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THE MECHANICAL PROPERTY DATA BASE FROM AN AIR FORCE/INDUSTRY
COOPERATIVE TEST PROGRAM ON ADVANCED ALUMINUM ALLOYS

MARY ANN PHILLIPS and STEVEN R. THOMPSON
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June 1990

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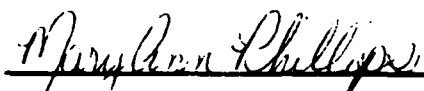
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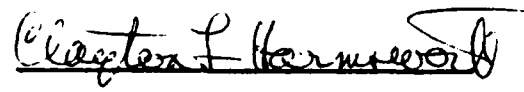
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19 ABSTRACT (Continue on reverse if necessary and identify by block number) Development of a mechanical property data base on Pechiney aluminum-lithium structural alloys is detailed. Aluminum-lithium alloys tested were 2091-T3 sheets, 2091-T8X sheets, 2091-T351 plates, 2091-T8X plates, 2091-T6 forgings, and 8090-T651 T-extrusion. Basic mechanical property data consists of tension, compression, bearing, shear, and fracture toughness. Fatigue data were developed for both smooth and notched specimens. Constant amplitude fatigue crack growth rate data and spectrum test data was performed on most products. Corrosion characteristics were also obtained. All other data developed by the participants are documented. <i>(Signature)</i>					
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PREFACE

This report was prepared by the Materials Engineering Branch (WRDC/MLSE), Systems Support Division, Materials Laboratory, Wright Research and Development Center, Wright Patterson Air Force Base, Ohio, under Project 2418, "Metallic Structural Materials," Task 241807, "Systems Support," Work Unit 24180703, "Engineering and Design Data."

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SECTION I

INTRODUCTION

High performance aerospace systems are dependent on materials that are lighter, have improved mechanical properties, and/or offer a cost savings. Aluminum alloys that met this criteria were the newly developed aluminum-lithium alloys and the second generation powder metallurgy alloys.

In 1985 the Air Force along with the aerospace community found it important to investigate the potential of these promising aluminum alloys. A cooperative program was formed by the WRDC Materials Laboratory, Systems Support Division and a number of aerospace industries. The Air Force would obtain the test material from the producers, compile the test data, and submit reports to the participants. The participants agreed to support the program by performing mechanical property tests which includes tension, compression, bearing, shear, fracture toughness, and fatigue related properties (S/N, da/dn). The Air Force elected to perform spectrum fatigue crack growth testing on most alloys. A list of participants is shown in the following table.

This interim report contains only the aluminum-lithium alloys produced by Pechiney: 2091-T3 sheet 0.063 inch thick, 2091-T351 plate 0.42 inch thick, 2091-T6 forging, and 8090-T651 T-extrusion. Comparisons to other materials, and ranking of materials is generally avoided since each potential application may be based on different evaluation criteria.

TABLE
Participants and Advanced Aluminum Alloys
in the Cooperative Test Program

PARTICIPANTS	ALUMINUM LITHIUM ALLOYS								P/M ALUMINUM ALLOYS								
	PECHINEY				ALCAN	IncoMAP		ALCOA	KAISER		ALCOA						
	2091-T3 Sheet (0.063" T)	2091-T351 Plate (0.420" T)	2091-T6 Forging	8090-T651 T-extrusion	8090-T651 Extrusion	PM IN905XL Forging	PM AL905XL Forging	2091-T3 Sheet (0.063" T)	2091-T3 Sheet (0.144" T)	2091-T8 Plate (0.50" T)	8090 Extrusion	7064-T7451 Extrusion	7064-T74 Forging	CM67 Sheet (0.063" T)	CM67 Plate (0.40" T)	CM67 Extrusion	CM67 Forging
AVCO, TN	X							X									
Wyman-Gordon							X										
Boeing, WA	X	X	X	X													
Douglas Aircraft, CA							X	X	X	X	X						
General Dynamics, CA	X	X						X	X	X							
General Dynamics, TX	X	X	X	X			X	X	X	X	X						
Grumman Aerospace, NY	X	X			X		X					X	X			X	X
Lockheed, CA	X			X			X	X	X								
Lockheed, GA			X		X			X	X			X				X	
LTV, TX	X			X			X	X	X		X	X	X		X		
Martin Marietta, LA	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X
McDonnell Douglas Astro, CA									X								
McDonnell Douglas Helicopter, AR							X										X
MCAIR, MO	X						X	X	X			X		X		X	
NASA, VA					X		X	X									
Naval Air Development Center		X		X			X			X							X
Northrop, CA	X	X	X		X		X	X	X	X	X						
Sikorsky, CT							X		X			X		X		X	
Jet Propulsion, CA							X										
Air Force WPAFB, OH	X				X		X		X	X	X	X	X	X	X	X	X

SECTION II

MATERIALS AND TESTS

• The aluminum-lithium alloys tested were 2091 which was developed for maximum damage tolerance and 8090 which is a damage tolerant, higher strength alloy.

• Basic mechanical tests including fatigue, fatigue crack growth, spectrum fatigue, and stress corrosion tests were performed by the participants. ASTM standards were used for testing when applicable.

SECTION III

PRESENTATION

The purpose of this effort was to generate mechanical property data on newly developed aluminum alloys.

Each participant compiled a data package which contained the data they generated. Some of these data packages contain discussions and in other cases only the data were provided. The tensile, compression, bearing, shear, and fracture toughness data from each package were put in tabular form. Fatigue, fatigue crack growth, and spectrum fatigue crack growth data were placed in tabular and graphical form. Corrosion results were prepared in tabular and written descriptions.

Constant amplitude fatigue crack growth tests were conducted according to ASTM E647 Standard unless otherwise specified. The A-N data supplied were reduced using a seven-point incremental polynomial method. This involves fitting a second-order polynomial (parabola) to sets of seven successive data points. K-increasing (load increasing) method. The most often used spectrums were FALSTAFF and Mini-TWIST. Corrosion results were documented almost exactly as they were received from the participants.

SECTION IV

RESULTS AND DISCUSSIONS

This interim report contains only the aluminum-lithium material produced by Pechiney. There are four appendices to this report. Each appendix contains the results for a specific alloy and product form. The following table lists the form, aluminum-lithium alloy and the appendix for the four combinations.

Table
Contents of Appendices

Form	Aluminum-Lithium Alloy	Appendix
Plate	2091-T351 and 2091-T8X	A
Sheet	2091-T3 and 2091-T8X	B
Forging	2091-T6	C
T-Extrusion	8090-T651	D

Some of the alloys were re-heat treated by the participant from the T3 condition to a temper that would give them the optimum properties of their interest. The procedures used for tempering are included on the second page of each appendix.

SECTION V

CONCLUSIONS

Eleven aerospace laboratories participated in generating data on the Pechiney aluminum-lithium materials for the cooperative test program. These data combined with future interim reports on the Air Force/Industry Cooperative Test Program on Advanced Aluminum Alloys will provide an extensive data base on aluminum-lithium alloys.

APPENDIX A

PECHINEY 2091-T351 AND 2091-T8X PLATE (0.42" X 39" X 39")

INTRODUCTION

The Pechiney 2091-T351 0.42-inch plate was received the second quarter of 1986. Some participants heat treated the 2091-T351 to a T8X temper. Three participants heat treated the plate to a T8X temper; Northrop - T8 condition was achieved by aging the 2091 plate at 275° for 12 hours, Grumman (-T8X) at 275°F for 12 hours, and General Dynamics, TX (-T851) at 335°F for 16 hours.

TESTING

Basic mechanical properties (tension, compression, bearing, etc.) were tested according to ASTM standards, unless otherwise specified.

Constant amplitude fatigue crack growth tests were conducted according to ASTM E647 standard. The growth rate a-N data that was generated by the participants (Northrop, Grumman, General Dynamics CA, and Air Force) were reduced using a seven-point incremental polynomial method. This involves fitting a second-order polynomial (parabola) to sets of seven successive data points. The data are also checked against size requirements per ASTM E647, Section 7.2. General Dynamics, TX performed constant amplitude fatigue crack growth tests using a K-increasing (load increasing) method.

