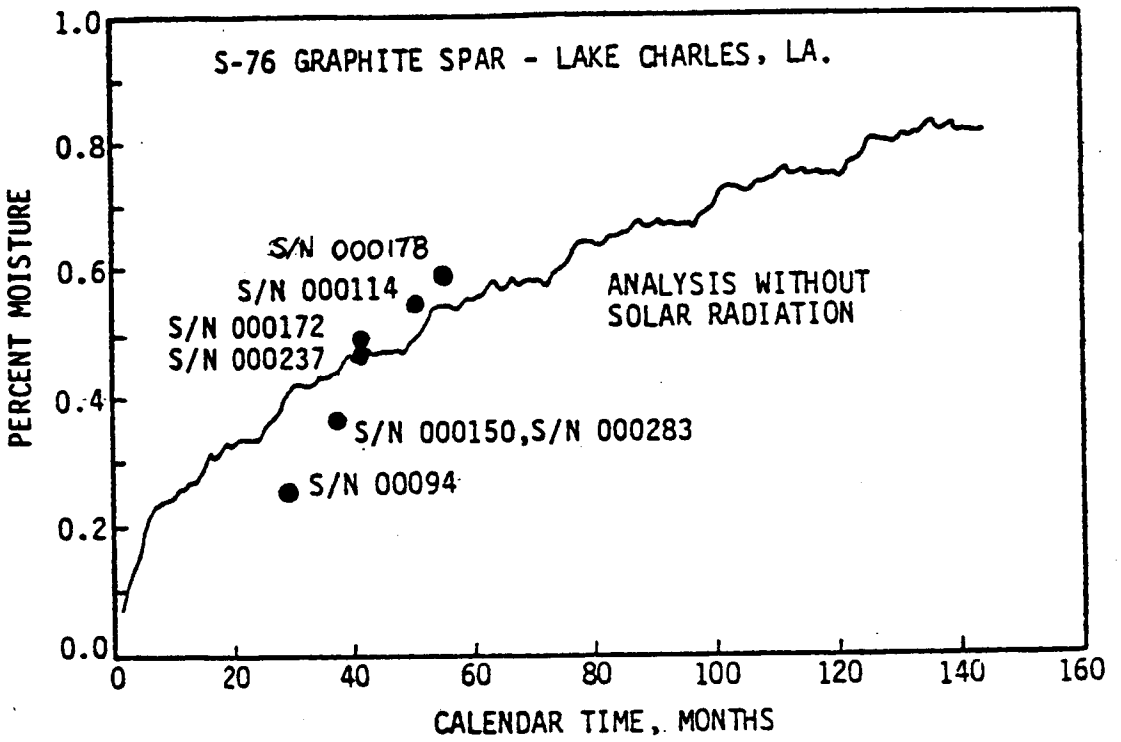


FIGURE 11. MEASURED MOISTURE VERSUS ANALYSIS FOR GRAPHITE/EPOXY TAIL ROTOR SPARS

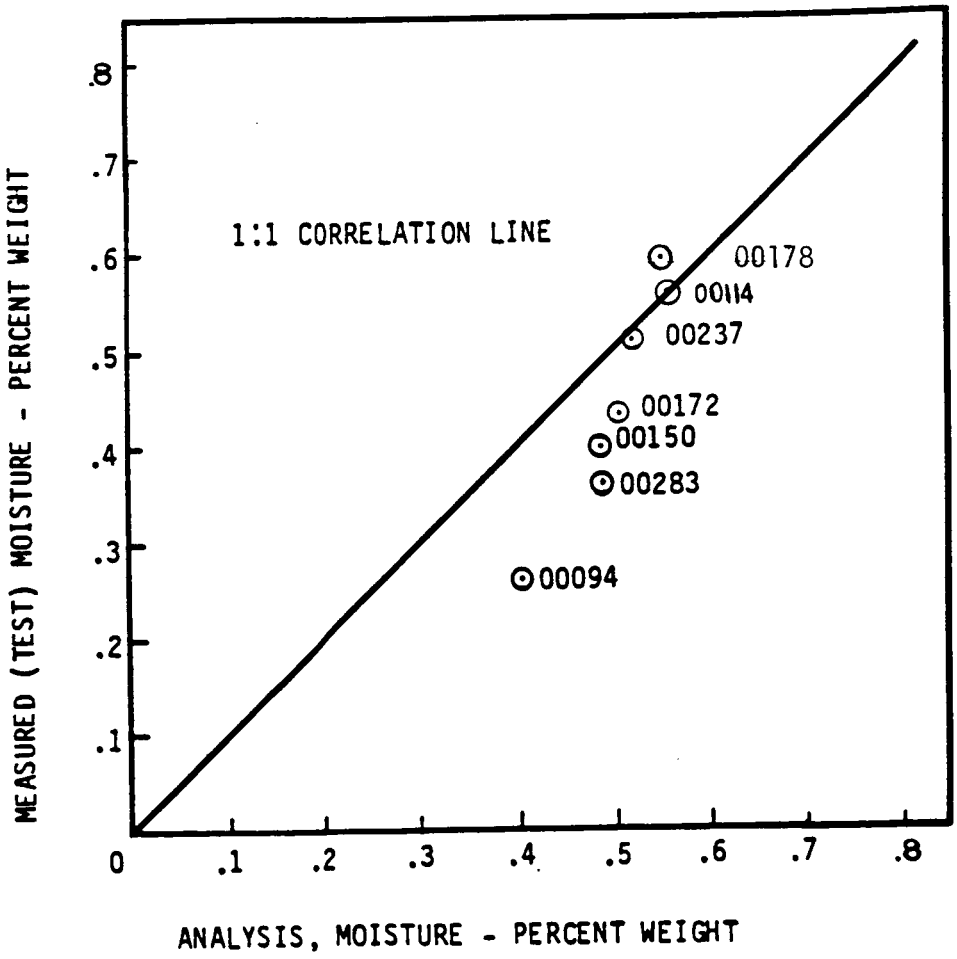


FIGURE 12. CORRELATION BETWEEN MEASURED MOISTURE AND ANALYSIS FOR GRAPHITE/EPOXY TAIL ROTOR SPARS

4.0 MATERIAL EVALUATION

4.1 Field Exposed Panels

As part of a Sikorsky internal research and development program, entitled the Life Extension Program for Composite Structures, AS1/6350 graphite/epoxy and 285/5143 Kevlar/epoxy panels are exposed to the environment in two weathering locations: West Palm Beach, Florida and Stratford, Connecticut. Three graphite/epoxy panel configurations are exposed as part of this evaluation: 6, 14 and 33 ply panels, with a nominal per ply thickness of 0.012 inch. One Kevlar/epoxy configuration is examined: 5 ply panels, having a nominal per ply thickness of 0.009 inch. The ply configurations of the panels are representative of S-76 components. Data is presented herein for comparison purposes.

4.1.2 Moisture Measurements

Panels are returned from the weathering locations annually to determine moisture content and mechanical properties. During this reporting period, panels having four and five years exposure to the environment were returned for evaluation.

