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D.A. Jansen, K.L. Boyd
Analytical Services and Materials, Inc.
107 Research Drive
Hampton, Virginia 23666

Volume V: Verification of Humidity and Age Effects on C/KC-135 Aircraft Fuselage
Skin 2024-T3, 2024-T4, and 7075-T6 Aluminum Alloys.

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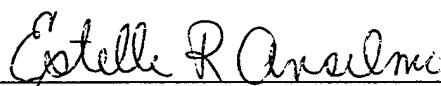
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DAVID S. CONLEY, Structural Integrity Engr
Fatigue, Fracture & Reliability Section


ESTELLE R. ANSELMO, Actg Tech Mgr
Fatigue, Fracture & Reliability Section


JEROME PEARSON, Chief
Structural Integrity Branch
Structures Division

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FOREWORD

This report was prepared by Analytical Services & Materials, Inc., Hampton Virginia for WL/FIBEC, Wright-Patterson Air Force Base, Ohio under contract F33615-94-D-3212, "Structural Integrity Analysis and Verification for Aircraft Structures." The contract monitor was Mr. James A. Harter, WL/FIBEC. The government project engineer responsible for this effort was Capt. Daniel J. Groner. The period of performance for this report was 4 May 95 through 31 Sept 95.

The work performed under this project (Delivery Order 0005) was performed by Analytical Services & Materials, Inc. personnel located at the WL/FIBEC Fatigue & Fracture Test Facility, Bldg. 65, Area B, Wright-Patterson AFB, OH. The Principal Investigator of this research was Mr. Kevin L. Boyd. The authors of this report were Mr. Daniel A. Jansen and Mr. Kevin L. Boyd. Technical inputs were submitted by Mr. James A. Harter and Capt. Daniel J. Groner.

1. INTRODUCTION

The C/KC-135 first entered service in 1957; as some of these aircraft approach 40 years of service, corrosion has become an important consideration in the aircraft structural health. Understanding the effects of age and humidity on the fatigue characteristics of the aircraft structure should improve the ability to monitor the aircraft structural health and reliability. This effort was part of the larger "Integrated C/KC-135 Corrosion Program Round Robin Test Program" sponsored by the Oklahoma City Air Logistics Center. The testing performed for this program was intended to characterize the fatigue crack growth behavior of aged 2024-T3, 2024-T4 and 7075-T6 Al alloys subjected to low (<15%) and high (>85%) levels of relative humidity. These materials were taken from retired C/KC-135 aircraft by government personnel and are believed to representative of the general fleet with respect to age and overall condition.

In order to quantify the degradation in material behavior due to the influence of age and humidity, it is very important that testing be performed under reduced variable conditions. By limiting variables to material age and environmental humidity, comparisons between data will better demonstrate the effect of those variables. For example, in two tests that differ only in the material's age, any variation in test results can be attributed to age with greater confidence. It is anticipated that the data generated under this research effort will aid in the understanding of age and humidity effects on the crack-growth behavior of 2024-T3, 2024-T4 and 7075-T6 Al alloys.

2. EXECUTIVE SUMMARY

The objective of this research was to characterize the effects of material age and environmental humidity on the fatigue-crack-growth behavior of 2024-T3, 2024-T4 and 7075-T6 Al alloys. These alloys were taken from the fuselage and wing skin of USAF C/KC-135 aircraft representative of the USAF fleet of C/KC-135 aircraft in age and mission use. The research was broken down into two activities: experimental testing and data reduction and comparison.

The experimental testing activity consisted of two tasks. The first task was to perform specimen testing under “wet” (>85% relative humidity) conditions while the second task was to perform testing under “dry” (<15% relative humidity) conditions. For each task, middle tension specimens of the three aluminum alloys had cracks grown from machined center notches to predetermined lengths before test data was recorded.

Test data was compared to data from the Damage Tolerant Design Handbook (WL-TR-94-4055) and WL/FIBEC in-house data to determine the effects of age and humidity. The in-house data was obtained, over time, from standard laboratory test specimens. This “standard” data was generally from pristine material that had been taken from sheet or plate stock. Standard tests were generated under ambient air, temperature, and humidity conditions.

Plots of da/dN vs. ΔK indicated that the fatigue crack growth rates of the 7075-T6 Al alloy were influenced by the presence of humidity while the fatigue crack growth rates of the 2024 Al alloys were not.

Additionally, age comparisons made for 2024-T3 aluminum suggested no age effects, whereas comparisons for 7075-T6 aluminum were inconclusive due to the lack of control data. Age comparisons were not made for 2024-T4 aluminum due to the lack of data for non-aged material.

3. TESTING

3.1. Specimen Configurations

The specimens used in this test program were prepared by Boeing-PSD Engineering and delivered in "as-received" condition [1]. "As-received" means that the material was obtained from the fuselage of retired C/KC-135 aircraft without artificial corrosion. The alloys were all clad, with nominal thickness of 0.063 inches, and TL specimen orientation. The test specimens were prepared as ASTM E647-93 Middle Tension specimens with EDM wire cut starter notches (Figure 1). The area local to the starter notch had been polished to facilitate optical crack measurement and protected with special cellophane tape which had no adhesive residue.

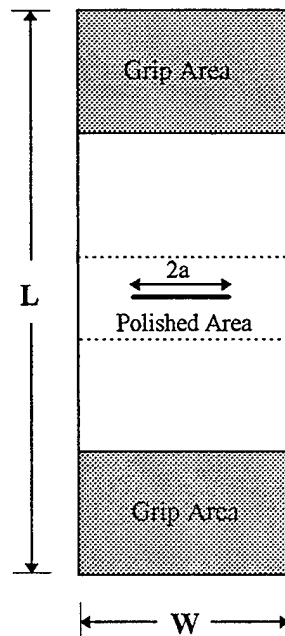


Figure 1 Typical Middle Tension Specimen According to ASTM E647-93

The nominal specimen dimensions are shown in the table below:

Table 1 Nominal Specimen Dimensions

Alloy	# of Specimens	Width	Length	Thickness	Starter Notch (2a)
2024-T3	8	1.75	7.0	0.063	0.350
2024-T4	8	1.50	6.0	0.063	0.300
7075-T6	8	1.75	7.0	0.063	0.350

3.2. Testing Apparatus

All testing was performed in the Fatigue & Fracture Test Facility, Building 65, Area B, Wright-Patterson AFB, Ohio. The specimens were tested in either a 35 kip or 20 kip MTS servo-hydraulic fatigue test frame using 5 kip and 2 kip load range settings respectively. These test frames are numbered 14 and 15 in the test facility. All tests were conducted at 10 Hz. These test frames were operated in load control using MTS Model 458 test controllers with load signals generated on MS-DOS based computers running MATE software. MATE, MAterial Test and Evaluation, is a software package written by the University of Dayton Research Institute. Load cell data from the MTS Model 458 was recorded using High Gain DC conditioners and a Model RS3800 strip chart recorder. Crack lengths were measured optically using Gaertner Scientific microscopes mounted on Velmex Unislide precision sliding assemblies with a graduated scale of precision ± 0.0005 inches.

The two humidity conditions tested were artificially introduced using an ordinary aquarium air pump to pump air into a column of water (or desiccant), then into a small chamber surrounding the test specimen. The air pump was controlled by a humidity sensor mounted in-line with an exhaust hose leading away from the chamber. For the "wet" testing, the column was filled with ASTM D1193 Type III or better reagent water to provide high humidity air. During the "dry" testing, the water was replaced with DESI-PAK, a clay mineral desiccant from United Catalysts Inc. The desiccant conformed to standard Mil-D-3464E. These setups easily provided a relative humidity above 85% and below 15%, respectively.

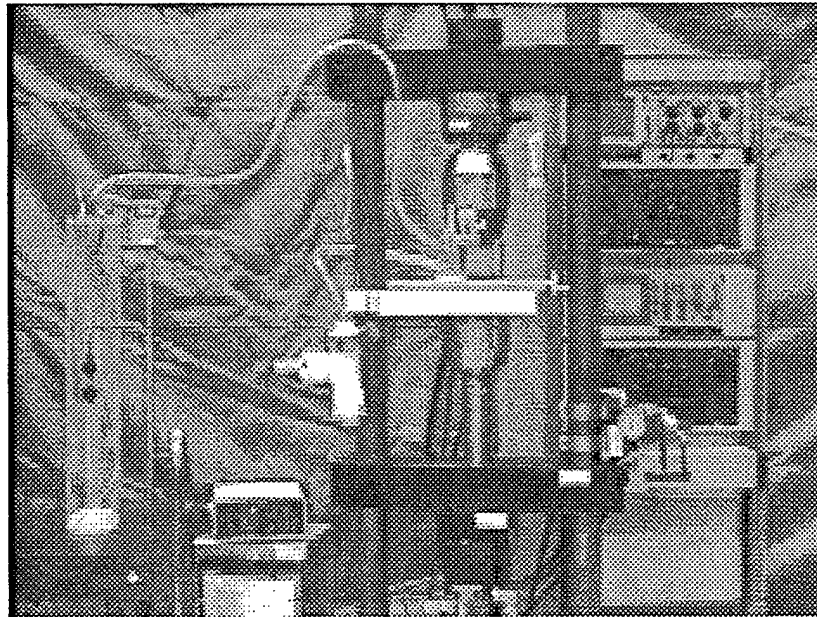


Figure 2 Typical Test Apparatus Showing Configuration for "Dry" Test

3.3. Testing Conditions

The test program consisted of three materials, two stress ratios ($R = \sigma_{\min}/\sigma_{\max}$), and two humidity ranges as shown in Table 2.

Table 2 Test Matrix for Humidity Effects

Alloy	# of Specimens	Stress Ratio	Humidity Level
2024-T3	2 each	0.05	>85%
			<15%
		0.50	>85%
			<15%
2024-T4	2 each	0.05	>85%
			<15%
		0.50	>85%
			<15%
7075-T6	2 each	0.05	>85%
			<15%
		0.50	>85%
			<15%

The specimens were subjected to the loads and conditions specified by the Integrated Round Robin Testing Program [1] and designated on each specimen traveling data sheet, as listed in Appendix A.

The crack for each specimen was grown an additional 0.100 inches from the starter notch during pre-cracking. The pre-cracking loads were identical to the test loads and were introduced under ambient humidity and temperature conditions. After pre-cracking, an environmental chamber was placed around the test specimen and environmental conditions were allowed to stabilize at the predetermined humidity levels before fatigue crack-growth rate testing began.

During testing, the specimens were subjected to constant amplitude fatigue loading with a frequency of 10 Hz at the designated maximum stress and stress ratio (R). The specimens were fatigued sufficiently for the total crack (2a) to grow 0.030 inches, at which time the crack was

measured. During crack measurement, the specimen was loaded to eighty percent of the test maximum stress to facilitate optical measurements.

The result of this testing was a record of crack length versus cycle count. The data was hand recorded on each specimen's traveling data sheet. These records can be found in Appendix B.

4. DATA REDUCTION

During testing, crack lengths were recorded at cyclic intervals sufficient to grow the total crack (2a) approximately 0.030 inches. These data were then transferred into an EXCEL spreadsheet where mathematical relationships were solved for stress intensities and crack-growth rates.