Spectrum tests were performed by the Air Force using FALSTAFF (a severe fatigue environment) and Mini-TWIST (a moderately intense fatigue environment) spectrums.

PECHINEY
2091-T351 PLATE

TABLE A1
TENSILE RESULTS AT t/2 LOCATION FOR PECHINEY
2091-T351 PLATE (0.42" X 39" X 39")

COMPANY	TEST TEMP (DEGREES F)	ORIENT- ATION	ULTIMATE STRENGTH (KSI)	YIELD STRENGTH (KSI)	ELONG (%)	RA (%)	E (MSI)
BOEING, WA	RT	LONG	64.5	51.3		17.0	
			64.5	51.2		16.0	
			64.6	51.4		17.0	
GENERAL DYNAMICS, CA	RT	LONG	64.3	51.3	10.2	20.2	10.8
			63.8	53.7	12.4	23.1	10.9
			63.9	51.0	12.5	25.8	10.9
			64.3	50.8	10.2	20.0	11.4
NADC	RT	LONG	68.2	55.5	15.0		11.2
			67.9	57.0	16.0		10.4
			68.2	55.2	15.0		11.7
			67.9	56.5	16.0		10.7
NORTHROP	RT	LONG	66.7	54.7	10.6	18.5	11.3
			67.3	55.2	11.0	18.1	11.3
			66.9	54.8	11.3	19.5	11.7
MARTIN MARIETTA, LA	RT	LONG	64.9	52.1	15.0	15.0	
			64.5	52.7	14.0	14.0	
			64.7	52.3	15.0	13.0	
AVERAGE			65.9	53.6	13.2	18.6	11.1
STANDARD DEVIATION			1.7	2.1	2.2	3.8	0.4

TABLE A2
TENSILE RESULTS AT t/2 LOCATION FOR PECHINEY
2091-T351 PLATE (0.42" X 39" X 39")

COMPANY	TEST TEMP (DEGREES F)	ORIENT- ATION	ULTIMATE STRENGTH (KSI)	YIELD STRENGTH (KSI)	ELONG (%)	RA (%)	E (MSI)
BOEING, WA	RT	L TRANS	64.5 65.3 64.8	44.8 45.6 45.5		20.0 18.0 19.0	
GENERAL DYNAMICS, CA	RT	L TRANS	64.7 64.4 64.6 65.2	46.3 46.5 46.7 47.7	13.8 13.4 15.9 14.2	21.9 24.4 22.1 22.2	11.0 11.1 10.9 11.2
NADC	RT	L TRANS	67.9 66.2 67.3 66.2	50.9 49.9 49.9 49.9	15.0 16.0 16.0 15.0		10.3 11.7 12.2 10.7
NORTHROP	RT	L TRANS	67.2 67.7 67.6	49.1 49.1 49.0	12.1 12.4 12.8	23.4 22.0 24.8	11.7 11.7 12.3
MARTIN MARIETTA, LA	RT	L TRANS	65.8 65.4 65.2	46.6 46.0 46.6	16.0 20.0 18.0	15.0 17.0 15.0	
		AVERAGE	65.9	47.6	15.0	20.4	11.3
		STANDARD DEVIATION	1.2	1.9	2.2	3.3	0.6

TABLE A3
COMPRESSION RESULTS AT t/2 LOCATION FOR PECHINEY
2091-T351 PLATE (0.42" X 39" X 39")

COMPANY	TEST TEMPERATURE (DEGREES F)	ORIENTATION	COMPRESSIVE YIELD STRENGTH (KSI)	COMPRESSIVE MODULUS (KSI)
BOEING, WA	RT	LONG	42.7	
			42.8	
			42.6	
GENERAL DYNAMICS, CA	RT	LONG	42.0	11.4
			41.7	11.6
			41.6	11.7
NADC	RT	LONG	44.7	
			44.7	
			42.3	
			43.9	
			45.5	
			47.3	
MARTIN MARIETTA, LA	RT	LONG	44.5	12.4
AVERAGE			43.8	11.8
STANDARD DEVIATION			1.9	0.4

TABLE A4

COMPRESSION RESULTS AT t/2 LOCATION FOR PECHINEY

2091-T351 PLATE (0.42" X 39" X 39")

COMPANY	TEST TEMPERATURE (DEGREES F)	ORIENTATION	COMPRESSIVE YIELD STRENGTH (KSI)	COMPRESSIVE MODULUS (KSI)

BOEING, WA	RT	L TRANS	48.7	
			48.6	
			48.8	
GENERAL DYNAMICS, CA	RT	L TRANS	41.1	11.4
			48.4	11.6
			48.0	11.7
NADC	RT	L TRANS	50.9	
			49.9	
			49.4	
			47.2	
			52.8	
			47.7	
51.7				
MARTIN MARIETTA, LA	RT	L TRANS	51.6	12.5
AVERAGE			48.9	11.8
STANDARD DEVIATION			2.8	0.5

TABLE A5
RIVET SHEAR RESULTS FOR PECHINEY
2091-T351 PLATE (0.42" X 39" X 39")

COMPANY	ORIENTATION	SHEAR STRENGTH (KSI)
GENERAL DYNAMICS, CA	LONG	34.3
		33.9
		33.4
	AVERAGE	33.9
	STANDARD DEVIATION	0.5

TABLE A6
RIVET SHEAR RESULTS FOR PECHINEY
2091-T351 PLATE (0.42" X 39" X 39")

COMPANY	ORIENTATION	SHEAR STRENGTH (KSI)
GENERAL DYNAMICS, CA	L TRANS	32.6
		36.6
		33.0
	AVERAGE	34.1
	STANDARD DEVIATION	2.2

TABLE A7
 AMSLER DOUBLE SHEAR RESULTS FOR PECHINEY
 2091-T351 PLATE (0.42" X 39" X 39")

COMPANY	ORIENTATION	SHEAR STRENGTH (KSI)
BOEING, WA	L-S	35.2
		35.3
		35.2
	AVERAGE	35.2
	STANDARD DEVIATION	0.1
BOEING, WA	L-T	38.2
		38.0
		37.9
	AVERAGE	38.0
	STANDARD DEVIATION	0.2
BOEING, WA	T-S	34.4
		34.0
		34.5
	AVERAGE	34.3
	STANDARD DEVIATION	0.3
BOEING, WA	T-L	38.0
		38.0
		37.9
	AVERAGE	38.0
	STANDARD DEVIATION	0.1

TABLE A8
BEARING RESULTS FOR PECHINEY
2091-T351 PLATE (0.42" X 39" X 39")

COMPANY	ORIENTATION	e/D	BEARING		BEARING
			ULT.	STR.	YIELD STR.
			(KSI)		(KSI)
BOEING. WA	LONG	1.5		88.0	66.4 *
				87.0	67.2
				90.0	67.2 *
GENERAL DYNAMICS. CA	LONG	1.5		90.8	81.6
				89.4	72.0
				89.4	70.5
AVERAGE				89.1	70.8
STANDARD DEVIATION				1.4	5.7

(*): INDICATES SHEAR TEAR OUT FAILURE

TABLE A9
BEARING RESULTS FOR PECHINEY
2091-T351 PLATE (0.42" X 39" X 39")

COMPANY	ORIENTATION	e/D	BEARING		BEARING	
			ULT.	STR.	YIELD	STR.
			(KSI)		(KSI)	
BOEING. WA	L TRANS	1.5		90.9		66.1
				90.0		66.4
				90.9		67.7
GENERAL DYNAMICS. CA	L TRANS	1.5		91.9		72.3
				92.5		71.7
				89.7		71.8
AVERAGE				91.0		69.3
STANDARD DEVIATION				1.1		2.9

TABLE A10
BEARING RESULTS FOR PECHINEY
2091-T351 PLATE (0.42" X 39" X 39")

COMPANY	ORIENTATION	e/D	BEARING	
			ULT. STR. (KSI)	YIELD STR. (KSI)

BOEING. WA	LONG	2.0	111.0	79.8
			111.8	81.0
			110.3	81.5
GENERAL DYNAMICS. CA	LONG	2.0	113.9	90.6
			115.8	85.8
			113.5	86.4
AVERAGE			112.7	84.2
STANDARD DEVIATION			2.1	4.1