Moisture coupons, removed from exposed panels, are desorbed in an environmentally controlled chamber at 150 ± 2°F. A summary of the moisture measurements for panels with two, three, four and five years of exposure is presented in Table XVI. Inspection of the table shows 6 ply panels have reached saturation at levels in agreement with the 1.1 percent design moisture level for AS-1/6350 graphite/epoxy. Fourteen and thirty-three ply panels are not expected to reach saturation for several years.

A comparison of predicted versus measured moisture content for six ply panels weathered in Stratford, Connecticut is typical, and presented in Figure 13. As seen in the plot, measured moisture values are in good accord with predicted levels.

4.2 Coupon Strength Tests

4.2.1 Static Strength

Coupons were also removed from the environmentally exposed panels for mechanical testing. Flexural shear, static short beam shear, and short beam shear fatigue tests were conducted on graphite/epoxy specimens. The static flexural properties were determined in accordance with ASTM D 790, Reference (5). Static and fatigue short beam shear strengths were determined in accordance with the methods previously described. Tensile tests were conducted on Kevlar/epoxy coupons, in accordance with ASTM D 3039, Reference (6). Specimen configurations were as shown in Figure 14. Results of all coupon tests are summarized in Table XVII.

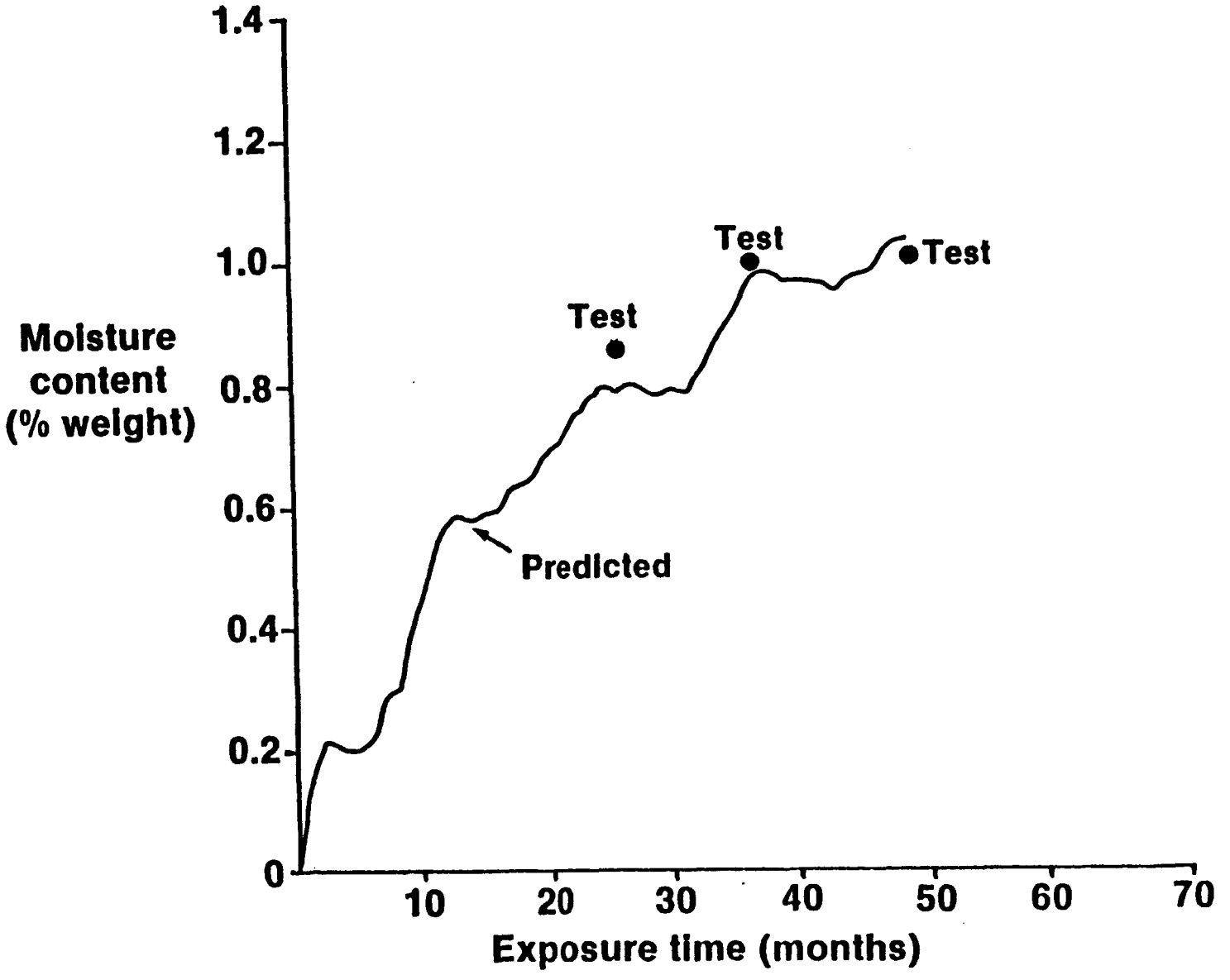
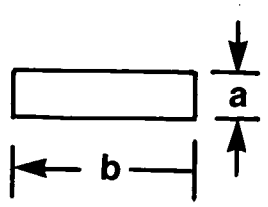