The secant method [2] was used to calculate fatigue crack-growth rates, where:

$$\frac{da}{dN} = \frac{((a_{r1} - a_{l1}) - (a_{r0} - a_{l0})) / 2}{(N_1 - N_0)} \quad \text{Equation 1}$$

where: a_{r1} = Current Right Crack Tip Measurement
 a_{r0} = Previous Right Crack Tip Measurement
 a_{l1} = Current Left Crack Tip Measurement
 a_{l0} = Previous Left Crack Tip Measurement
 N_1 = Current Cycle Count
 N_0 = Previous Cycle Count

This equation (5-1) gives the average crack-growth rate for the cyclic interval between the two measurements.

To calculate the applied stress intensity range, ΔK , the following equations were used:

$$\Delta K = \frac{\Delta P}{B} \sqrt{\frac{\pi \alpha}{2W} \sec\left(\frac{\pi \alpha}{2}\right)} \quad \text{Equation 2}$$

$$\alpha = \frac{2\left(\frac{(a_{r1} - a_{l1}) + (a_{r0} - a_{l0})}{4}\right)}{W} \quad \text{Equation 3}$$

where: ΔP = Maximum Load - Minimum Load for stress ratios greater than 0
 B = Thickness of the Specimen
 W = Width of the Specimen

This form of the stress intensity factor equation was used in order to calculate the stress intensity for the average crack length of the cyclic interval. This corresponded to the crack length used in the secant method of calculating the fatigue crack-growth rate (Equation 1).

These data were then plotted for da/dN vs. ΔK on a log-log graph and can be found in Section 5.

5. DATA ANALYSIS

To determine the effect of humidity on fatigue crack-growth rates, plots of da/dN vs. ΔK were compared by humidity level for the same materials at the same stress ratios. The data from this test program were compared to data retrieved from the Damage Tolerant Design Handbook [3] and existing in-house data to determine if there were any age effects

5.1. 2024-T3 Aluminum Alloy

Figures 3 and 4 contain the fatigue crack-growth rate data for the 2024-T3 Al alloy. Each figure contains data for four specimens tested at the same stress ratio but two different humidity levels. Also, the figures contain in-house data from pristine material for age comparisons.

Figure 3 shows the "wet" and "dry" data for $R=0.05$ and suggests no apparent humidity effect on the fatigue crack-growth rates of the 2024-T3 Al alloy. Since these data closely resemble in-house data, it might be concluded that aged material has the same fatigue crack-growth rate characteristics as new material. Likewise, the data for the tests at $R=0.50$ (shown in Figure 4) suggest the same conclusions.

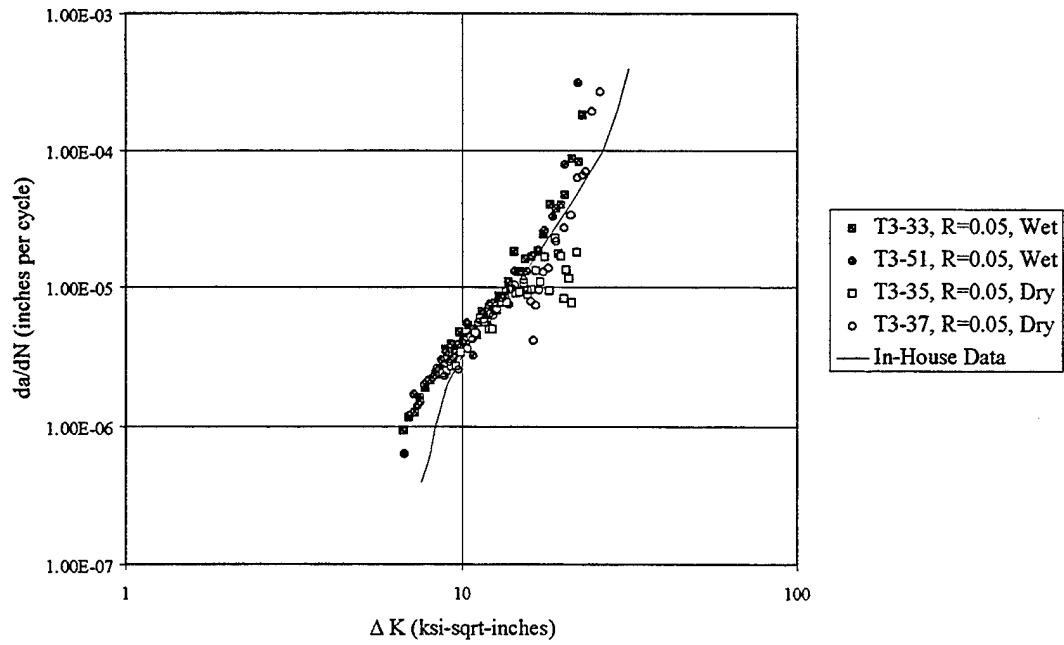


Figure 3 Fatigue Crack Growth Rates for 2024-T3 Al; R=0.05

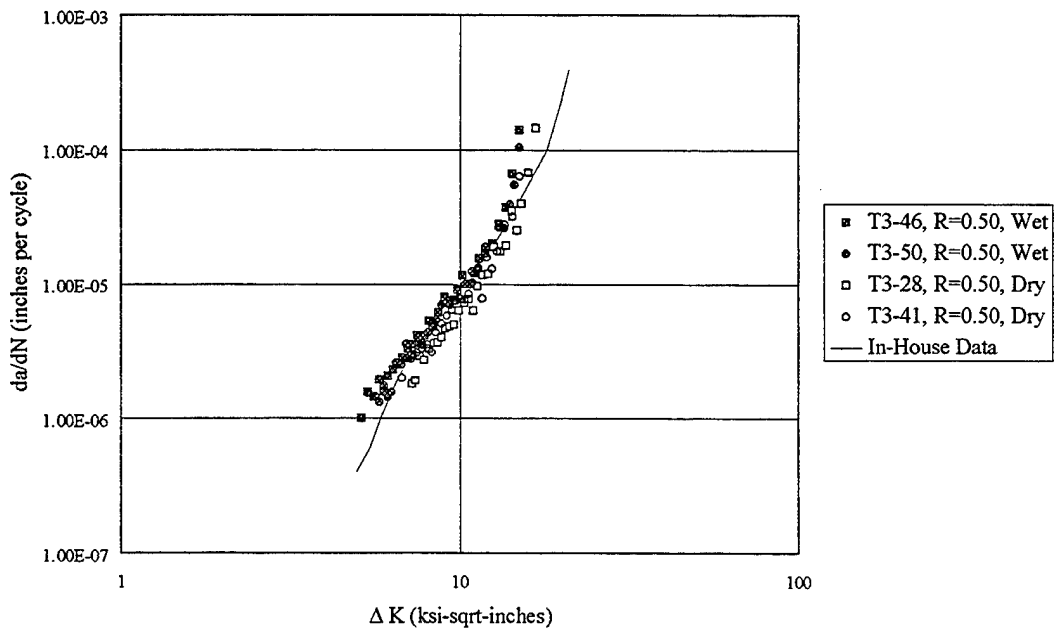


Figure 4 Fatigue Crack Growth Rates for 2024-T3 Al; R=0.50

5.2. 2024-T4 Aluminum Alloy

Figures 5 and 6 show the “wet” and “dry” crack-growth rate data for the 2024-T4 Al alloy. Each figure contains data for the same stress ratios but different humidity levels. There were no published fatigue-crack-growth-rate data available from the Damage Tolerant Design Handbook [3] or in-house to make comparisons between aged and new materials of this aluminum alloy. Therefore, there were no comparisons of this nature made in this report.

At both stress ratios, there was little or no variation of data due to humidity. While Figure 5 demonstrates some scatter of the data, the scatter is consistent within both humidity levels and does not necessarily indicate any appreciable differences in fatigue crack-growth rates. Figure 6 shows both “wet” and “dry” data at the higher stress ratio with less scatter and no apparent humidity effect.