TABLE A11
BEARING RESULTS FOR PECHINEY
2091-T351 PLATE (0.42" X 39" X 39")

COMPANY	ORIENTATION	e/D	BEARING		BEARING	
			ULT.	STR.	YIELD	STR.
			(KSI)		(KSI)	
BOEING. WA	L TRANS	2.0		114.8		82.3
				112.6		82.3
				115.2		83.2
GENERAL DYNAMICS. CA	L TRANS	2.0		113.0		87.6
				114.2		95.1
				114.6		87.4
AVERAGE				114.1		86.3
STANDARD DEVIATION				1.0		4.9

TABLE A12
FRACTURE TOUGHNESS RESULTS FOR PECHINEY
2091-T351 PLATE (0.42" X 39" X 39")

COMPANY	ORIENTATION	KIC (KSI in ^{-0.5})	Kq (KSI in ^{-0.5})	COMMENT

GENERAL DYNAMICS, CA	L-T		37.0	(1,2,3)
			34.5	(1,2,3)
			35.4	(1,2,3)
NADC	L-T		42.6	(1)
			42.6	(1)
			40.6	(1)
			36.6	(1)
AVERAGE			38.5	
STANDARD DEVIATION			3.4	

- (1): INVALID DUE TO $P_{max}/P_q > 1.10$
 (2): INVALID DUE TO $a < 2.5(KQ/Fty)^{-2}$
 (3): INVALID DUE TO $B < 2.5(KQ/Fty)^{-2}$

TABLE A13
FRACTURE TOUGHNESS RESULTS FOR PECHINEY
2091-T351 PLATE (0.42" X 39" X 39")

COMPANY	ORIENTATION	KIC (KSI in ^{-0.5})	Kq (KSI in ^{-0.5})	COMMENT
GENERAL	T-L		38.7	(1,2,3)
DYNAMICS, CA			36.5	(1,2,3)
			33.0	(1,2,3)
	AVERAGE		36.1	
	STANDARD DEVIATION		2.9	

- (1): INVALID DUE TO $P_{max}/P_q > 1.10$
 (2): INVALID DUE TO $a < 2.5(KQ/Fty)^{-2}$
 (3): INVALID DUE TO $B < 2.5(KQ/Fty)^{-2}$

R-CURVE FOR 2091 PLATE (longitudinal)
(effective crack length adjusted for plastic zone)

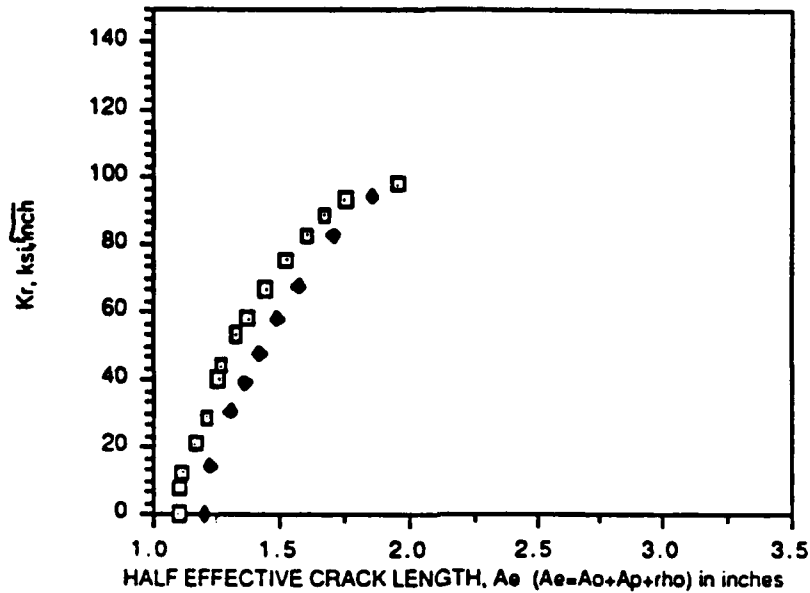


Figure A1 R-Curve Results for 2091-T351 0.42" Plate (longitudinal).
Martin Marietta LA.

R-CURVE FOR 2091 PLATE (transverse)
(effective crack length adjusted for plastic zone)

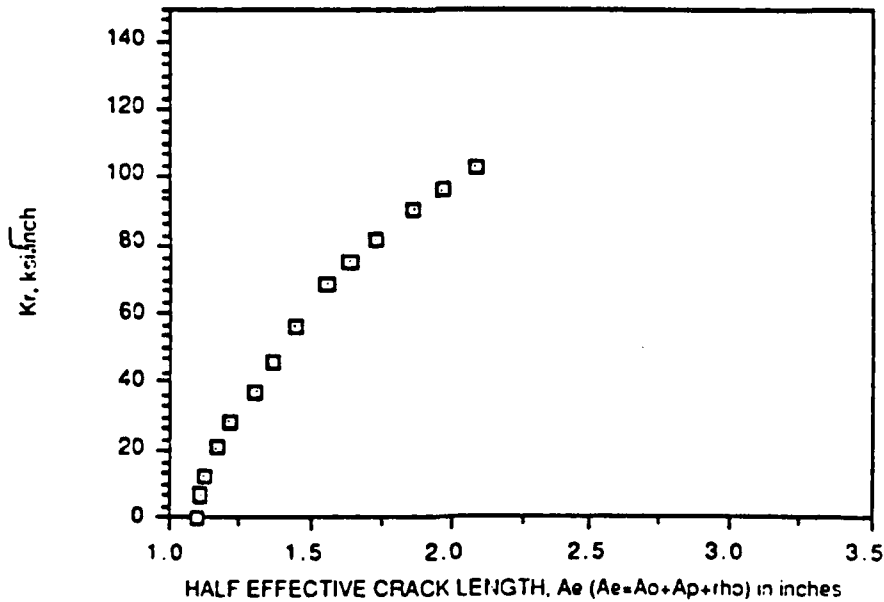


Figure A2 R-Curve Results for 2091-T351 0.42" Plate (transverse).
Martin Marietta LA.

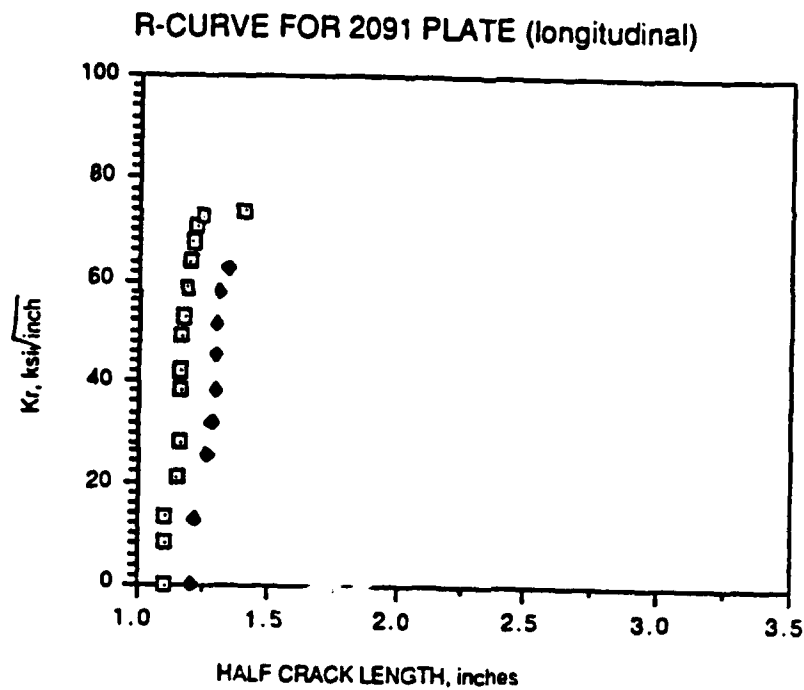


Figure A3 R-Curve Results for 2091-T351 0.42" Plate (longitudinal).
Martin Marietta LA.