FIGURE 13. MEASURED AND PREDICTED MOISTURE LEVEL FOR SIX PLY AS1/6350 GRAPHITE EPOXY PANELS (WEATHERED IN STRATFORD, CONNECTICUT)

TABLE XVI SUMMARY OF MOISTURE MEASUREMENTS FOR FIELD EXPOSED PANELS

MATERIAL	NUMBER OF PLIES	EXPOSURE LOCATION	EXPOSURE TIME (MONTHS)	PERCENT MOISTURE (BY WEIGHT)
AS1/6350 GRAPHITE/ EPOXY	6	WPB	26	1.02
			35	1.23
			48.5	1.15
		WPB	60.5	DIP*
		STRATFORD	25	0.86
			36	1.00
			49	0.99
	6	STRATFORD	62	DIP*
AS1/6350 GRAPHITE/ EPOXY	14	STRATFORD	25	0.37
			34.5	0.48
			48	0.44
	14	STRATFORD	61	DIP*
AS1/6350 GRAPHITE/ EPOXY	33	WPB	26	0.27
			35	0.37
			48.5	0.35
		WPB	60.5	DIP*
		STRATFORD	25	0.18
			36	0.22
			49.5	0.24
	33	STRATFORD	62	DIP*
285/5143 KEVLAR/ EPOXY	5	WPB	26	1.56
			35	2.08
			48.5	1.90
		WPB	60.5	DIP*
		STRATFORD	26	1.53
			37	1.72
			50	1.75
	5	STRATFORD	63	DIP*

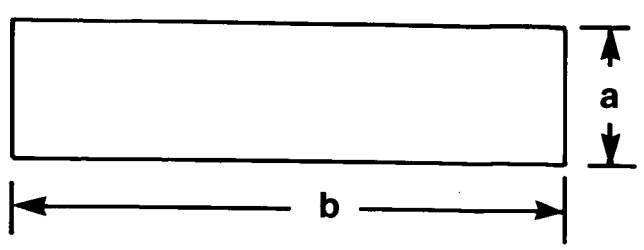
NOTE: DIP* - DESORPTION IN PROGRESS



AS/6350 Where:

a=0.25 in b=1.0 in	For 6 ply panels
a=0.25 in b=1.0 in	For 14 ply panels
a=0.4 in b=3.5 in	For 33 ply panels

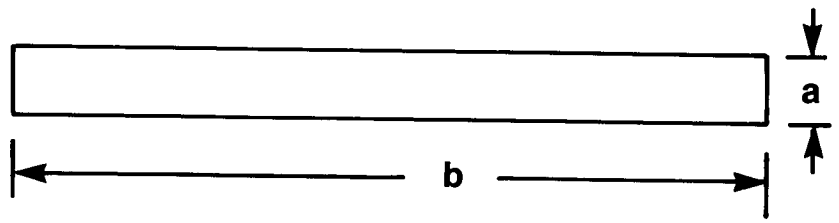
(a) Short Beam Shear Specimen Configuration



AS/6350 Where:

a=1.0 in b=4.0 in	For 6 ply panels
a=1.0 in b=5.5 in	For 14 ply panels
a=0.5 in b=11.0 in	For 33 ply panels