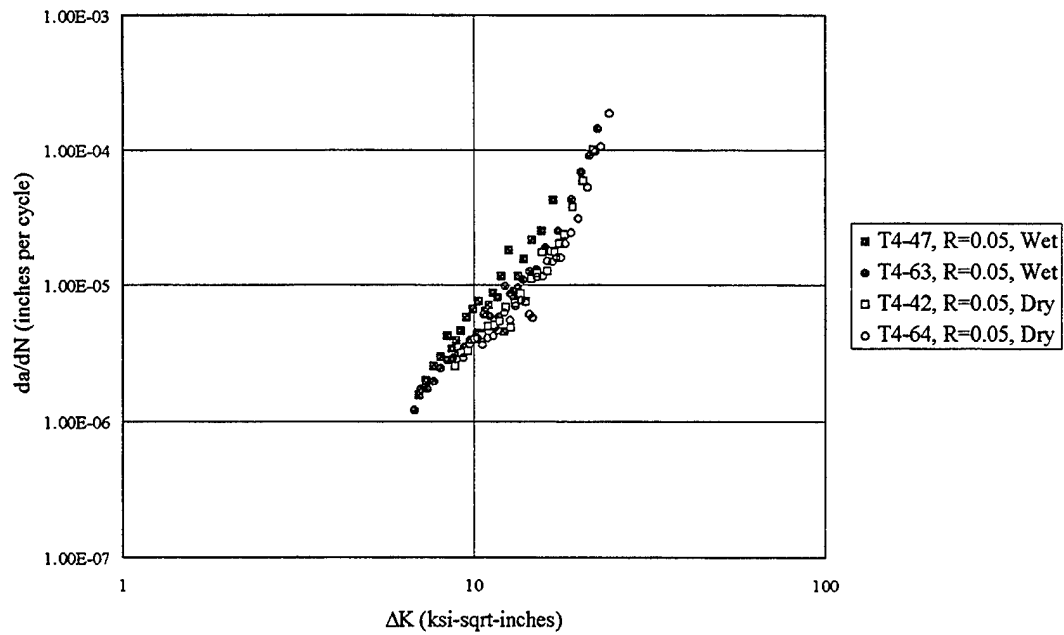


Figure 5 Fatigue Crack-Growth Rates for 2024-T4 Al; $R = 0.05$

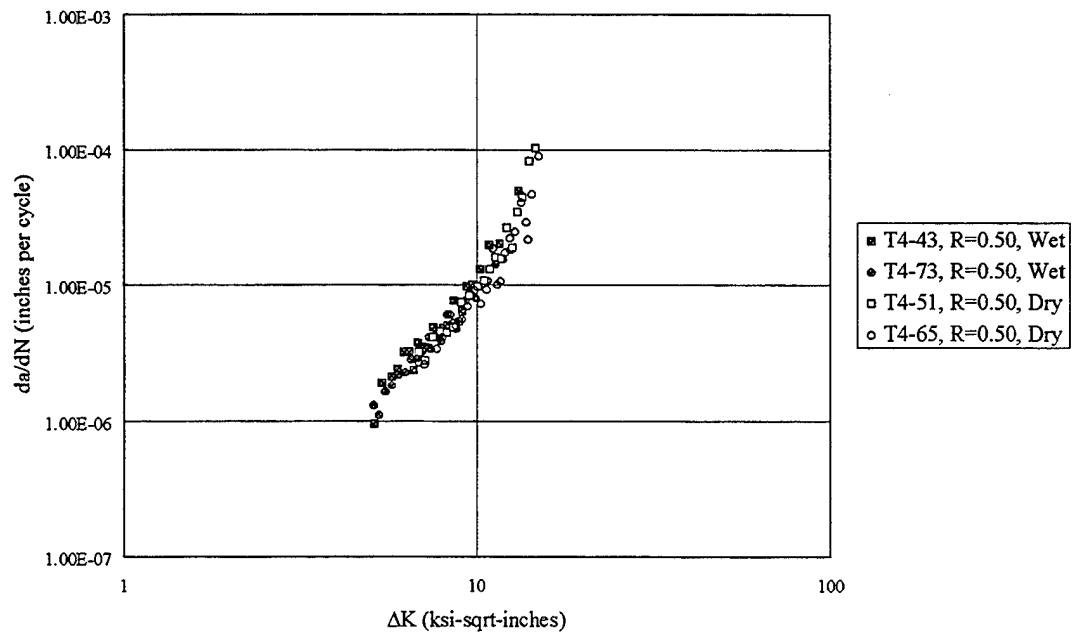


Figure 6 Fatigue Crack-Growth Rates for 2024-T4 Al; $R = 0.50$

5.3. 7075-T6 Aluminum Alloy

Figures 7 and 8 contain the fatigue crack-growth rate data for the 7075-T6 Al alloy. Figure 7 contains the limited data found in the Damage Tolerant Design Handbook [3] for 7075-T6 aluminum tested at a stress ratio of 0.50. It should be noted that both plots include in-house data for 7075-T651 aluminum. The 7075-T6 aluminum was not represented in the in-house data, and 7075-T651 aluminum was used because of its similarity in fatigue crack-growth rate behavior to the tested material. Both the handbook and in-house data correspond to non-aged material tested in room temperature lab air environments with "ambient" humidity levels of approximately 50-70% which could be used for age effect comparisons.

Both figures (7 and 8) show a clear difference in the fatigue crack-growth rates of 7075-T6 aluminum subjected to different humidity levels which could be attributed to the effect of humidity. Again in both figures, the "wet" test data agrees with the Design Handbook and the lower portion of the in-house data curve. This resemblance between data sets might be attributable to a lack of age effects or an interaction of the effects of age and humidity. The design of the test matrix and limited number of specimens did not allow for the isolation of possible age effects from humidity effects, so it is unclear what effect age had on the fatigue crack-growth rates of 7075-T6 aluminum.

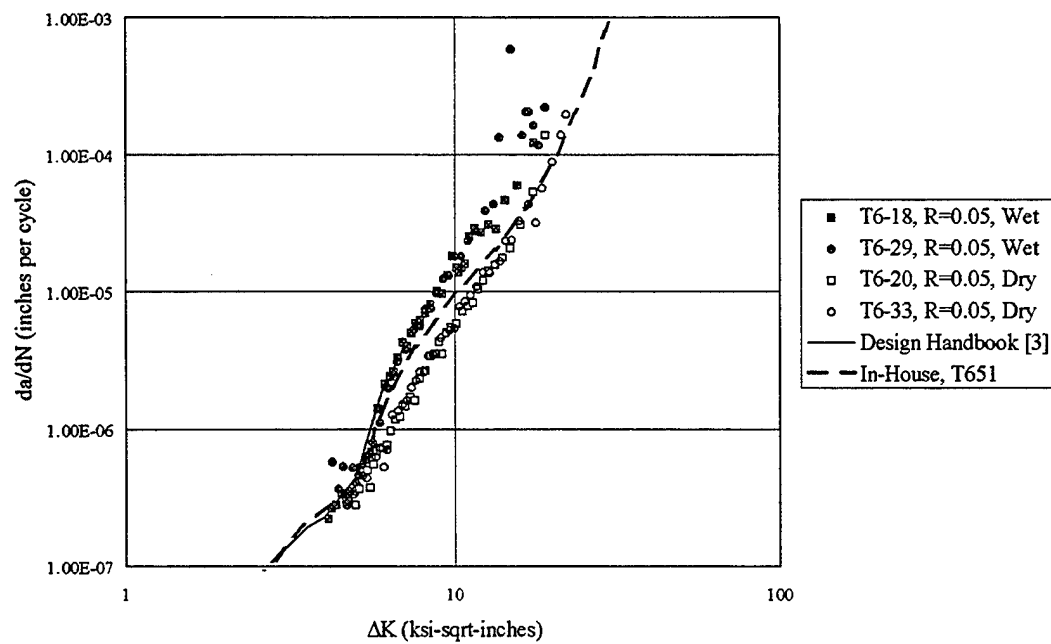


Figure 7 Fatigue Crack Growth Rates for 7075-T6 Al; R= 0.05

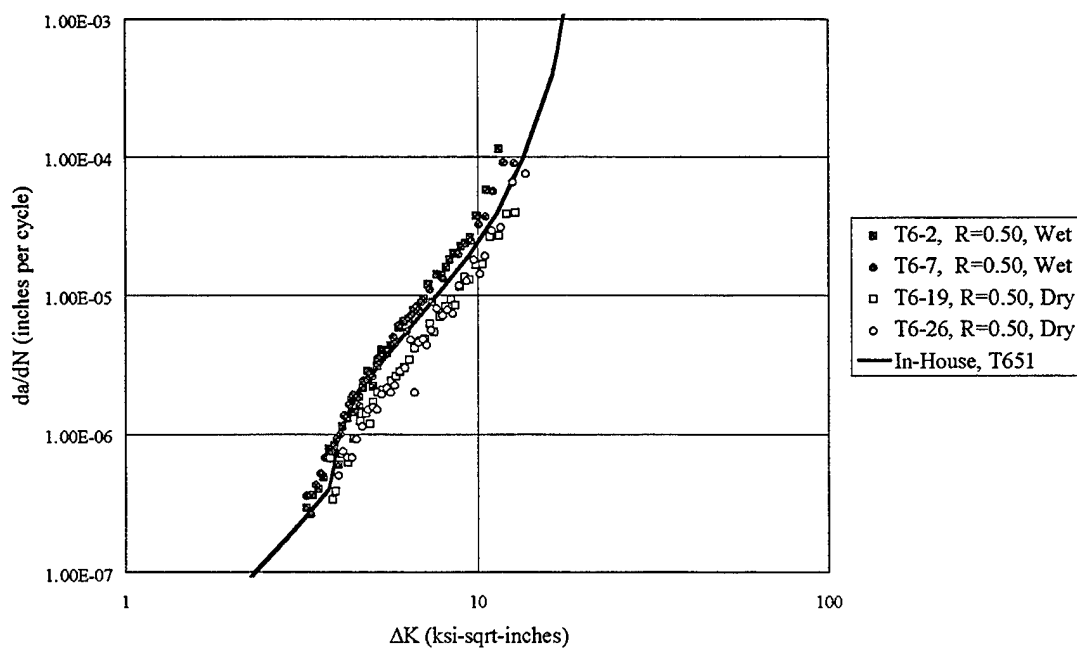


Figure 8 Fatigue Crack Growth Rates for 7075-T6 Al; R= 0.50

If there are no age effects, as was the case suggested for 2024-T3 aluminum, then two other observations might be made from examining Figures 7 and 8. First, at both stress ratios, the “wet” data agreed closely with the ambient data from the Design Handbook and in-house data while the data from the “dry” tests fell lower on the graphs. This may suggest that 7075-T6 Al alloy possesses a humidity level threshold where higher humidity levels would have no further effect on 7075-T6 aluminum’s fatigue crack growth rates.

Second, the separation between “wet” and “dry” data is less for the higher stress ratio than the lower. This smaller difference may suggest that the humidity effects are sensitive to the applied stress ratio, where a higher stress ratio diminishes the humidity effects.

6. CONCLUSIONS

This research effort included gathering data on three clad aluminum alloys removed from the fuselage of retired U.S. Air Force C/KC-135 aircraft more than 30 years old. These materials were 2024-T3, 2024-T4, and 7075-T6 Al alloys. The test was designed to further the understanding of the effects of humidity and age on the aluminum alloys' fatigue crack growth rates. The testing performed under this Delivery Order involved identical test specimen configurations subjected to fatigue loading while exposed to two different humidity levels, "wet" (>85%) and "dry" (<15%). Furthermore, these test results were compared to the results of similar tests involving relatively "new" materials to determine if there were any age effects.

Of the three materials, only the 7075-T6 aluminum demonstrated a humidity effect. For the two test conditions of "wet" and "dry" at stress ratios of $R=0.50$ and $R=0.05$, 7075-T6 Al displayed an increase of fatigue crack-growth rates in the "wet" environment. These results seem to indicate that the humidity effects were less pronounced in tests conducted at higher stress ratios. Other research examining the effects of corrosion have shown that corrosion effects are diminished by increasing load ratios [4]. Similarly, it would seem that increasing stress ratios may also diminish the effects of humidity.

Additionally, from the results of this effort it seems that fatigue crack-growth rates are similar for relative humidity levels of 60% and 90%, while humidity levels near 5% showed slightly lower crack growth rates. The lack of significant difference in fatigue crack growth rates at the two higher humidity levels suggests that humidity levels above a certain percentage will no longer

influence the fatigue crack-growth rate behavior of the 7075-T6 Al alloy. Additional testing, involving a range of humidity levels between 5% and 50-60%, may help to better understand at what levels humidity has no further effect on the fatigue crack-growth rates of 7075-T6 aluminum. Also, further testing would be required to determine the effect of stress ratio on humidity effects. Testing to include stress ratios of 0.7, 0.33, 0.02, and -1.0, which are represented in the Design Handbook, would provide "wet" data to compare against the Design Handbook's baseline data to better understand this phenomenon.

Of the two cases where age effects on fatigue crack-growth rates were examined in this report, 2024-T3 aluminum and 7075-T6 aluminum, only the 2024-T3 aluminum demonstrated no age effect. The results for 7075-T6 aluminum were inconclusive with respect to age, due to lack of data for aged specimens tested at ambient conditions. Therefore, no comparisons could be made with the non-aged data contained in the Design Handbook and in-house data. However, the lack of age effects on fatigue crack-growth rates of several materials has been demonstrated by the research of other organizations [5], which suggests the 7075-T6 aluminum examined in this effort would have behaved similarly. Also, it has been reported, that the effect of age on fatigue crack-growth rates of materials is minimal, while the effects attributed to corrosion appear much more severe [5,6,7].