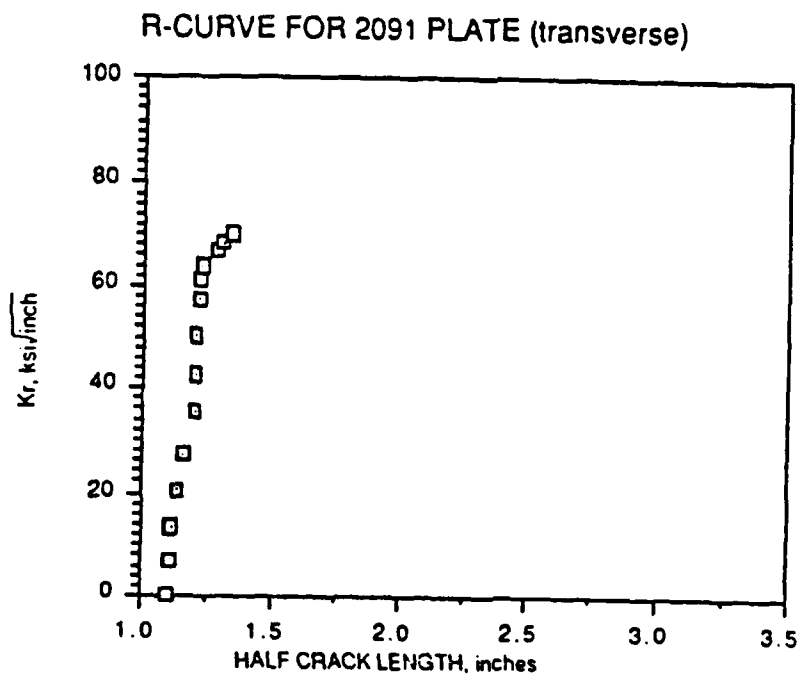


Figure A4 R-Curve Results for 2091-T351 0.42" Plate (transverse).
Martin Marietta LA.

TABLE A14
DATA FOR SPECIMEN NO. 1, 2091
LONGITUDINAL PLATE

Load, kips	Half Crack Length (c) inch	Half Crack Length, (c + rho) inch	Corresponding Fracture Toughness, ksi / inch	
			Not Adjusted	Adjusted for Plasticity
0.00	1.202	1.202	0.0	0.0
20.14	1.217	1.229	12.44	14.57
40.32	1.257	1.310	25.41	30.34
50.22	1.282	1.369	32.05	38.8
60.00	1.292	1.422	38.48	47.34
69.98	1.297	1.491	44.99	57.88
79.84	1.297	1.567	51.33	68.3
89.98	1.312	1.711	58.28	82.93
94.90	1.342	1.857	62.38	94.28

Thickness = .420 inch
Yield = 52.4 ksi
Specimen Width = 7.00 inch

TABLE A15
DATA FOR SPECIMEN NO. 2 2091
LONGITUDINAL PLATE

Load, kips	Half Crack Length (c) inch	Half Crack Length, (c + rho) inch	Corresponding Fracture Toughness, ksi $\sqrt{\text{inch}}$	
			Not Adjusted	Adjusted for Plasticity
0.0	1.100	1.100	0.0	0.0
12.54	1.100	1.104	8.45	7.93
20.3	1.100	1.110	13.68	12.84
30.09	1.145	1.171	20.80	21.06
40.17	1.165	1.213	28.08	28.71
54.79	1.165	1.257	38.30	39.89
60.16	1.165	1.278	42.06	44.16
69.79	1.165	1.329	48.79	53.14
75.44	1.175	1.375	53.03	58.74
83.47	1.180	1.440	58.84	66.95
90.09	1.190	1.522	63.86	75.72
95.15	1.200	1.600	67.82	82.82
98.00	1.215	1.673	70.43	86.90
99.15	1.245	1.750	72.43	93.30
93.49	1.400	1.958	74.14	96.06

Thickness = .420 inch
 Yield = 52.4 ksi
 Specimen Width = 7.00 inch

TABLE A16
DATA FOR SPECIMEN NO. 3, 2091
TRANSVERSE PLATE

Load, kips	Half Crack Length (c) inch	Half Crack Length, (c + rho) inch	Corresponding Fracture Toughness, ksi $\sqrt{\text{inch}}$	
			Not Adjusted	Adjusted for Plasticity
0.0	1.100	1.100	0.0	0.0
9.93	1.110	1.113	6.73	6.31
19.81	1.115	1.127	13.46	12.61
20.65	1.135	1.167	20.38	20.69
39.73	1.160	1.220	27.70	28.46
49.74	1.205	1.307	35.50	37.13
59.86	1.210	1.364	42.90	45.68
69.86	1.210	1.444	50.06	56.28
79.58	1.215	1.561	57.39	68.41
85.32	1.215	1.639	61.32	75.71
88.14	1.230	1.728	63.87	82.05
91.82	1.280	1.872	66.82	90.59
91.79	1.305	1.973	68.35	96.81
90.86	1.340	2.090	69.83	103.00

Thickness = .420 inch
Yield = 42.4 ksi
Specimen width = 7.00 inch

TABLE A17
FATIGUE RESULTS WITH R=0.1 AND Kt=1.0 FOR
PECHINEY 2091-T351 PLATE (0.42" X 39" X 39")

COMPANY	ORIENTATION	STRESS (KSI)	CYCLES
NADC	LONG	60.0	28,300
		60.0	29,600
		50.0	72,400
		50.0	87,000
		45.0	395,500
		45.0	779,200
		40.0	1.47E+06
		40.0	2.00E+06
		35.0	1.11E+07
		32.5	1.00E+08 *

(*): RUN OUT

Pechiney 2091-T351 Plate (0.42" X 39" X 39")

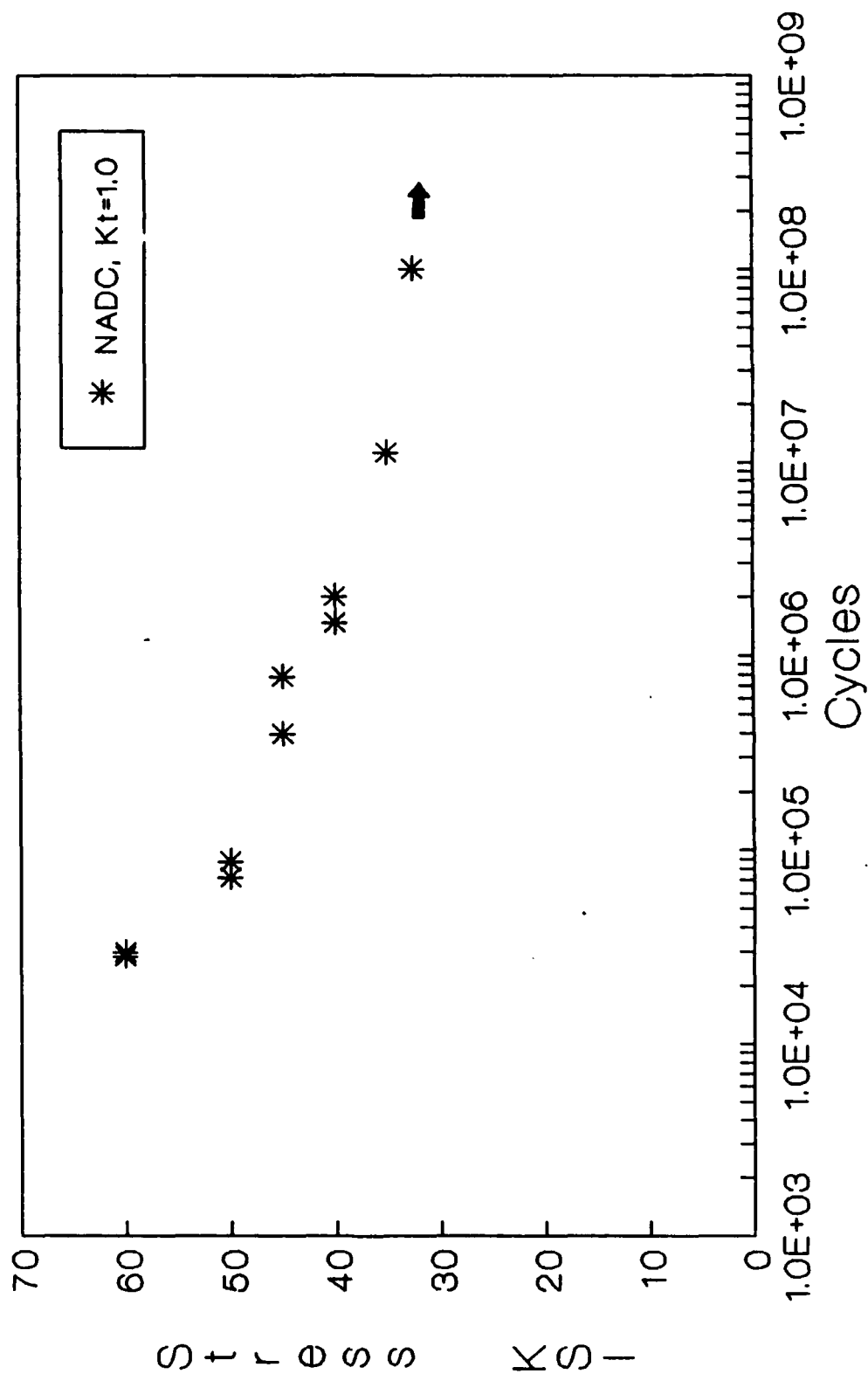


Figure A5 Fatigue Results for 2091-T351 0.42" Plate ($R=0.1$, $K_t=1.0$). NADC.