(b) Flexural (Bending) Shear Specimen Configuration



285/5143 Where:

a=.875 in b=16.5 in	For 5 ply panels

(c) Tensile Specimen Configuration

FIGURE 14. LIFE EXTENSION PROGRAM TEST SPECIMEN CONFIGURATIONS

TABLE XVII. SUMMARY OF COUPON TEST RESULTS FOR FIELD EXPOSED PANELS

Material	Test	Ply Orientation	Number of Tests	Test Temperature °C	(°F)	Strength MPa	(KSI)	Coefficient of Variation	Exposure
Graphite/ Epoxy AS1/6350	SBS, Static	0_6	23	23.8	(75)	110.3	(16.0)	4.6	Qualification Baseline, RTD
	SBS, Static	0_6	19	23.8	(75)	113.1	(16.4)	5.7	Panel Coupons, Baseline RTD
	SBS, Static	0_6	18	23.8	(75)	100.7	(14.6)	5.0	2 Years, Stratford
	SBS, Static	0_6	18	23.8	(75)	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 Coupons, Baseline RTD
	SBS, Static	$(0_{12}/-20/0/+20/0_{1.5})_S$	15	23.8	(75)	83.4	(12.1)	5.3	2 Years, Stratford
	SBS, Static	$(0_{12}/-20/0/+20/0_{1.5})_S$	15	23.8	(75)	84.1	(12.2)	5.0	2 Years, West Palm Beach
	SBS, Static	0_6	18	23.8	(75)	91.0	(13.2)	3.7	3 Years, Stratford
	SBS. Static	0_6	18	23.8	(75)	95.9	(13.9)	2.5	3 Years, Stratford
	SBS, Static	0_6	18	23.8	(75)	89.0	(12.9)	3.1	3 Years, West Palm Beach
	SBS, Static	0_6	18	23.8	(75)	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
	SBS, Static	0_6	18	23.8	(75)	89.6	(13.0)	3.4	4 Years, Stratford
	SBS, Static	0_6	18	23.8	(75)	90.3	(13.1)	1.9	4 Years, West Palm Beach
	SBS, Static	0_{14}	18	23.8	(75)	89.6	(13.0)	4.3	4 Years, Stratford
	SBS, Static	0_{14}	18	76.6	(170)	67.6	(9.8)	4.8	4 Years, Stratford
	SBS, Static	$(0_{12}/-20/0/+20/0_{1.5})_S$	14	23.8	(75)	82.0	(11.9)	3.8	4 Years, Stratford
	SBS, Static	$(0_{12}/-20/0/+20/0_{1.5})_S$	10	23.8	(75)	80.0	(11.6)	3.3	4 Years, West Palm Beach
	SBS, Static	0_6	18	23.8	(75)	90.0	(12.9)	4.8	5 Years, Stratford
	SBS, Static	0_6	18	23.8	(75)	90.0	(12.9)	2.9	5 Years, Stratford
	SBS, Static	0_6	18	23.8	(75)	84.8	(12.3)	3.7	5 Years, West Palm Beach
	SBS, Static	0_6	18	23.8	(75)	86.9	(12.6)	3.5	5 Years, West Palm Beach
	SBS, Static	0_{14}	18	23.8	(75)	93.1	(13.5)	2.6	5 Years, Stratford
	SBS, Static	0_{14}	18	76.6	(170)	64.1	(9.3)	2.2	5 Years, Stratford
	SBS, Static	$(0_{12}/-20/0/+20/0_{1.5})_S$	18	23.8	(75)	80.5	(11.7)	3.5	5 Years, Stratford
	SBS, Static	$(0_{12}/-20/0/+20/0_{1.5})_S$	18	23.8	(75)	78.8	(11.4)	4.0	5 Years, West Palm Beach
	Tension,Static	$(0/90)_6$	14	23.8	(75)	590.2	(85.6)	4.4	Qualification Baseline RTD
	Tension,Static	$(0/90)_5$	18	23.8	(75)	631.5	(91.6)	6.0	Panel Coupon, Baseline RTD
Kevlar/ Epoxy 285/5143	Tension,Static	$(0/90)_5$	9	23.8	(75)	666.7	(96.7)	8.7	2 Years, Stratford
	Tension,Static	$(0/90)_5$	10	23.8	(75)	632.2	(91.7)	6.5	2 Years, West Palm Beach
	Tension,Static	$(0/90)_5$	10	23.8	(170)	677.7	(98.3)	6.6	2 Years, Stratford
	Tension,Static	$(0/90)_5$	7	23.8	(75)	476.6	(96.8)	6.5	3 Years, Stratford
	Tesnion,Static	$(0/90)_5$	7	23.8	(75)	465.5	(98.2)	12.9	3 Years, West Palm Beach
	Tension,Static	$(0/90)_5$	7	76.6	(170)	435.9	(85.3)	11.7	3 Years, Stratford
	Tension,Static	$(0/90)_5$	7	76.6	(170)	419.3	(85.5)	6.6	3 Years, West Palm Beach

FOLDOUT FRAME

FOLDOUT FRAME

TABLE XVII. SUMMARY OF COUPON TEST RESULTS FOR FIELD EXPOSED PANELS (Continued)