7. REFERENCES

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8. APPENDICES

8.1. Appendix A - Loads and Conditions

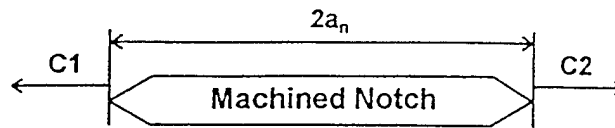
2024-T3			
Specimen #	Smax	Stress Ratio	Humidity
28	15.1	0.50	<15%
35	10.3	0.05	<15%
37	10.3	0.05	<15%
41	15.1	0.50	<15%
33	7.8	0.05	>85%
46	11.5	0.50	>85%
50	11.5	0.50	>85%
51	7.8	0.05	>85%

2024-T4			
Specimen #	Smax	Stress Ratio	Humidity
42	10.9	0.05	<15%
43	12.2	0.50	>85%
47	8.3	0.50	>85%
51	16	0.50	<15%
63	8.3	0.05	>85%
64	10.9	0.05	<15%
65	16	0.50	<15%
73	12.2	0.50	>85%

7075-T6			
Specimen #	Smax	Stress Ratio	Humidity
2	7.3	0.50	>85%
7	7.3	0.50	>85%
18	4.9	0.05	>85%
19	8.5	0.50	<15%
20	5.8	0.05	<15%
26	8.5	0.50	<15%
29	4.9	0.05	>85%
33	5.8	0.05	<15%

8.2. Appendix B - Test Data

TEST REQUIREMENTS									
Corrosion State		Smax	R-ratio		Cyclic Frequency		Relative Humidity		
As-received	Artificial	15.1	+0.05	+0.50	0.1hz	10hz	15%	>85%	



$$2a_{n\text{-nearside}} = 3.526 - 3.876$$

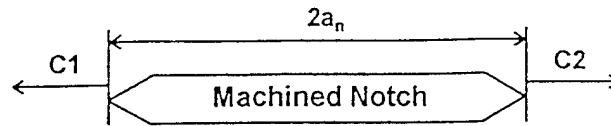
$$2a_{n\text{-farside}} = \underline{\hspace{2cm}}$$

View looking at specimen Near Side

TEST ACTUALS									
Specimen ID:		2024T3-28				NEAR SIDE		FAR SIDE	
PRE	Test date:	1 Aug 95	1 Aug 95	N		C1	C2	C2	C1
Lab ID Machine ID		WL/FIBEC	#14	17	1,504	3.233	4.174		
W(inch) t(inch):		1.7490 1.7507	0.06330 0.0632	18	1,304	3.216	4.187		
P _{max} (kip) P _{min} (kip):		1.679	0.8324	19	1304	3.193	4.212		
Temp(degF) %RH		71°	6.9%	20	1004	3.180	4.233		
	N	NEAR SIDE		FAR SIDE					
		C1	C2	C2	C1				
				21	804	3.168	4.251		
				22	602	3.144	4.268		
Pre-crack	46,503	3.477	3.939	23	403	3.137	4.281		
1	5,004	3.469	3.949	24	404	3.121	4.297		
2	5,002	3.459	3.958	25	304	3.101	4.318		
3	5,004	3.444	3.971	26	152	3.084	4.344		
4	5,003	3.432	3.985	27	35	2.827	4.575		
5	5,004	3.417	4.002	28					
6	4,003	3.402	4.015	29					
7	3,004	3.391	4.025	30					
8	3,002	3.379	4.037	31					
9	3,003	3.365	4.051	32					
10	3,004	3.351	4.066	33					
11	3,004	3.337	4.081	34					
12	3,002	3.318	4.100	35					
13	2,504	3.298	4.116	36					
14	2,003	3.281	4.130	37					
15	1,802	3.268	4.141	38					
16	1,703	3.251	4.156	39					

FATIGUE CRACK GROWTH RATE DATA SHEET

TEST REQUIREMENTS									
Corrosion State		Smax	R-ratio		Cyclic Frequency		Relative Humidity		
As-received	Artificial	10.3	+0.05	+0.50	0.1hz	10hz	<15%	>85%	



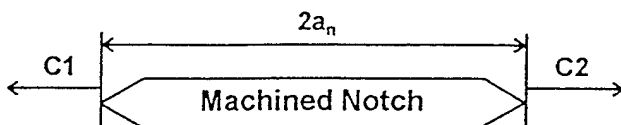
View looking at specimen Near Side

$$2a_{n\text{-nearside}} = 3.595 - 3.945$$

$$2a_{n\text{-farside}} = \underline{\hspace{2cm}}$$

TEST ACTUALS									
Specimen ID:		2024T3-35				NEAR SIDE		FAR SIDE	
PRE	Test date:	1 Aug 95	1 Aug 95	N		C1	C2	C2	C1
Lab ID Machine ID		WL/FIBEC	#15	17	1503	3.299	4.240		
W(inch) t(inch):		1.7525 1.7538	0.06350 0.0634	18	1,304	3.289	4.253		
P _{max} (kip) P _{min} (kip):		1.1498	0.0582	19	1307	3.276	4.268		
Temp(degF) %RH		71°	6.9%	20	1304	3.268	4.282		
	N	NEAR SIDE		FAR SIDE		21	1304	3.255	4.296
		C1	C2	C2	C1	22	1304	3.241	4.315
Pre-crack	35.007	3.548	3.997			23	1007	3.232	4.328
1	5,003	3.536	4.008			24	1006	3.212	4.341
2	5,005	3.525	4.022			25	1005	3.203	4.352
3	5,008	3.511	4.034			26	1024	3.183	4.379
4	5,005	3.496	4.047			27	604	3.169	4.385
5	5,004	3.478	4.062			28	604	3.164	4.390
6	4,003	3.461	4.078			29	604	3.155	4.397
7	3,007	3.447	4.091			30	607	3.148	4.404
8	3,005	3.432	4.104			31	907	3.140	4.410
9	3,006	3.416	4.124			32	907	3.124	4.426
10	2500	3.400	4.136			33	653	2.894	4.646
11	2,508	3.388	4.149			34			
12	2,504	3.375	4.162			35			
13	2505	3.360	4.182			36			
14	2004	3.344	4.197			37			
15	1804	3.330	4.210			38			
16	1707	3.315	4.228			39			

TEST REQUIREMENTS									
Corrosion State		Smax	R-ratio		Cyclic Frequency		Relative Humidity		
<u>As-received</u>	Artificial	10.3	<u>+0.05</u>	+0.50	0.1hz	<u>10hz</u>	<u><15%</u>	>85%	



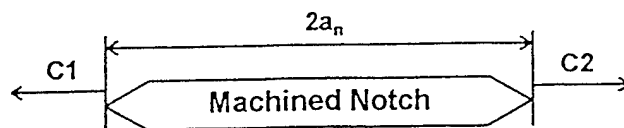
View looking at specimen Near Side

$$2a_{n-nearside} = 4.044 - \frac{3.694}{10}$$

$$2a_{n-farside} = \underline{\hspace{2cm}}$$

TEST ACTUALS						NEAR SIDE		FAR SIDE	
Specimen ID:		2024T3-37							
Test date:		8 Aug 95	8 Aug 95	N		C1	C2	C2	C1
Lab ID Machine ID		WL/FIBEL	#15	17	1,305	4.304	3.336		
W(inch) t(inch):		1.7540 1.7547	0.06340 0.0632	18	1,240	4.315	3.319		
P _{max} (kip) P _{min} (kip):		1.146	0.056	19	1,206	4.332	3.313		
Temp(degF) %RH		71°F	7.19%	20	1,205	4.347	3.310		
	N	NEAR SIDE		FAR SIDE					
		C1	C2	C2	C1				
Pre-crack	31,007	4.091	3.632			21	1,208	4.354	3.306
1	5,007	4.100	3.617			22	1,207	4.366	3.300
2	5,004	4.113	3.602			23	1,204	4.379	3.290
3	5,004	4.126	3.585			24	1,206	4.398	3.277
4	4,507	4.132	3.569			25	1,204	4.413	3.260
5	4,504	4.148	3.550			26	1,204	4.434	3.229
6	4,007	4.162	3.535			27	803	4.455	3.208
7	4,005	4.176	3.514			28	406	4.470	3.197
8	3,507	4.193	3.492			29	304	4.486	3.176
9	3,004	4.207	3.472			30	107	4.494	3.170
10	2,507	4.218	3.452			31	107	4.499	3.160
11	2,007	4.228	3.437			32	107	4.515	3.136
12	2,007	4.244	3.424			33	56	4.529	3.121
13	1,805	4.255	3.405			34	36	4.746	3.292
14	1,604	4.266	3.386			35			
15	1,408	4.278	3.371			36			
16	1,408	4.289	3.354			37			
						38			
						39			

TEST REQUIREMENTS									
Corrosion State		Smax	R-ratio		Cyclic Frequency		Relative Humidity		
As-received	Artificial	15.1	+0.05	+0.50	0.1hz	10hz	<15%	>85%	



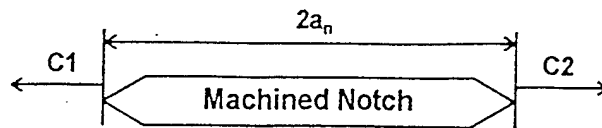
View looking at specimen Near Side

$$2a_{n-nearside} = 3.913 - 3.563$$

$$2a_{n-farside} =$$

TEST ACTUALS						NEAR SIDE		FAR SIDE	
Specimen ID:		2024T3-41							
Test date:		8 Aug 95		8 Aug 95		N			
Lab ID Machine ID		WL/FIBEC		#14		17		1,402	
W(inch) t(inch):		1.7510		0.0645		18		1.214	
P _{max} (kip) P _{min} (kip):		1.706		0.8545		19		1203	
Temp(degF) %RH		71° F		6.8%		20		1003	
	N	NEAR SIDE		FAR SIDE			N		
		C1	C2	C2	C1			C2	C1
Pre-crack	41,004	3.959	3.509			21	1004	4.254	3.171
1	5,003	3.969	3.499			22	1004	4.284	3.145
2	5,003	3.983	3.485			23	503	4.299	3.129
3	5,002	3.999	3.471			24	403	4.322	3.101
4	5,002	4.014	3.455			25	119	4.613	2.863
5	4,503	4.028	3.438			26			
6	4,503	4.043	3.421			27			
7	4,004	4.059	3.412			28			
8	4,004	4.075	3.392			29			
9	3,502	4.091	3.373			30			
10	3,004	4.110	3.357			31			
11	2,504	4.124	3.338			32			
12	2,003	4.140	3.324			33			
13	1,802	4.150	3.306			34			
14	1,703	4.160	3.290			35			
15	1,603	4.173	3.276			36			
16	1,502	4.185	3.258			37			
						38			
						39			

TEST REQUIREMENTS									
Corrosion State		Smax	R-ratio		Cyclic Frequency		Relative Humidity		
As-received	Artificial	10.9	+0.05	+0.50	0.1hz	10hz	<15%	>85%	



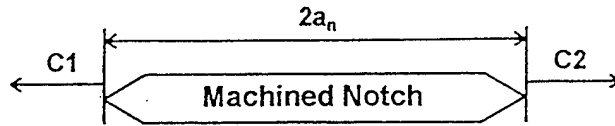
View looking at specimen Near Side

$$2a_{n\text{-nearside}} = 3.823 - 3.523$$

$$2a_{n\text{-farside}} = \underline{\hspace{2cm}}$$

TEST ACTUALS						NEAR SIDE		FAR SIDE	
Specimen ID:		2024T4-42							
Test date:		14 Aug 95	14 Aug 95	N		C1	C2	C2	C1
Lab ID Machine ID		WL/FIBEC	#14	17	603	4.148	3.247		
W(inch) t(inch):		1.4825	0.06250	18	602	4.160	3.239		
P _{max} (kip) P _{min} (kip):		1.014	0.046	19	604	4.170	3.229		
Temp(degF) %RH		76°	7.9%	20	603	4.185	3.221		
	N	NEAR SIDE		FAR SIDE					
		C1	C2	C2	C1				
Pre-crack	31,304	3.873	3.474			21	603	4.202	3.210
1	5,004	3.884	3.461			22	603	4.231	3.194
2	5,004	3.901	3.446			23	404	4.261	3.178
3	5,004	3.918	3.432			24	175	4.288	3.169
4	5,002	3.937	3.412			25	602	4.414	2.932
5	3,602	3.953	3.397			26			
6	3,602	3.973	3.382			27			
7	3,002	3.990	3.368			28			
8	3,003	4.008	3.354			29			
9	2,504	4.027	3.339			30			
10	2,004	4.038	3.331			31			
11	2,004	4.057	3.320			32			
12	1,756	4.073	3.305			33			
13	1,602	4.086	3.294			34			
14	1,604	4.105	3.278			35			
15	1,203	4.121	3.266			36			
16	902	4.139	3.254			37			
						38			
						39			