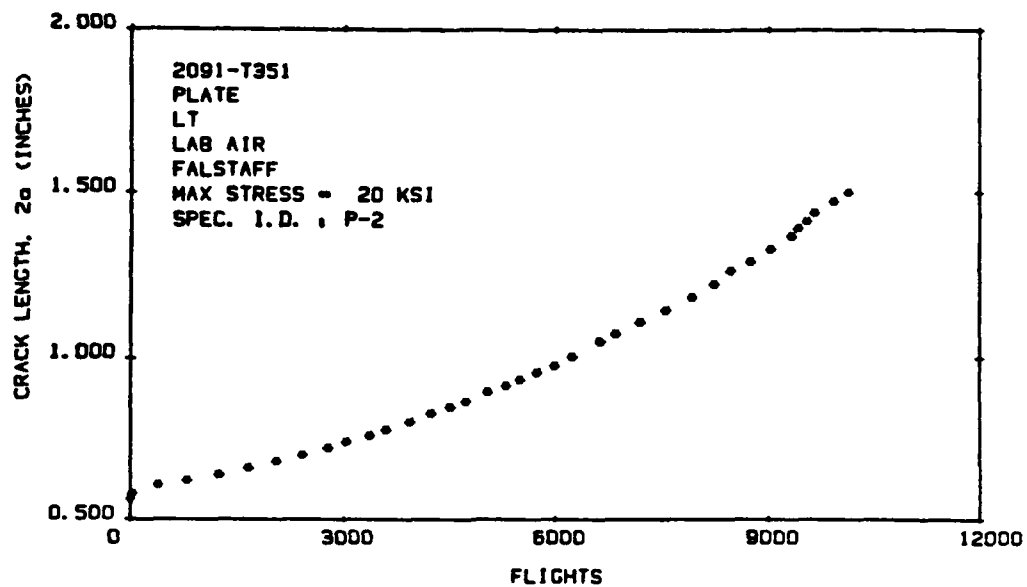


Figure A6 Crack Length Versus Flights for 2091-T351 Plate Under FALSTAFF Loading, Max Stress = 20 KSI.

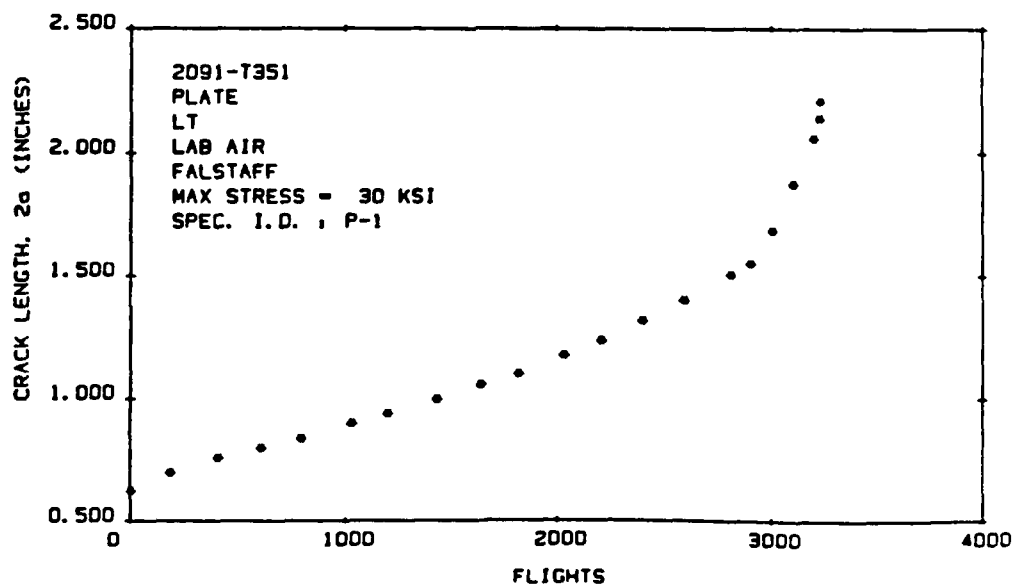


Figure A7 Crack Length Versus Flights for 2091-T351 Plate Under FALSTAFF Loading, Max Stress = 30 KSI.

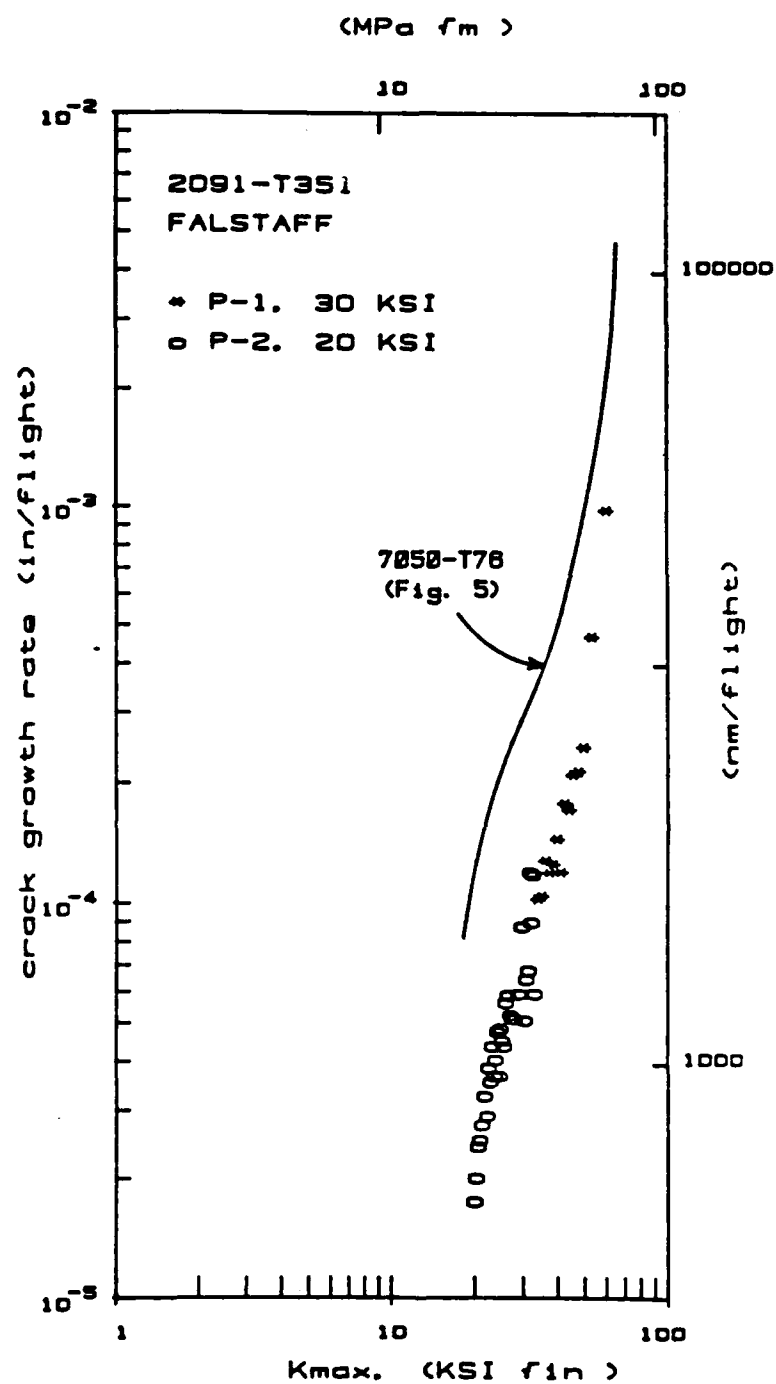


Figure A8 FALSTAFF Spectrum Results for 2091-T351 Reduced in Terms of Growth Rate and Maximum Spectrum Stress Intensity.