Material	Test	Ply Orientation	Number of Tests	Test Temperature °C	(°F)	Strength MPa	(KSI)	Coefficient of Variation	Exposure
	Tension,Static	$(0/90)_5$	8	23.8	(75)	688.6	(99.8)	4.9	4 Years, Stratford
	Tension,Static	$(0/90)_5$	7	23.8	(75)	672.5	(97.5)	3.3	4 Years, West Palm Beach
	Tension,Static	$(0/90)_5$	8	76.6	(170)	688.3	(99.8)	7.6	4 Years, Stratford
	Tension,Static	$(0/90)_5$	4	23.8	(75)	602.1	(87.3)	4.0	5 Years, Stratford
	Tension,Static	$(0/90)_5$	4	23.8	(75)	644.1	(93.4)	6.0	5 Years, Stratford
	Tension,Static	$(0/90)_5$	4	23.8	(75)	646.2	(93.7)	2.8	5 Years, West Palm Beach
	Tension,Static	$(0/90)_5$	4	23.8	(75)	627.6	(91.0)	9.2	5 Years, West Palm Beach
	Tension,Static	$(0/90)_5$	4	76.6	(170)	636.6	(92.3)	2.0	5 Years, Stratford
	Tension,Static	$(0/90)_5$	4	76.6	(170)	629.7	(91.3)	7.7	5 Years, Stratford
	Tension,Static	$(0/90)_5$	4	76.6	(170)	664.7	(97.1)	6.4	5 Years, West Palm Beach
	Tension,Static	$(0/90)_5$	4	76.6	(170)	651.0	(94.4)	5.3	5 Years, West Palm Beach
Graphite/ Epoxy AS/6350	Flex, Static	0_6	20	23.8	(75)	1696.0	(246.0)	5.9	Panel Coupon Baseline RTD
	Flex, Static	0_6	18	23.8	(75)	1782.3	(268.5)	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	$(0_{12}/-20/0/+20/0_{1\cdot5})_S$	13	23.8	(75)	1209.3	(175.4)	5.5	Panel Coupon Baseline RTD
	Flex, Static	$(0_{12}/-20/0/+20/0_{1\cdot5})_S$	18	23.8	(75)	1260.3	(182.8)	6.7	2 Years, Stratford
	Flex, Static	$(0_{12}/-20/0/+20/0_{1\cdot5})_S$	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	$(0_{12}/-20/0/+20/0_{1\cdot5})_S$	12	23.8	(75)	1185.5	(171.9)	6.4	3 Years, West Palm Beach
	Flex, Static	$(0_{12}/-20/0/+20/0_{1\cdot5})_S$	12	23.8	(75)	1235.2	(179.1)	6.0	3 Years, Stratford
	Flex, Static	0_6	18	23.8	(75)	1761.6	(255.5)	6.5	4 Years, Stratford
	Flex, Static	0_6	18	23.8	(75)	1860.9	(269.9)	7.3	4 Years, West Palm Beach
	Flex, Static	0_{14}	18	23.8	(75)	1431.4	(207.6)	3.7	4 Years, Stratford
	Flex, Static	0_{14}	18	23.8	(75)	1391.4	(201.8)	3.5	4 Years, Stratford
	Flex, Static	$(0_{12}/-20/0/+20/0_{1\cdot5})_S$	12	23.8	(75)	1206.6	(175.0)	4.3	4 Years, Stratford
	Flex, Static	$(0_{12}/-20/0/+20/0_{1\cdot5})_S$	12	23.8	(75)	1142.5	(165.7)	4.0	4 Years, West Palm Beach
	Flex, Static	0_6	18	23.8	(75)	1681.4	(243.8)	7.1	5 Years, Stratford
	Flex, Static	0_6	18	23.8	(75)	1730.3	(250.9)	7.1	5 Years, Stratford
	Flex, Static	0_6	18	23.8	(75)	1620.0	(234.9)	8.0	5 Years, West Palm Beach
	Flex, Static	0_6	18	23.8	(75)	1620.0	(234.9)	6.6	5 Years, West Palm Beach
	Flex, Static	0_{14}	18	23.8	(75)	1453.8	(210.8)	4.4	5 Years, Stratford

TABLE XVII. SUMMARY OF COUPON TEST RESULTS FOR FIELD EXPOSED PANELS (Continued)

Material	Test	Ply Orientation	Number of Tests	Test Temperature °C	(°F)	Strength MPa	(KSI)	Coefficient of Variation	Exposure
	Flex, Static	0_{14}	18	23.8	(75)	1453.8	(210.8)	3.8	5 Years, Stratford
	Flex, Static	0_{14}	18	23.8	(75)	1476.6	(214.1)	3.8	5 Years, Stratford
	Flex, Static	$(0_{12}/-20/0/+20/0_{1\cdot5})_S$	18	23.8	(75)	1209.7	(175.4)	4.5	5 Years, Stratford
	Flex, Static	$(0_{12}/-20/0/+20/0_{1\cdot5})_S$	18	23.8	(75)	1174.5	(170.3)	3.5	5 Years, West Palm Beach
Graphic/ Epxoy AS/6350	SBS, Fatigue	0_6	10	23.8	(75)	64.1	(9.3)[1]		Qualification Baseline RTD
	SBS, Fatigue	0_6	4	23.8	(75)	58.6	(8.5)[1]		2 Years, Stratford
	SBS, Fatigue	$(0_{12}/-20/0/+20/0_{1\cdot5})_S$	9	23.8	(75)	53.4	(7.7)[1]		Panel Coupon Baseline RTD
	SBS, Fatigue	$(0_{12}/-20/0/+20/0_{1\cdot5})_S$	12	23.8	(75)	43.4	(6.3)[1]		2 Years, Stratford
	SBS, Fatigue	$(0_{12}/-20/0/+20/0_{1\cdot5})_S$	10	23.8	(75)	42.1	(6.1)[1]		2 Years, West Palm Beach
	SBS, Fatigue	$(0_{12}/-20/0/+20/0_{1\cdot5})_S$	14	23.8	(75)	50.6	(7.3)[1]		3 Years, West Palm Beach
	SBS, Fatigue	$(0_{12}/-20/0/+20/0_{1\cdot5})_S$	14	23.8	(75)	56.5	(8.2)[1]		4 Years, West Palm Beach

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

5.0 ANALYSIS OF TEST RESULTS

5.1 Environmental Factor Trends

In evaluating environmental effects on composite materials, results of component coupon and panel testing are compared to environmental factor trends determined previously for AS1/6350 graphite/epoxy and 285/5143 Kevlar/epoxy. The static environmental factor is defined as the ratio of mean strength at the environmental condition to the mean room temperature dry strength.