TEST REQUIREMENTS									
Corrosion State		Smax	R-ratio		Cyclic Frequency		Relative Humidity		
As-received	Artificial	16.0	+0.05	+0.50	0.1hz	10hz	<15%	>85%	



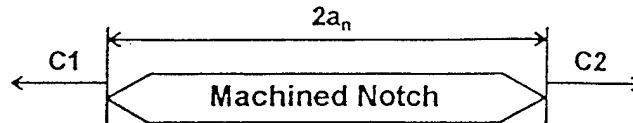
View looking at specimen Near Side

$$2a_{n-nearside} = 4.147 - 3.847$$

$$2a_{n-farside} = \underline{\hspace{2cm}}$$

TEST ACTUALS						NEAR SIDE		FAR SIDE	
Specimen ID:		2024T4-S1							
Test date:		14 Aug 95		14 Aug 95		N			
Lab ID Machine ID		WL/FIBEC		#15		C1		C2	
W(inch) t(inch):		1.4820		0.06650					
P _{max} (kip) P _{min} (kip):		1.481		0.733					
Temp(degF) %RH		76°		8.1%					
	N	NEAR SIDE		FAR SIDE					
		C1	C2	C2	C1				
Pre-crack	37.007	4.199	3.799						
1	5.003	4.212	3.780						
2	5.007	4.229	3.769						
3	5.007	4.250	3.749						
4	4.1004	4.269	3.733						
5	3.604	4.282	3.714						
6	3.608	4.299	3.696						
7	3.004	4.317	3.671						
8	3.005	4.344	3.648						
9	2.005	4.306	3.631						
10	1.508	4.384	3.616						
11	1.005	4.397	3.603						
12	1.186	4.416	3.584						
13	707	4.428	3.574						
14	704	4.448	3.557						
15	500	4.457	3.546						
16	406	4.468	3.530						

TEST REQUIREMENTS									
Corrosion State		Smax	R-ratio		Cyclic Frequency		Relative Humidity		
As-received	Artificial	16.0	+0.05	+0.50	0.1hz	10hz	<15%	>85%	



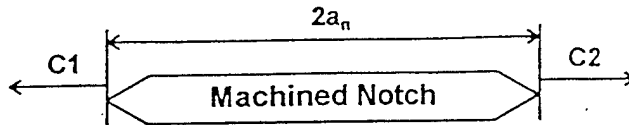
View looking at specimen Near Side

$$2a_{n-nearside} = 4.095 - 3.796$$

$$2a_{n-farside} =$$

TEST ACTUALS		View looking at Specimen Near Side							
Specimen ID:		2024T4-65				NEAR SIDE		FAR SIDE	
PRE	Test date:	4 Aug 95	7 Aug 95		N	C1	C2	C2	C1
Lab ID Machine ID	WL/FIBEC		#15	17	607	4.402	3.499		
W(inch) t(inch):	1.41825		0.0628	18	504	4.411	3.484		
P _{max} (kip) P _{min} (kip):	1.4913		0.7382	19	441	4.429	3.467		
Temp(degF) %RH	69°		7.5%	20	207	4.437	3.463		
		NEAR SIDE		FAR SIDE		21	207	4.443	3.460
	N	C1	C2	C2	C1	22	257	4.453	3.447
Pre-crack	40,005	4.147	3.742			23	228	4.475	3.428
1	5,005	4.160	3.729			24	71	4.687	3.205
2	5,007	4.174	3.718			25			
3	5,006	4.190	3.700			26			
4	4,007	4.203	3.686			27			
5	4,007	4.219	3.670			28			
6	3505	4.239	3.649			29			
7	2605	4.253	3.637			30			
8	2607	4.268	3.623			31			
9	2604	4.286	3.604			32			
10	2105	4.303	3.583			33			
11	2005	4.321	3.572			34			
12	1908	4.339	3.554			35			
13	807	4.353	3.537			36			
14	805	4.365	3.533			37			
15	805	4.374	3.525			38			
16	806	4.386	3.510			39			

TEST REQUIREMENTS		Smax		R-ratio		Cyclic Frequency		Relative Humidity	
Corrosion State									
As-received	Artificial	10.9	+0.05	+0.50	0.1hz	10hz	<15%	>85%	



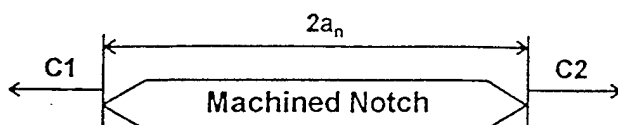
View looking at specimen Near Side

$$2a_{n-nearside} = 3.850 - 3.551$$

$$2a_{n-farside} =$$

TEST ACTUALS						NEAR SIDE		FAR SIDE	
Specimen ID:		2024T4-64							
PRE	Test date:	4 Aug 95	7 Aug 95			N			
Lab ID Machine ID		WL / FIBEC	#14	17	1004	4.139	3.262		
W(inch) t(inch):		1.41825	.0631	18	904	4.151	3.248		
P _{max} (kip) P _{min} (kip):		1.036	0.0495	19	719	4.163	3.238		
Temp(degF) %RH		69°	7.3%	20	604	4.175	3.230		
	N	NEAR SIDE		FAR SIDE					
		C1	C2	C2	C1				
Pre-crack	30,002	3.899	3.497			21	604	4.184	3.219
1	5,002	3.915	3.485			22	602	4.196	3.208
2	5,004	3.930	3.471			23	602	4.210	3.193
3	5,003	3.949	3.453			24	603	4.224	3.171
4	4,003	3.965	3.437			25	403	4.247	3.153
5	3,503	3.978	3.425			26	104	4.256	3.142
6	3,503	3.991	3.411			27	104	4.264	3.128
7	3,503	4.006	3.397			28	102	4.285	3.111
8	3,502	4.020	3.380			29	28	4.442	2.960
9	3,002	4.039	3.362			30			
10	2,403	4.052	3.348			31			
11	2,402	4.068	3.331			32			
12	1,903	4.080	3.315			33			
13	1,504	4.092	3.306			34			
14	1,502	4.100	3.296			35			
15	1,503	4.108	3.287			36			
16	1,503	4.127	3.273			37			
						38			
						39			

TEST REQUIREMENTS									
Corrosion State		Smax	R-ratio		Cyclic Frequency		Relative Humidity		
As-received	Artificial	8.5	+0.05	+0.50	0.1hz	10hz	<15%	>85%	

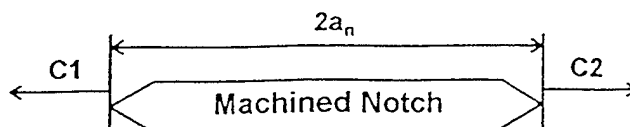


$$2a_{n-nearside} = 3.550 - 3.900$$

$$2a_{n-farside} = \underline{\hspace{2cm}}$$

TEST ACTUALS		View looking at Specimen Near Side							
Specimen ID:		7075T6-19				NEAR SIDE		FAR SIDE	
PRE Test date:	17 Jul 95	18 Jul 95		N		C1	C2	C2	C1
Lab ID Machine ID	WL/FIBEC	#14	17	5.003	3.262	4.194			
W(inch) t(inch):	1.7535 1.7546	0.0632 0.0631	18	5.003	3.245	4.211			
P _{max} (kip) P _{min} (kip):	0.945	0.476	19	4.003	3.229	4.228			
Temp(degF) %RH	76°F	7.2%	20	3.004	3.216	4.244			
	NEAR SIDE		FAR SIDE		21 <td>3.003</td> <td>3.200</td> <td>4.257</td> <td></td>	3.003	3.200	4.257	
	N	C1	C2	C2	C1	22	2.502	3.185	4.272
Pre-crack	190.003	3.496	3.952			23	2.502	3.173	4.286
1	15.003	3.488	3.964			24	2.503	3.156	4.303
2	15.004	3.482	3.968			25	2.002	3.139	4.320
3	30.003	3.473	3.982			26	1.503	3.122	4.332
4	30.003	3.451	4.004			27	1.005	3.114	4.341
5	25.003	3.433	4.018			28	1.004	3.100	4.351
6	20.004	3.415	4.038			29	1.003	3.090	4.367
7	15.002	3.396	4.057			30	1.003	3.076	4.380
8	10.002	3.380	4.070			31	1.002	3.061	4.398
9	8.002	3.371	4.080			32	752	3.050	4.411
10	8.004	3.357	4.092			33	753	3.030	4.430
11	8.004	3.345	4.111			34	503	3.017	4.444
12	7.003	3.331	4.126			35	403	3.003	4.460
13	6.003	3.319	4.138			36	304	2.997 2.997	4.479
14	6.002	3.304	4.153			37	203	2.849	4.602
15	5.002	3.291	4.165			38			
16	5.005	3.277	4.179			39			

TEST REQUIREMENTS		Corrosion State		Smax	R-ratio		Cyclic Frequency		Relative Humidity	
As-received	Artificial			5.8	+0.05	+0.50	0.1hz	10hz	<15%	>85%



View looking at specimen Near Side

$$2a_{n-nearside} = 3.632 - 3.982$$

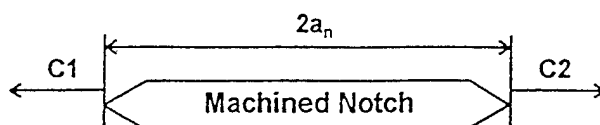
$$2a_{n-farside} = \underline{\hspace{2cm}}$$

TEST ACTUALS									
Specimen ID:		7075T6-20				NEAR SIDE		FAR SIDE	
PRE	Test date:	17 Jul 95	18 Jul 95		N	C1	C2	C2	C1
Lab ID Machine ID	WL/FIBEC	#15		17	9,003	3.306	4.274		
W(inch) t(inch):	1.7551 ✓	0.06370	0.0639	18	7,004	3.351	4.296		
P _{max} (kip) P _{min} (kip):	0.650	0.0305		19	5,006	3.335	4.313		
Temp(degF) %RH	76°F	6.8%		20	4,005	3.319	4.325		
		NEAR SIDE	FAR SIDE	21	3,004	3.306	4.338		
	N	C1	C2	C2	C1	22	3,004	3.297	4.350
Pre-crack	190,008	3.578	4.043	23	3,004	3.284	4.366		
1	25,006	3.571	4.051	24	3,008	3.267	4.382		
2	30,006	3.562	4.064	25	3,004	3.249	4.400		
3	30,007	3.548	4.079	26	2,500	3.232	4.420		
4	20,006	3.538	4.088	27	2,004	3.217	4.436		
5	20,005	3.530	4.095	28	1,507	3.205	4.448		
6	20,006	3.521	4.107	29	1,507	3.191	4.466		
7	14,377	3.512	4.118	30	1,004	3.180	4.480		
8	15,006	3.503	4.131	31	1,005	3.167	4.495		
9	15,007	3.491	4.141	32	1,004	3.152	4.511		
10	15,006	3.480	4.153	33	1,004	3.137	4.532		
11	15,007	3.465	4.166	34	758	3.123	4.548		
12	15,006	3.448	4.183	35	754	3.105	4.575		
13	13,004	3.432	4.200	36	408	3.093	4.606		
14	12,007	3.417	4.220	37	105	3.091	4.634		
15	10,006	3.402	4.238	38	22	2.929	4.684		
16	9,005	3.385	4.250	39					