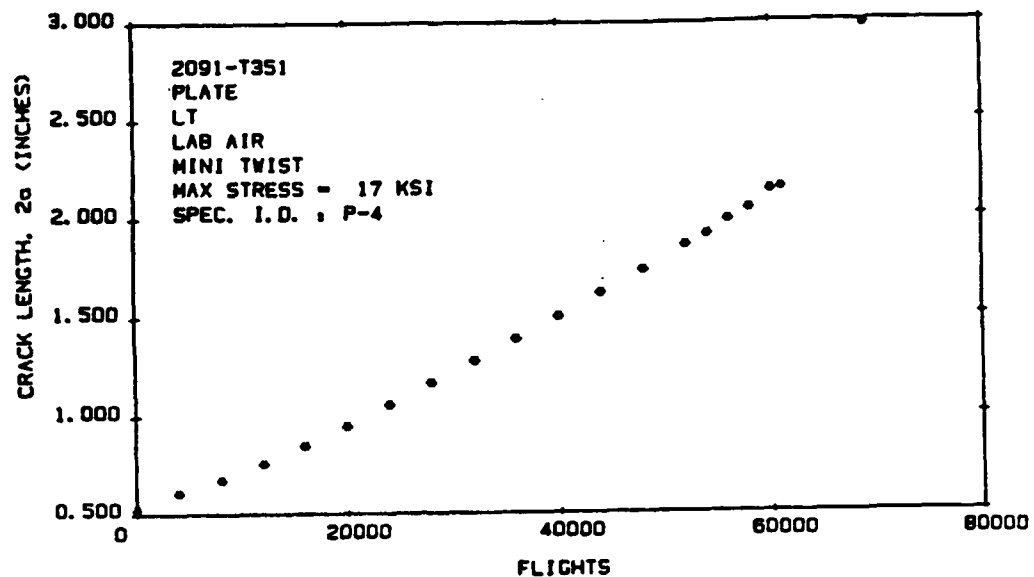


Figure A9 Crack Length Versus Flights for 2091-T351 Plate Under Mini-TWIST Loading, Max Stress = 17 KSI.

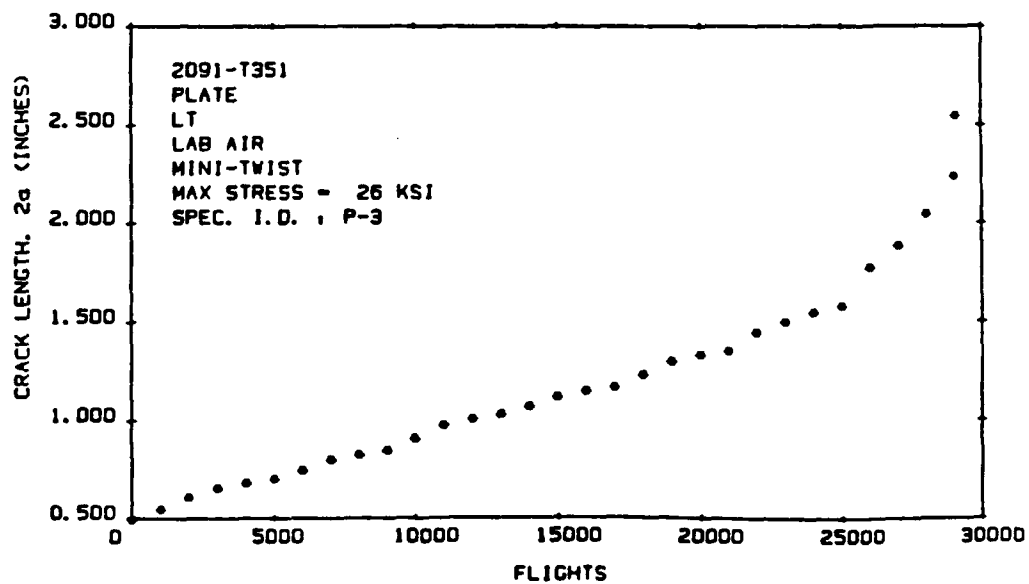


Figure A10 Crack Length Versus Flights for 2091-T351 Plate Under Mini-TWIST, Max Stress = 26 KSI.

ASTM E647 da/dN CHART C-6-LT-I

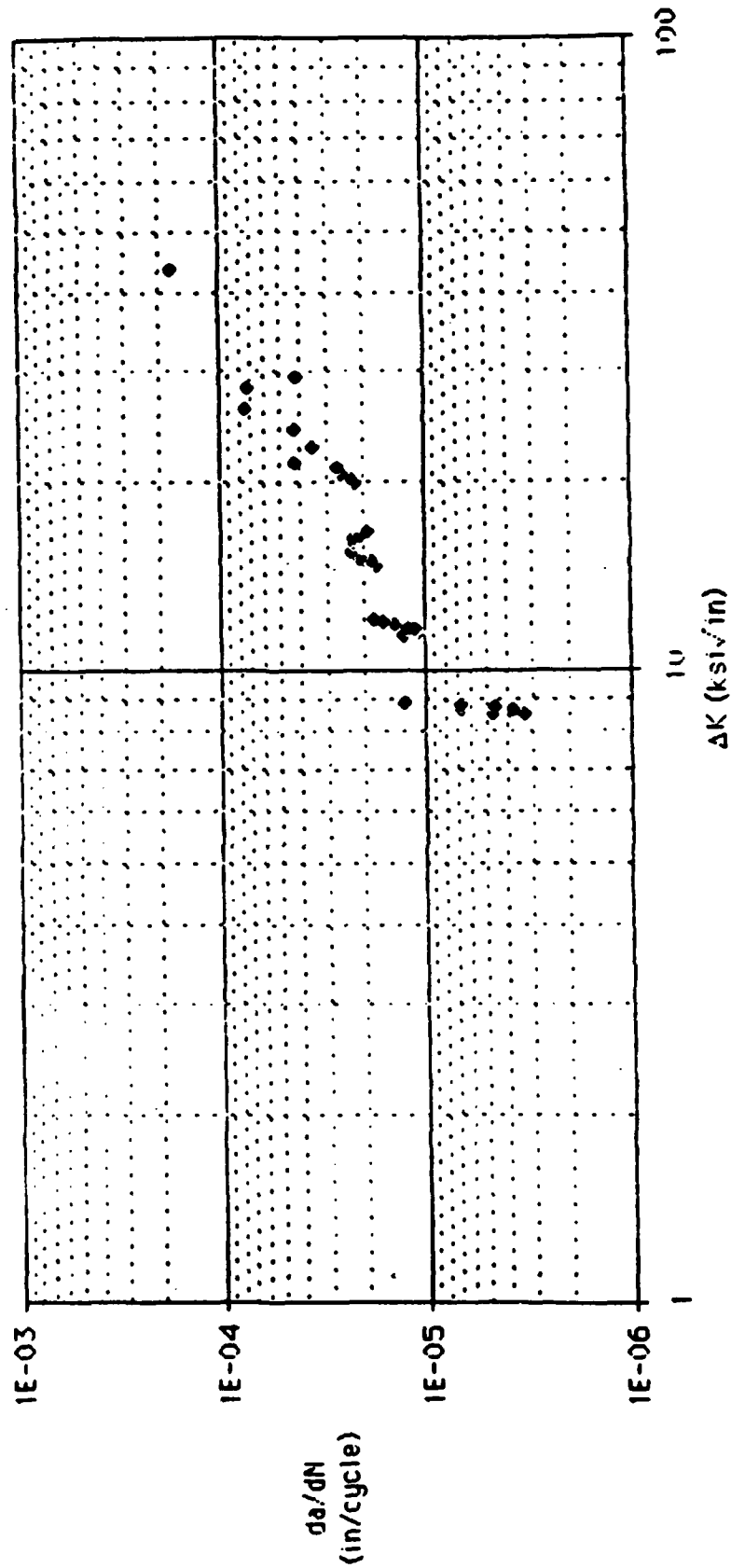


Figure A10A Fatigue Crack Growth Rate Data for 2091-T351
0.42" Plate (L-T Orientation). General Dynamics CA.