Figure 15 compares AS1/6350 panel test results with a plot of the environmental factor trends for interlaminar shear. Test data falls in accord with laboratory predictions. Figures 16 and 17 compare panel test results with plots of the environmental factor trends for flexural shear and tensile strengths, for AS1/6350 and 285/5143 respectively. Examination of the plots shows results obtained in panel tests to be consistently above environmental factor requirements.

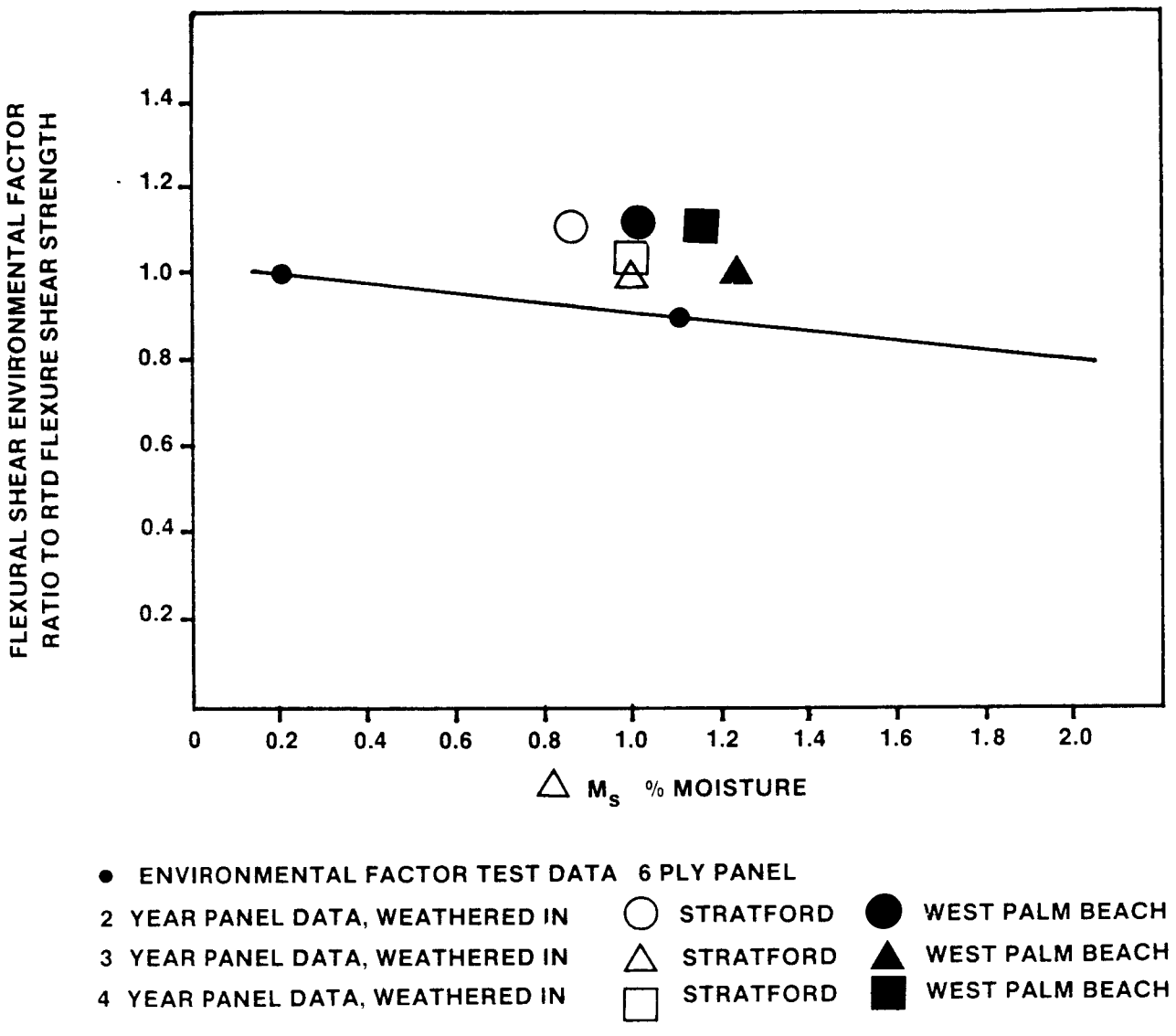


FIGURE 15 COMPARISON OF LIFE EXTENSION PROGRAM FLEXURAL SHEAR ENVIRONMENTAL FACTOR DATA WITH AS1/6350 ENVIRONMENTAL FACTOR TRENDS