FATIGUE CRACK GROWTH RATE DATA SHEET

Boeing-PSD

TEST REQUIREMENTS									
Corrosion State		Smax	R-ratio		Cyclic Frequency		Relative Humidity		
As-received	Artificial	8.5	+0.05	-0.50	0.1hz	10hz	<15%	>85%	



View looking at specimen Near Side

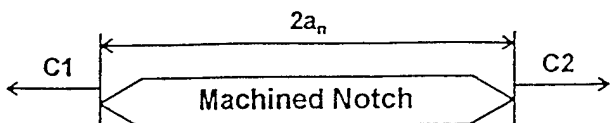
$$2a_{n-nearside} = 3.572 - 3.922$$

$$2a_{n-farside} = \underline{\hspace{2cm}}$$

TEST ACTUALS									
Specimen ID:		7075T6-26				NEAR SIDE		FAR SIDE	
PRE	Test date:	25 Jul 95	26 July 95	N		C1	C2	C2	C1
Lab ID Machine ID		WL-FIBEC	#14	17	5,003	3.274	4.210		
W(inch) t(inch):		1.7520 1.7529	0.00325 0.0029	18	4,004	3.260	4.224		
P _{max} (kip) P _{min} (kip):		0.945	0.476	19	3,503	3.249	4.237		
Temp(degF) %RH		75°F	7.5%	20	3504	3.233	4.253		
		NEAR SIDE		FAR SIDE		21	2,504	3.220	4.264
		C1	C2	C2	C1	22	2,520	3.209	4.275
Pre-crack	167,004	3.521	3.972			23	2,504	3.195	4.289
1	30,003	3.508	3.981			24	2,504	3.175	4.309
2	30,003	3.493	3.999			25	1903	3.161	4.322
3	20,004	3.483	3.979	4.009		26	1904	3.146	4.338
4	20,003	3.466	4.022			27	1704	3.133	4.350
5	17,003	3.455	4.034			28	1704	3.113	4.371
6	17,002	3.442	4.045			29	1303	3.097	4.388
7	17,002	3.428	4.063			30	1002	3.077	4.405
8	15,002	3.410	4.080			31	702	3.069	4.417
9	12,003	3.393	4.099			32	602	3.059	4.430
10	9,002	3.378	4.112			33	602	3.044	4.449
11	8,002	3.365	4.123			34	602	3.044	4.449
12	8,004	3.349	4.138			35	503	3.029	4.464
13	7,004	3.332	4.152			36	404	3.008	4.497
14	6,005	3.320	4.164			37	152	2.993	4.506
15	6,004	3.305	4.176			38	90	2.871	4.623
16	6,004	3.287	4.193			39			

6

Corrosion State		Smax	R-ratio		C ₁	Frequency	Relative Humidity	
As-received	Artificial	5.8	+0.05	+0.50	0.1hz	10hz	<15%	>85%



$$2a_{n-nearside} = 3.622 - 3.972$$

$$2a_{n-farside} = \underline{\hspace{2cm}}$$

View looking at specimen Near Side

TEST ACTUALS		Specimen ID: 7075T6-33				NEAR SIDE		FARSIDE	
PRE	Test date:	25 Jul 95	26 Jul 95	N		C1	C2	C2	C1
Lab ID Machine ID		WL-FIBEC	#15	17	5,004	3.334	4.256		
W(inch) t(inch):		1.7532 ✓	0.06320 0.0628	18	5,006	3.317	4.273		
P _{max} (kip) P _{min} (kip):		0.650	0.0315	19	4,006	3.305	4.289		
Temp(degF) %RH		75°F	7%	20	3,506	3.291	4.308		
	N	NEARSIDE		FARSIDE					
		C1	C2	C2	C1				
Pre-crack	160,007	3.576	4.025						
1	30,008	3.565	4.035						
2	30,007	3.551	4.049						
3	25,005	3.541	4.062						
4	25,006	3.529	4.071						
5	25,005	3.504	4.077						
6	20,004	3.494	4.093						
7	20,004	3.479	4.106						
8	17,006	3.476	4.114						
9	17,005	3.459	4.127						
10	17,007	3.437	4.148						
11	13,008	3.420	4.165						
12	11,007	3.405	4.182						
13	9,008	3.391	4.198						
14	8,005	3.376	4.214						
15	6,005	3.362	4.227						
16	6,006	3.348	4.245						

FATIGUE CRACK GROWTH RATE DATA SHEET

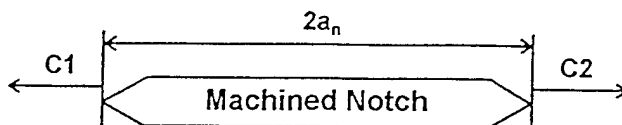
Boeing-PSD

August 30, 1994

36	3.024	4.954
36	3.018	4.602
36	2.920	4.673



TEST REQUIREMENTS							
Corrosion State		Smax	R-ratio		Cyclic Frequency		Relative Humidity
As-received	Artificial	7.8	+0.05	+0.50	0.1hz	10hz	<15% >85%



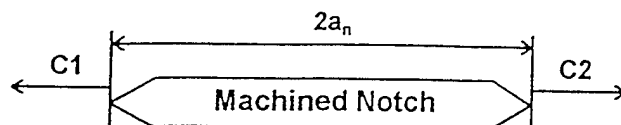
$$2a_{n-nearside} = 3.955 - 3.605$$

$$2a_{n-farside} = \underline{\hspace{2cm}}$$

View looking at specimen Near Side

TEST ACTUALS										
Specimen ID:		2024T3-33				N	NEAR SIDE		FAR SIDE	
Test date:		26 Jun 95	27 Jun 95				C1	C2	C2	C1
Lab ID Machine ID		WL / FIBEC		#14		17	3,004	4.279	3.285	
W(inch) t(inch):		1.7545 1.7550		.0633 ✓		18	2,003	4.291	3.274	
P _{max} (kip) P _{min} (kip):		0.868		0.041		19	2,002	4.307	3.261	
Temp(degF) %RH		75°		88%		20	1,503	4.319	3.250	
	N	NEAR SIDE		FAR SIDE		21	1,502	4.332	3.238	
		C1	C2	C2	C1	22	1,502	4.346	3.226	
Pre-crack	128,003	3.993	3.542			23	1,503	4.363	3.210	
1	15,002	4.007	3.529			24	1,003	4.381	3.193	
2	15,003	4.029	3.516			25	1,005	4.397	3.183	
3	12,003	4.043	3.501			26	1,004	4.415	3.169	
4	10,003	4.061	3.487			27	1,002	4.430	3.151	
5	9,002	4.080	3.472			28	805	4.445	3.138	
6	8,003	4.099	3.457			29	603	4.462	3.125	
7	7,002	4.119	3.444			30	404	4.478	3.110	
8	6,003	4.134	3.429			31	203	4.483	3.100	
9	5,504	4.154	3.411			32	202	4.487	3.098	
10	4,502	4.172	3.395			33	203	4.497	3.093	
11	4,004	4.184	3.381			34	203	4.507	3.084	
12	4,004	4.201	3.361			35	203	4.527	3.070	
13	3,004	4.216	3.350			36	55	4.536	3.069	
14	3,003	4.227	3.329			37	47	4.545	3.062	
15	3,004	4.246	3.318			38	50	4.661	2.907	
16	3,003	4.258	3.303			39				

TEST REQUIREMENTS								
Corrosion State		Smax	R-ratio		Cyclic Frequency		Relative Humidity	
As-received	Artificial	11.5	+0.05	+0.50	0.1hz	10hz	<15%	>85%



View looking at specimen Near Side

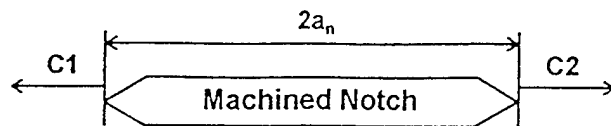
$$2a_{n-nearside} = 3.957 - 3.607$$

$$2a_{n-farside} = \underline{\hspace{2cm}}$$

TEST ACTUALS									
Specimen ID:		2024T3-46				NEAR SIDE		FAR SIDE	
PRE	Test date:	26 Jun 95	27 Jun 95		N	C1	C2	C2	C1
Lab ID Machine ID	WL/FIBEC	#15		17	3,007	4.251	3.290		
W(inch) t(inch):	1.7504 ✓	.0634 ✓		18	2,505	4.274	3.274		
P _{max} (kip) P _{min} (kip):	1.277	0.637		19	2,004	4.286	3.256		
Temp(degF) %RH	76°	88%		20	1,506	4.298	3.245		
		NEAR SIDE	FAR SIDE	21	1,504	4.311	3.232		
	N	C1	C2	22	1,505	4.326	3.213		
Pre-crack	117,004	4.008	3.559	23	1,003	4.336	3.202		
1	10,007	4.016	3.548	24	1,005	4.347	3.193		
2	15,005	4.037	3.522	25	1,007	4.360	3.182		
3	9,008	4.049	3.507	26	1,004	4.374	3.165		
4	8,007	4.064	3.491	27	1,004	4.390	3.146		
5	7,005	4.076	3.480	28	8,09	4.403	3.127		
6	7,007	4.090	3.465	29	606	4.422	3.112		
7	6,504	4.104	3.448	30	406	4.432	3.092		
8	6,005	4.119	3.433	31	203	4.448	3.081		
9	5,505	4.134	3.417	32	104	4.460	3.065		
10	5,008	4.147	3.398	33	40	4.454	2.904		
11	4,507	4.163	3.383	34					
12	4,005	4.182	3.369	35					
13	3,007	4.193	3.357	36					
14	3,008	4.204	3.343	37					
15	3,008	4.220	3.326	38					
16	3,007	4.235	3.312	39					

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TEST REQUIREMENTS									
Corrosion State		Smax	R-ratio		Cyclic Frequency		Relative Humidity		
As-received	Artificial	11.5	+0.05	+0.50	0.1hz	10hz	<15%	>85%	