TABLE A17A

Fatigue Crack Growth Rate Data
Associated with Figure A10A

SEVEN-POINT INCREMENTAL POLYNOMIAL METHOD FOR DETERMINING da/dN

ASTM Method E647

Specimen No. C-6-L1-1 Specimen Type: CT

W = 2.007 in B = 0.423 in $a_0 = 0.665$ in
F_{ty} = 51.7 ksi R = 0.35

No.	Cycles	P _{max}	a (in)	a (mgr)	MCC	K _{max}	K _{min}	ΔK ksi $\sqrt{in}$	$da/dN \times 10^6$
1	0	1000	0.800			12096	3629	8467	
2	1000	1000	0.805			12171	3651	8520	4.7000
3	2000	1000	0.808			12224	3667	8557	3.3000
4	3000	1000	0.811	0.8117	0.9983	12279	3684	8595	3.8357
5	4000	1000	0.815	0.8155	0.9988	12344	3703	8641	3.7515
6	5000	1000	0.819	0.8193	0.9677	12408	3723	8686	6.7718
7	6000	1000	0.824	0.8215	0.948	12479	3744	8736	4.6049
8	7500	1000	0.829	0.8284	0.9677	12565	3769	8795	6.7718
9	9000	1000	0.835	0.8397	0.9814	12671	3801	8870	12.6917
10	10000	1250	0.854	0.8507	0.9814	16249	4875	11374	12.6917
11	10500	1250	0.859	0.8575	0.9561	16369	4911	11458	11.0374
12	11000	1250	0.865	0.8651	0.9736	16494	4948	11546	11.3000
13	11500	1250	0.871	0.8692	0.9736	16630	4989	11641	11.3000
14	12000	1250	0.871	0.8749	0.9777	16630	4989	11641	12.0560
15	12500	1250	0.883	0.8807	0.984	16906	5072	11834	14.0461
16	13000	1250	0.889	0.8884	0.9872	17047	5114	11933	16.0594
17	13460	1250	0.895	0.8975	0.9929	17190	5157	12033	17.5812
18	14000	1500	0.908	0.9066	0.9938	21007	6302	14705	17.2518
19	14500	1500	0.917	0.9159	0.9965	21276	6383	14893	18.0480
20	15000	1500	0.924	0.9240	0.9829	21488	6446	15042	20.8274
21	15500	1500	0.933	0.9339	0.9908	21767	6530	15237	22.2143
22	16000	1500	0.943	0.9468	0.9786	22083	6625	15458	22.8571
23	16500	1500	0.964	0.9605	0.9823	22771	6831	15940	22.4850
24	17000	1500	0.974	0.9712	0.9833	23111	6933	16178	22.1518
25	17500	1500	0.980	0.9807	0.9788	23319	6996	16323	20.7250
26	18250	1500	0.991	0.9931	0.9971	23709	7113	16596	19.2289
27	19000	1750	1.009	1.0082	0.9977	28431	8529	19902	21.5293
28	19500	1750	1.021	1.0199	0.9985	28966	8690	20276	23.0100
29	20000	1750	1.032	1.0317	0.9982	29470	8841	20629	25.5919
30	20500	1750	1.044	1.0441	0.9996	30038	9011	21026	26.8690
31	21000	1750	1.057	1.0583	0.9978	30674	9202	21472	42.7238
32	22000	1750	1.091	1.0886	0.9976	32450	9735	22715	35.5854
33	23000	1750	1.128	1.1280	0.9978	34591	10377	24214	42.7238
34	24000	1750	1.169	1.1705	0.9685	37261	11178	26083	75.9364
35 *	24500	1750	1.206			39988	11996	27992	74.0000
36 *	25000	1750	1.227			41691	12507	29184	42.0000 *
37 *	26000	1750	1.401			62237	18671	43566	174.0000 *

* - Indicates data violates specimen size requirements

+ - Indicates no curve smoothing

ASTM E647 da/dN CHART C-6-TL-1

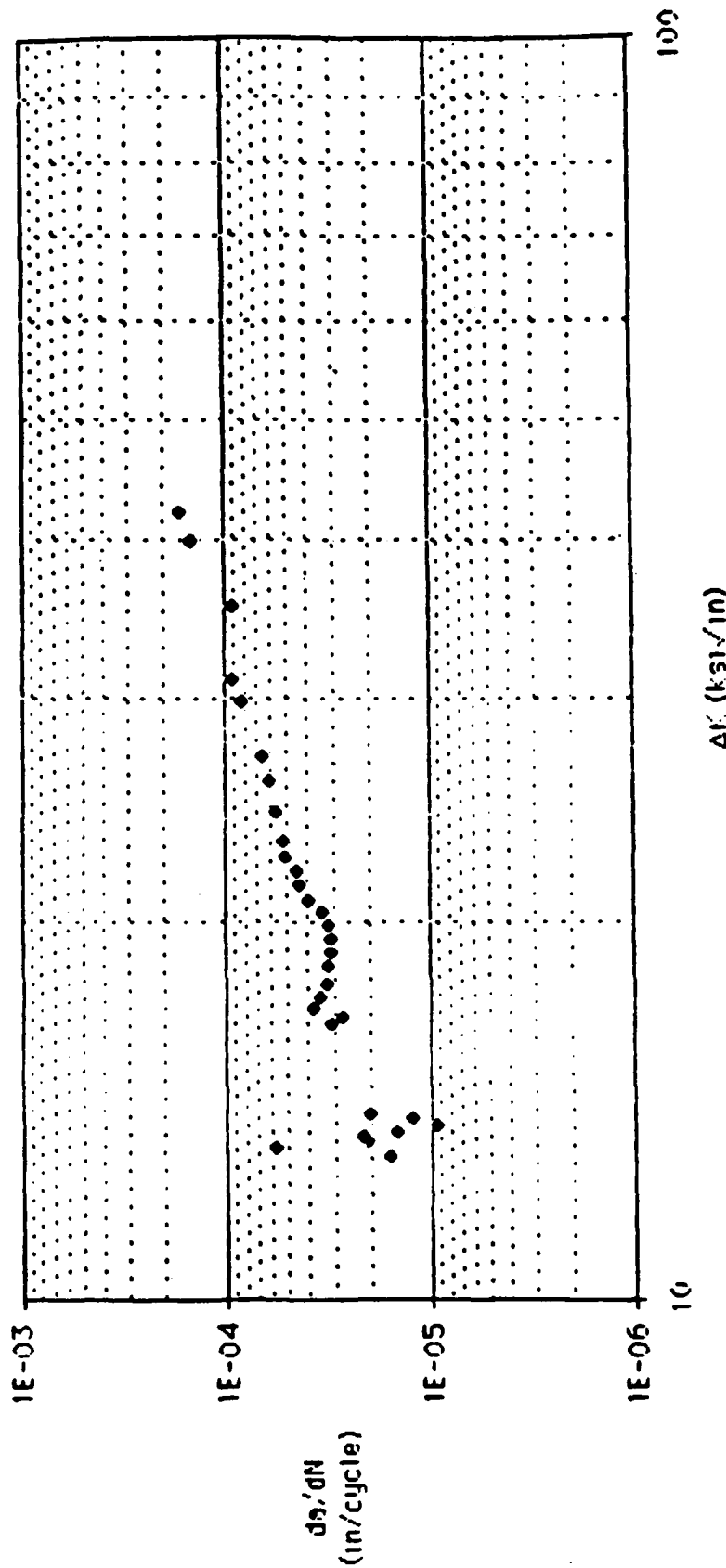


Figure A10b Fatigue Crack Growth Rate Data for 2091-T351 0.42" Plate (T-L Orientation). General Dynamics CA.