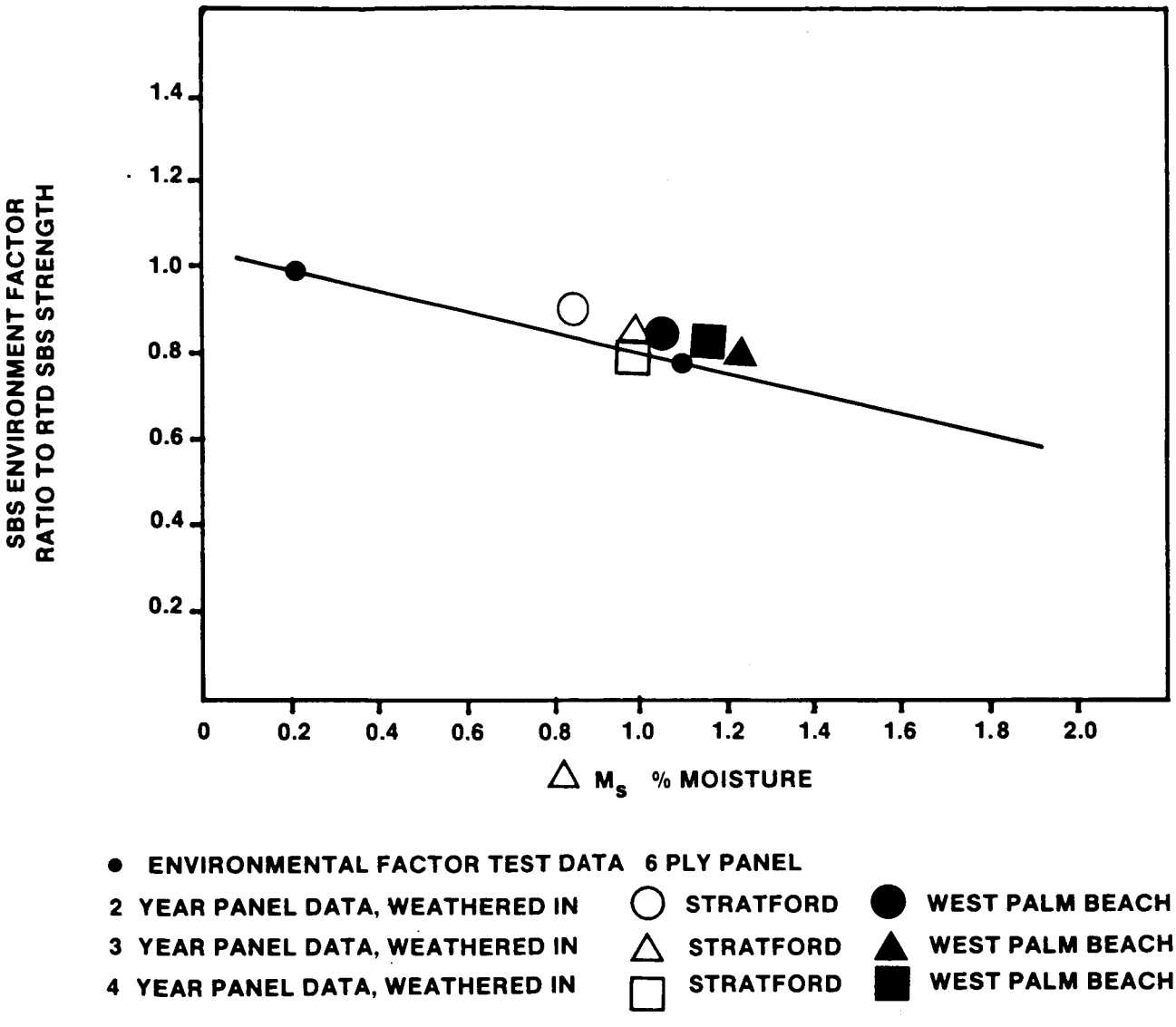


FIGURE 16 COMPARISON OF LIFE EXTENSION PROGRAM INTERFAMINAR SHEAR (STATIC) ENVIRONMENTAL FACTOR DATA WITH AS1/6350 ENVIRONMENTAL FACTOR TRENDS