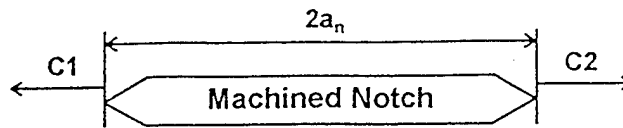
View looking at specimen Near Side

$$2a_{n-nearside} = 3.939 - 3.589$$

$$2a_{n-farside} = \underline{\hspace{2cm}}$$

TEST ACTUALS						NEAR SIDE		FAR SIDE	
Specimen ID:		2024T3-50							
PRE	Test date:	30 Jun 95		N		C1	C2	C2	C1
Lab ID Machine ID		WL/FIBEC	#15	17	3007	4.238	3.308		
W(inch) t(inch):		1.7500 +1.7500	0.0636 +0.0636	18	2004	4.252	3.290		
P _{max} (kip) P _{min} (kip):		1.2848	0.6344	19	2004	4.267	3.276		
Temp(degF) %RH		79°	88%	20	2004	4.282	3.262		
		NEAR SIDE		FAR SIDE		21	2004	4.299	3.249
						22	2008	4.311	3.229
Pre-crack	127,006	3.999	3.537			23	2004	4.330	3.208
1	15,002 2,988	2.988 2.511				24	1504	4.350	3.191
2	15,006	4.019	3.511			25	1504	4.370	3.173
3	10,004	4.038	3.501			26	1006	4.389	3.155
4	8,007	4.047	3.488			27	805	4.404	3.138
5	8,003	4.061	3.473			28	805	4.412	3.124
6	7,004	4.070	3.462			29	605	4.422	3.124
7	7,005	4.083	3.453			30	403	4.432	3.113
8	7,006	4.100	3.434			31	307	4.441	3.097
9	6,005	4.115	3.419			32	155	4.451	3.090
10	5,005	4.132	3.400			33	106	4.462	3.078
11	4,007	4.144	3.390			34	35	4.639	2.889
12	4,003	4.155	3.377			35			
13	4,005	4.172	3.362			36			
14	4,003	4.188	3.350			37			
15	4,004	4.205	3.332			38			
16	3,007	4.222	3.321			39			

TEST REQUIREMENTS									
Corrosion State		Smax	R-ratio		Cyclic Frequency		Relative Humidity		
As-received	Artificial	7.8	+0.05	+0.50	0.1hz	10hz	<15%	>85%	



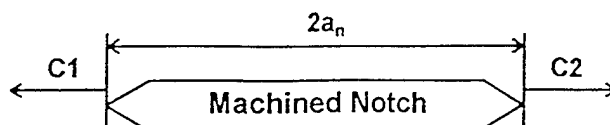
$$2a_{n-nearside} = 3.896 - 3.547$$

$$2a_{n-farside} = \underline{\hspace{2cm}}$$

View looking at specimen Near Side

TEST ACTUALS									
Specimen ID:		2024T3-51				NEAR SIDE		FAR SIDE	
PRE	Test date:	30 Jun 95		N		C1	C2	C2	C1
Lab ID Machine ID	WL/FIBEC	#14	17	3003		3.265	4.138		
W(inch) t(inch):	1.7526✓	0.0636 0.0636	18	2002		3.255	4.145		
P _{max} (kip) P _{min} (kip):	0.8795	0.0354	19	2004		3.249	4.152		
Temp(degF) %RH	79°	88%	20	2502		3.238	4.164		
	N	NEAR SIDE		FAR SIDE		21	2504	3.224	4.179
		C1	C2	C2	C1	22	2505	3.206	4.192
Pre-crack	135,002	3.985	3.489		23	2502	3.187	4.210	
1	15,006	3.943	3.478		24	2002	3.169	4.220	
2	15,002	3.943	3.478		25	2003	3.151	4.234	
3	15,002	3.458	3.960		26	2004	3.132	4.250	
4	5,004	3.449	3.968		27	1002	3.124	4.257	
5	5,002	3.441	3.975		28	1003 2006	3.095	4.279	
6	7,003	3.430	3.985		29	1003	3.079	4.289	
7	7,002	3.416	3.998		30	1003	3.066	4.302	
8	7,004	3.400	4.012		31	1004	3.046	4.316	
9	6,003	3.387	4.026		32	703	3.032	4.328	
10	5,005	3.374	4.038		33	702	3.010	4.342	
11	5,003	3.362	4.056		34	603	2.985	4.356	
12	5,005	3.343	4.071		35	403	2.942	4.377	
13	4,003	3.330	4.082		36	53	2.919	4.386	
14	4,004	3.316	4.093		37	17	2.846	4.598	
15	4,002	3.300	4.107		38				
16	4,002	3.283	4.123		39				

TEST REQUIREMENTS								
Corrsion State		Smax	R-ratio		Cyclic Frequency		Relative Humidity	
As-received	Artificial	12.2	+0.05	+0.50	0.1hz	10hz	<15%	>85%



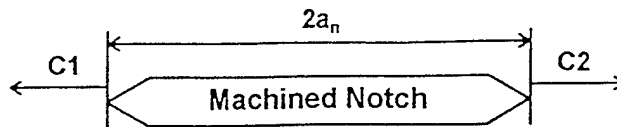
View looking at specimen Near Side

$$2a_{n-nearside} = 4.045 - 3.746$$

$$2a_{n-farside} = \underline{\hspace{2cm}}$$

TEST ACTUALS		Specimen ID: 202474-43				NEAR SIDE		FAR SIDE	
PRE	Test date:	15 June 95	19 Jun 95	N		C1	C2	C2	C1
Lab ID	Machine ID	WL/FIBEC	#14	17	1504	4.330	3.451		
W(inch)	t(inch):	1.41835	0.8625	18	1504	4.330	3.451		
P _{max} (kip)	P _{min} (kip):	1.129	0.565	19	1502	4.343	3.436		
Temp(degF)	%RH	77°F	89%	20	1503	4.357	3.421		
		NEAR SIDE		FAR SIDE					
	N	C1	C2	C2	C1				
Pre-crack	109,004	4.103	3.697	21	1503	4.377	3.402		
1	10,004	4.111	3.686	22	1253	4.403	3.380		
2	15,004	4.138	3.657	23	1254	4.424	3.352		
3	8,003	4.154	3.640	24	1003	4.480	3.309		
4	6,003	4.165	3.622	25	355	4.632	3.149		
5	5,004	4.177	3.603	26					
6	4,005	4.190	3.590	27					
7	4,003	4.199	3.580	28					
8	4,003	4.216	3.568	29					
9	4,003	4.228	3.552	30					
10	3,503	4.240	3.540	31					
11	3,504	4.255	3.521	32					
12	2,504	4.268	3.512	33					
13	2,504	4.278	3.498	34					
14	2,503	4.290	3.485	35					
15	2,503	4.313	3.469	36					
16	1,504	4.320	3.460	37					

TEST REQUIREMENTS									
Corrosion State		Smax	R-ratio		Cyclic Frequency		Relative Humidity		
As-received	Artificial	8.3	+0.05	+0.50	0.1hz	10hz	<15%	>85%	



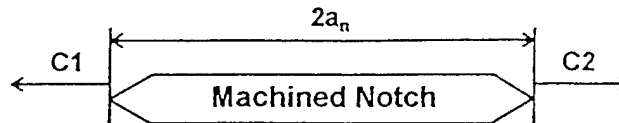
View looking at specimen Near Side

$$2a_{n-nearside} = \frac{4.107}{3807}$$

$$2a_{n-farside} = \underline{\hspace{2cm}}$$

TEST ACTUALS									
Specimen ID:		2024T4-47				NEAR SIDE		FAR SIDE	
PRE / Test date:		15 JUN 95 / 19 JUN 95		N		C1	C2	C2	C1
Lab ID / Machine ID		WL/FIBEC / #15		17	1006	4.420	3.531		
W(inch) / t(inch):		1.4830 / 0.0623		18	1004	4.429	3.530		
P _{max} (kip) / P _{min} (kip):		0.766 / 0.037		19	1007	4.454	3.520		
Temp(degF) / %RH		76°F / 89%		20	1006	4.462	3.510		
	N	NEAR SIDE		FAR SIDE					
		C1	C2	C2	C1				
				21	1007	4.474	3.499		
				22	1006	4.490	3.485		
Pre-crack	100003	4.177	3.748	23	1006	4.516	3.469		
1	10.004	4.192	3.731	24	803	4.540	3.454		
2	10.004	4.213	3.714	25	604	4.574	3.437		
3	8.009	4.236	3.698	26	208	4.698	3.215		
4	6.005	4.251	3.678	27					
5	4.007	4.272	3.667	28					
6	3.005	4.279	3.655	29					
7	3.003	4.293	3.646	30					
8	3.005	4.309	3.634	31					
9	3.005	4.325	3.617	32					
10	2.508	4.344	3.608	33					
11	2.005	4.361	3.591	34					
12	1.504	4.365	3.582	35					
13	1.504	4.375	3.574	36					
14	1.504	4.385	3.562	37					
15	1.503	4.402	3.552	38					
16	1.065	4.411	3.545	39					

TEST REQUIREMENTS								
Corrosion State		Smax	R-ratio		Cyclic Frequency		Relative Humidity	
As-received	Artificial	8.3	+0.05	+0.50	0.1hz	10hz	<15%	>85%



View looking at specimen Near Side

$$2a_{n-nearside} = 4.105 - 3.806$$

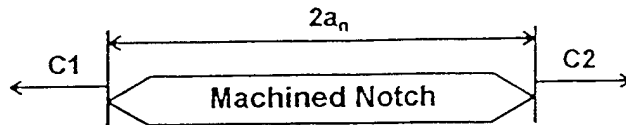
$$2a_{n-farside} = \underline{\hspace{2cm}}$$

TEST ACTUALS		View looking at specimen Near Side							
Specimen ID:		2024T4-63			N	NEAR SIDE		FAR SIDE	
PRE	Test date:	21 Jun 95	22 Jun 95			C1	C2	C2	C1
Lab ID Machine ID		WL FIBEC		#15	17	1,006	4.420	3.491	
W(inch) t(inch):		1.41830		0.0431	18	1,007	4.429	3.483	
P _{max} (kip) P _{min} (kip):		0.779		0.036	19	1,208	4.441	3.472	
Temp(degF) %RH		76		87.5	20	1,203	4.456	3.460	
	N	NEAR SIDE		FAR SIDE		21	1,205	4.470	3.444
		C1	C2	C2	C1	22	1,206	4.484	3.427
Pre-crack	96,007	4.163	3.753		23	1208	4.508	3.405	
1	10,003	4.175	3.741		24	1007	4.533	3.381	
2	10,008	4.191	3.723		25	505	4.555	3.360	
3	9,005	4.204	3.705		26	2154	4.565	3.350	
4	8,005	4.221	3.690		27	155	4.582	3.338	
5	7,003	4.240	3.674		28	56	4.590	3.330	
6	6,006	4.255	3.656		29	39	4.697	3.214	
7	5,006	4.270	3.641		30				
8	4,504	4.282	3.626		31				
9	4,505	4.300	3.613		32				
10	4,504	4.318	3.595		33				
11	4,004	4.333	3.576		34				
12	3,506	4.356	3.556		35				
13	2,500	4.368	3.539		36				
14	2,006	4.380	3.531		37				
15	2,006	4.395	3.522		38				
16	2,007	4.412	3.501		39				

FATIGUE CRACK GROWTH RATE DATA SHEET

Boeing-PSD

TEST REQUIREMENTS									
Corrosion State		S _{max}	R-ratio		Cyclic Frequency		Relative Humidity		
As-received	Artificial	12.2	+0.05	+0.50	0.1hz	10hz	<15%	>85%	