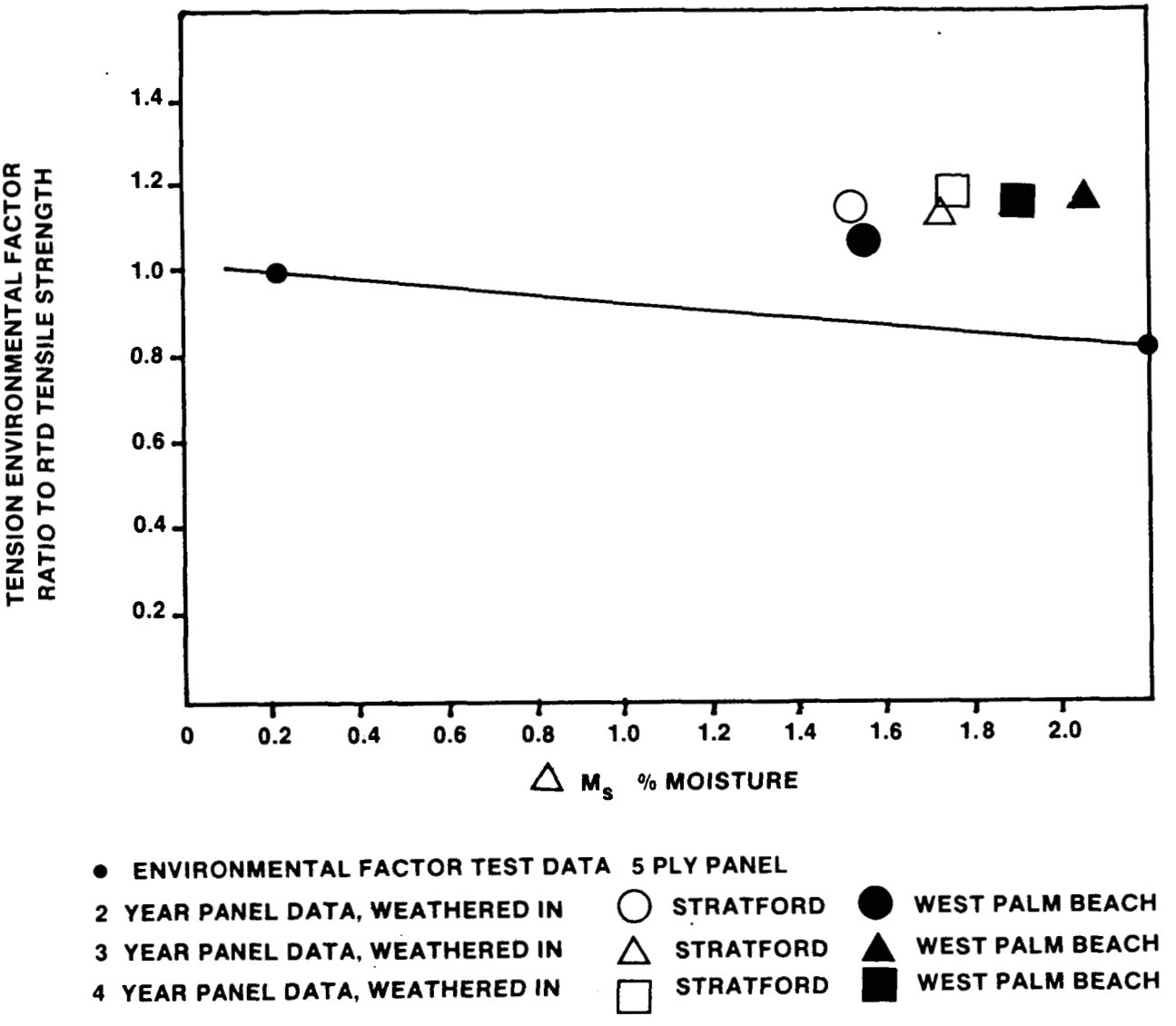


FIGURE 17 COMPARISON OF LIFE EXTENSION PROGRAM TENSION ENVIRONMENTAL FACTOR DATA WITH 285/5143 ENVIRONMENTAL FACTOR TRENDS

7.0 REFERENCES

References	Title
(1)	Rich, M. and Lowry, D. "Flight Service Evaluation of Composite Helicopter Components," First Annual Report March 1981 through April 1982, NASA CR-165952, (SER-510089) June 1982
(2)	Rich, M. and Lowry, D. "Flight Service Evaluation of Composite Helicopter Components" Second Annual Report May 1982 through September 1983, NASA CR-172562 (SER-510117), April 1985
(3)	ASTM D 2344-84, "Standard Test Method for Apparent Horizontal Shear Strength of Reinforced Plastics by Short Beam Method"
(4)	"Modern Elementary Statistics" John E. Freund, 1979 Prentice-Hall, Incorporated, Englewood Cliffs, New Jersey 07632, 1977
(5)	ASTM D 790-81, "Standard Methods of Test for Flexural Properties of Plastics"
(6)	ASTM D 3039-84, "Standard Test Method for Tensile Properties of Oriented Fiber Composites"

6.0 CONCLUSIONS

6.1 Conclusions

The following conclusions are based on the results of composite components and panels having up to five years of environmental exposure that have been returned from the field for evaluation during this reporting period.

1. Full scale testing of two stabilizers, S/N B-157-00009 and S/N B-157-00021 produced fractures in the stabilizer torque box between Buttline 3 Left and Buttline 3 Right as expected.

2. Coupons removed from stabilizer S/N B-157-00009 for desorption indicated moisture levels comparable to 14 ply graphite/epoxy panels having 48 months exposure to the environment in Stratford, Connecticut. Desorption of moisture coupons removed from stabilizer S/N B-157-00021 is in progress.

3. Small scale coupon tests of tail rotor spar S/N A-116-00178 generated results that were somewhat (8-14 percent) higher than expected when compared with past spar coupon testing, but consistent with panel coupon data having 48 month environmental exposure.

4. Results of panel coupon testing supported laboratory predictions for environmental factor trends.

Standard Bibliographic Page

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16. Abstract

This report presents an assessment of composite helicopter tail rotor spars and horizontal stabilizers, exposed to the effects of the environment, after up to five and a half years of commercial service. This evaluation is supported by test results of helicopter components and panels which have been exposed to outdoor environmental effects since September 1979. Full scale static and fatigue tests have been conducted on graphite/epoxy and Kevlar/epoxy composite components obtained from Sikorsky Model S-76 helicopters in commercial operations in the Gulf Coast region of Louisiana. Small scale static and fatigue tests are being conducted on coupons obtained from panels under exposure to outdoor conditions in Stratford, Connecticut and West Palm, Florida. The panel layups are representative of the S-76 components. Additionally, this report discusses the results of moisture absorption evaluations and strength tests on the S-76 components and composite panels with up to five years of outdoor exposure.

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