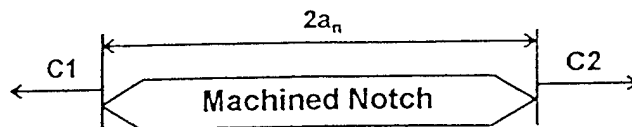
$$2a_{n-nearside} = 3.961 - 3.662$$

$$2a_{n-farside} = \underline{\hspace{2cm}}$$

View looking at specimen Near Side

TEST ACTUALS						NEAR SIDE		FAR SIDE	
Specimen ID:		2024T4-73							
PRE	Test date:	21 Jun 95	22 Jun 95	N		C1	C2	C2	C1
Lab ID / Machine ID		WL/FIBEC	#14	17	1,504	4.257	3.366		
W(inch) / t(inch):		1.4834	0.0620 0.0619	18	1,563	4.270	3.352		
P _{max} (kip) / P _{min} (kip):		1.124	0.560	19	1,504	4.282	3.340		
Temp(degF) / %RH		75	88.5	20	1,502	4.298	3.326		
	N	NEAR SIDE		FAR SIDE		21	1,504	4.314	3.310
		C1	C2	C2	C1	22	1,203	4.330	3.292
Pre-crack	116,003	4.006	3.610			23	1,002	4.346	3.277
1	10,003	4.020	3.598			24	802	4.360	3.261
2	10,004	4.031	3.587			25	603	4.386	3.231
3	10,003	4.048	3.571			26	289	4.554	3.070
4	9,002	4.062	3.553			27			
5	8,002	4.081	3.538			28			
6	7,003	4.096	3.522			29			
7	6,003	4.115	3.507			30			
8	5,004	4.130	3.493			31			
9	4,503	4.147	3.480			32			
10	4,504	4.165	3.462			33			
11	4,004	4.183	3.445			34			
12	3,504	4.195	3.430			35			
13	3,003	4.211	3.409			36			
14	2,002	4.224	3.401			37			
15	2,003	4.231	3.390			38			
16	2,003	4.246	3.377			39			

Corrosion State		S _{max}	R-ratio		Cyclic Frequency		Relative Humidity	
As-received	Artificial	7.3	+0.05	+0.50	0.1hz	10hz	<15%	>85%



View looking at specimen Near Side

$$2a_{n-nearside} = 4.101 - 3.600$$

$$2a_{n-farside} = \underline{\hspace{2cm}}$$

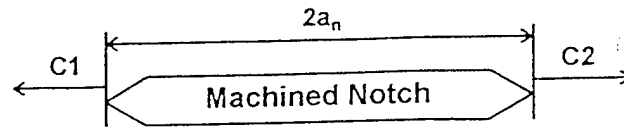
TEST ACTUALS								NEAR SIDE		FAR SIDE	
Specimen ID:		7075T6-2				N	N	C1	C2	C2	C1
Test date:		31 MAY 95						C1	C2		
Lab ID Machine ID		WL/FIBEC		# 14		17	4,003	4.327	3.387		
W(inch) t(inch):		1.7540 1.7548		0.06340 0.0630		18	3,003	4.338	3.375		
P _{max} (kip) P _{min} (kip):		0.816		0.411		19	3,003	4.351	3.363		
Temp(degF) %RH		75°		91%		20	2,504	4.363	3.352		
	N	NEAR SIDE		FAR SIDE		21	2,504	4.377	3.338		
		C1	C2	C2	C1	22	2,503	4.393	3.323		
Pre-crack	430,002	4.079	3.630			23	2,003	4.407	3.310		
1	50,004	4.092	3.615			24	2,003	4.425	3.296		
2	50,004	4.112	3.600			25	1,503	4.438	3.285		
3	35,004	4.127	3.587			26	1,502	4.452	3.270		
4	30,003	4.141	3.572			27	1,003	4.463	3.257		
5	25,003	4.159	3.552			28	1,007	4.475	3.251		
6	20,005	4.174	3.535			29	1,001	4.489	3.237		
7	15,004	4.181	3.525			30	800	4.501	3.227		
8	15,003	4.201	3.511			31	602	4.511	3.218		
9	10,003	4.212	3.496			32	500	4.521	3.209		
10	8,003	4.226	3.482			33	400	4.530	3.202		
11	7,005	4.237	3.473			34	401	4.539	3.195		
12	7,003	4.250	3.460			35	400	4.549	3.187		
13	7,003	4.265	3.445			36	400	4.562	3.181		
14	6,005	4.281	3.427			37	401	4.577	3.176		
15	5,005	4.294	3.418			38	401	4.595	3.163		
16	5,003	4.308	3.401			39	302	4.619	3.152		

FATIGUE CRACK GROWTH RATE DATA SHEET

Boeing-PSD

August 30, 1992

TEST REQUIREMENTS		Corrosion State		Smax	R-ratio		Cyclic Frequency		Relative Humidity	
As-received	Artificial	7.3			+0.05	+0.50	0.1hz	10hz	<15%	>85%



View looking at specimen Near Side

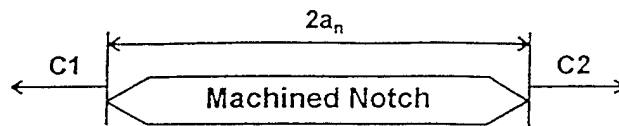
$$2a_{n-nearside} = 4.169 - 3.759$$

$$2a_{n-farside} = \underline{\hspace{2cm}}$$

TEST ACTUALS						NEAR SIDE		FAR SIDE	
Specimen ID:		7075T6-7							
Test date:		25 MAY 95							
Lab ID Machine ID		WPAFB #15		17		5,007		4.377 3.499	
W(inch) t(inch):		1.7548 1.7540 1.7540 0.0635 0.0630		18		5,005		4.396 3.483	
P _{max} (kip) P _{min} (kip):		0.812 0.4065		19		4,003		4.411 3.469	
Temp(degF) %RH		76°F 91.3%		20		4,004		4.426 3.452	
		NEAR SIDE		FAR SIDE		21		4,008	
		N							
		C1 C2		C2 C1					
Pre-crack		298,003		4.164 3.714		23		2,004	
1		35,007		4.173 3.698		24		2,004	
2		40,005		4.183 3.688		25		2,005	
3		35,006		4.198 3.672		26		1,507	
4		27,004		4.211 3.657		27		1,507	
5		20,004		4.228 3.647		28		3,005	
6		13,006		4.236 3.635		29		2,507	
7		15,008		4.248 3.626		30		2,005	
8		15,004		4.261 3.611		31		508	
9		11,004		4.272 3.600		32		508	
10		11,006		4.290 3.588		33		257	
11		8,004		4.300 3.572		34		257	
12		6,006		4.311 3.560		35		204	
13		6,004		4.322 3.550		36		105	
14		6,004		4.333 3.542		37		54	
15		6,006		4.349 3.528		38			
16		6,506		4.367 3.515		39			

FATIGUE CRACK GROWTH RATE DATA SHEET

TEST REQUIREMENTS									
Corrosion State		Smax	R-ratio		Cyclic Frequency		Relative Humidity		
As-received	Artificial	4.9	+0.05	+0.50	0.1hz	10hz	<15%	>85%	



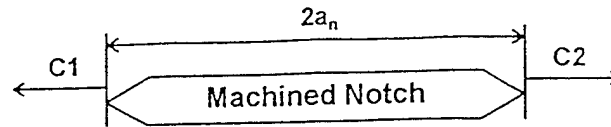
View looking at specimen Near Side

$$2a_{n-nearside} = \frac{4.115}{3.765}$$

$$2a_{n-farside} = \underline{\hspace{2cm}}$$

TEST ACTUALS						NEAR SIDE		FAR SIDE	
Specimen ID:		7075T6-18							
PRE	Test date:	8 Jun 95, 9 Jan 95		N		C1	C2	C2	C1
Lab ID Machine ID	WL1FIBEX #15		17	3010	4.438	3.456			
W(inch) t(inch):	1.7543 1.7530 0.06350 0.0630		18	3006	4.453	3.441			
P _{max} (kip) P _{min} (kip):	0.545 0.027		19	2504	4.470	3.429			
Temp(degF) %RH	76°F 88		20	2516	4.485	3.414			
	N	NEAR SIDE		FAR SIDE					
		C1	C2	C2	C1				
Pre-crack	273006	4.168	3.717			23	2008	4.543	3.363
1	36,007	4.175	3.707			24	1508	4.557	3.348
2	40,006	4.184	3.695			25	1004	4.574	3.338
3	50,004	4.198	3.680			26	753	4.586	3.323
4	50,027	4.217	3.665			27	507	4.595	3.316
5	40,007	4.231	3.655			28	510	4.602	3.310
6	40,006	4.242	3.638			29	507	4.610	3.303
7	40,007	4.258	3.626			30	507	4.620	3.296
8	40,042	4.279	3.605			31	507	4.634	3.285
9	30,036	4.297	3.587			32	507	4.651	3.274
10	25,007	4.312	3.568			33	507	4.668	3.263
11	20,014	4.341	3.541			34	512	4.684	3.247
12	10,008	4.364	3.522			35	408	4.696	3.235
13	5,008	4.376	3.510			36	411	4.717	3.217
14	5,008	4.390	3.498			37	304	4.737	3.201
15	5,004	4.407	3.482			38	205	4.773	3.187
16	4,006	4.425	3.467			39	23	4.817	3.064

TEST REQUIREMENTS		Smax		R-ratio		Cyclic Frequency		Relative Humidity	
Corrosion State									
As-received	Artificial	4.9		+0.05	+0.50	0.1hz	10hz	<15%	>85%



View looking at specimen Near Side

$$2a_{n-nearside} = 4.012 - 3.662$$

$$2a_{n-farside} = \underline{\hspace{2cm}}$$

TEST ACTUALS						NEAR SIDE		FAR SIDE	
Specimen ID:		7075T6-29							
PRE	Test date:	9 June 95, 12 June 95		N		C1	C2	C2	C1
Lab ID Machine ID		WL/FIBEC #14		17	2505	4.325	3.261		
W(inch) t(inch):		1.7510 0.0633 1.7519 0.0629		18	2502	4.342	3.241		
P _{max} (kip) P _{min} (kip):		0.550 0.030		19	2004	4.355	3.223		
Temp(degF) %RH		74°F 88		20	2004	4.370	3.199		
	N	NEAR SIDE		21	1504	4.387	3.178		
		C1	C2	C2	C1				
Pre-crack	270.004	4.063	3.610	22	1003	4.398	3.162		
1	40.005	4.085	3.585	23	1004	4.411	3.139		
2	30.003	4.090	3.568	24	1003	4.425	3.117		
3	30.007	4.106	3.552	25	752	4.435	3.092		
4	25.003	4.111	3.543	26	753	4.450	3.067		
5	25.003	4.116	3.533	27	503	4.461	3.040		
6	25.003	4.127	3.517	28		4.471	3.018		
7	25.004	4.135	3.505	29	303	4.466	3.018		
8	25.004	4.148	3.495	30	53	4.471	3.009		
9	25.004	4.160	3.483	31	53	4.485	2.961		
10	25.004	4.173	3.465	32	29	4.493			
11	25.007	4.187	3.439	33	22	4.502			
12	25.008	4.217	3.413	34	22	4.510			
13	15.004	4.240	3.377	35	43	4.525			
14	10.004	4.265	3.341	36	43	4.535			
15	7.504	4.288	3.307	37	43	4.554			
16	5.003	4.313	3.278	38	39	4.712			
				39					

FATIGUE CRACK GROWTH RATE DATA SHEET

Boeing-PSD

August 30, 1994