TABLE A17B

Fatigue Crack Growth Rate Data

Associated with Figure A10B

SEVEN-POINT INCREMENTAL POLYNOMIAL METHOD FOR DETERMINING da/dN

ASTM Method E647

Specimen No. C-6-7L-1 Specimen Type: CT

W = 2.003 in
Fty = 46.7 ksiB = 0.422 in
R = 0.33

an = 0.665

Nr	(cycles)	Pmax	a (in)	a (mgr)	MCC	Kmax	Kmin	ΔK ksi $\sqrt{\text{in}}$	da/dN IE6
1	0	1500	0.800			18252	5476	12776	
2	810	1500	0.813			18569	5571	12998	16.0494
3	1000	1500	0.824			18843	5653	13190	57.8947
4	1400	1500	0.835	0.8351	0.9172	19122	5737	13386	20.4983
5	1700	1500	0.839	0.8419	0.9080	19225	5768	13458	21.8550
6	1500	1500	0.847	0.8373	0.9167	19434	5830	13604	14.8135
7	3140	1500	0.855	0.8544	0.9467	19646	5894	13752	9.4950
8	4000	1500	0.863	0.8620	0.9477	19862	5958	13903	12.3536
9	4970	1500	0.871	0.8776	0.9385	20080	6024	14056	20.3209
10	5200	1750	0.878	0.8815	0.9732	23654	7096	16558	31.2525
11	5350	1750	0.887	0.8864	0.9610	23951	7185	16766	27.4423
12	5600	1750	0.898	0.8963	0.9948	24321	7296	17025	38.3779
13	6020	1750	0.914	0.9111	0.9951	24876	7463	17413	35.2983
14	6630	1750	0.930	0.9323	0.9976	25451	7635	17816	32.3402
15	7360	1750	0.954	0.9537	0.9987	26354	7906	18448	31.8564
16	7620	1750	0.969	0.9684	0.9984	26945	8083	18861	31.3680
17	8320	1750	0.985	0.9851	1.0000	27599	8260	19320	31.3809
18	8830	1750	1.001	1.0001	0.9976	28281	8484	19796	31.4888
19	9390	1750	1.017	1.0168	0.9946	28990	8697	20293	34.6364
20	9920	1750	1.032	1.0351	0.9966	29683	8905	20778	39.9120
21	10250	1750	1.048	1.0482	0.9979	30452	9136	21317	43.7701
22	10540	1750	1.064	1.0622	0.9974	31257	9377	21880	45.8995
23	10900	1750	1.080	1.0798	0.9985	32098	9629	22468	51.2355
24	11190	1750	1.095	1.0946	0.9990	32922	9877	23045	52.5461
25	11820	1750	1.127	1.1296	0.9993	34805	10442	24364	57.1945
26	12260	1750	1.158	1.1557	0.9994	36813	11044	25769	61.4515
27	12670	1750	1.182	1.1802	0.9986	38508	11552	26955	66.9568 *
28	13450	1750	1.233	1.2347	0.9963	42585	12775	29809	84.3019 *
29	13690	1750	1.253	1.2524	0.9981	44388	13317	31072	92.9751 *
30 +	14320	1750	1.312			50538	15161	35377	93.6508 *
31 +	14670	1750	1.363			57100	17130	39970	145.7143 *
32 +	14790	1750	1.383			60069	18021	42048	166.6667 *

* - Indicates data violates specimen size requirements

+ - Indicates no curve smoothing

PECHINEY

2091-T8X PLATE

TABLE A18
TENSILE RESULTS AT t/2 LOCATION FOR PECHINEY
2091-T8X PLATE (0.42" X 39" X 39")

COMPANY	TEST TEMP (DEGREES F)	ORIENT- ATION	ULTIMATE STRENGTH (KSI)	YIELD STRENGTH (KSI)	ELONG (%)	RA (%)	E (MSI)
NORTHROP	RT	LONG	71.4	60.6	10.0	16.0	11.5
			71.5	59.9	12.0	16.0	11.4
			71.8	61.1	11.0	16.0	11.4
			71.5	60.4	10.0		11.4
			72.0	60.4	11.0		11.4
			72.0	60.6	9.0		11.5
GRUMMAN	RT	LONG	68.7	58.2	6.0	6.2	11.8
			70.0	58.2	8.5	9.2	11.9
			67.6	58.4	6.5	6.8	11.1
GENERAL DYNAMICS. TX	RT	LONG	72.8	60.6	8.0		
			72.5	60.8	7.3		
AVERAGE			71.1	59.9	9.0	11.7	11.5
STANDARD DEVIATION			1.6	1.1	2.0	4.8	0.2

TABLE A19
TENSILE RESULTS AT t/2 LOCATION FOR PECHINEY
2091-T8X PLATE (0.42" X 39" X 39")

COMPANY	TEST TEMP (DEGREES F)	ORIENT- ATION	ULTIMATE STRENGTH (KSI)	YIELD STRENGTH (KSI)	ELONG (%)	RA (%)	E (MSI)
NORTHROP	RT	L TRANS	72.4	54.8	12.0	17.4	11.5
			72.5	55.0	12.0	17.8	11.6
			72.4	55.0	12.0	18.5	11.4
			69.2	51.1	15.0		11.4
			69.5	51.2	17.0		11.2
			69.1	50.9	16.0		11.8
GRUMMAN	RT	L TRANS	69.5	53.0	13.5	22.3	11.5
			69.0	51.1	13.0	16.8	13.0
			69.1	53.0	13.5	17.6	13.4
GENERAL DYNAMICS. TX	RT	L TRANS	71.8	55.9	11.0		
			72.0	55.9	11.0		
AVERAGE			70.6	53.4	13.3	18.4	11.9
STANDARD DEVIATION			1.6	2.0	2.0	2.0	0.8

TABLE A20

TENSILE RESULTS AT t/2 LOCATION FOR PECHINEY

2091-T8X PLATE (0.42' X 39' X 39')

COMPANY	TEST TEMP (DEGREES F)	ORIENT- ATION	ULTIMATE STRENGTH (KSI)	YIELD STRENGTH (KSI)	ELONG (%)	RA (%)	E (MSI)
GRUMMAN	RT	45	63.9	45.8	21.0	29.7	11.2
			62.5	45.7	21.5	27.2	11.1
			62.9	45.3	20.5	28.7	11.1
		AVERAGE	63.1	45.6	21.0	28.5	11.1
		STANDARD DEVIATION	0.7	0.3	0.5	1.3	0.1

TABLE A21

TENSILE RESULTS AT t/10 LOCATION FOR PECHINEY

2091-T8X PLATE (0.42' X 39' X 39')

COMPANY	TEST TEMP (DEGREES F)	ORIENT- ATION	ULTIMATE STRENGTH (KSI)	YIELD STRENGTH (KSI)	ELONG (%)	RA (%)	E (MSI)
NORTHROP	RT	LONG	71.6	60.0	10.0		11.3
			71.2	59.9	10.0		11.5
			71.4	60.4	10.0		11.1
		AVERAGE	71.4	60.1	10.0		11.3
		STANDARD DEVIATION	0.2	0.3	0.0		0.2

TABLE A22

TENSILE RESULTS AT t/10 LOCATION FOR PECHINEY

2091-T8X PLATE (0.42' X 39' X 39')

COMPANY	TEST TEMP (DEGREES F)	ORIENT- ATION	ULTIMATE STRENGTH (KSI)	YIELD STRENGTH (KSI)	ELONG (%)	RA (%)	E (MSI)
NORTHROP	RT	L TRANS	69.6	51.2	18.0		11.1
			69.3	51.1	16.0		11.6
			69.7	51.4	15.0		11.4
		AVERAGE	69.5	51.2	16.3		11.4
		STANDARD DEVIATION	0.2	0.2	1.5		0.3

TABLE A23

TENSILE RESULTS AT t/2 LOCATION WITH 100 HOURS EXPOSURE FOR

PECHINEY 2091-T8X PLATE (0.42" X 39" X 39")

COMPANY	TEST TEMP (DEGREES F)	EXPOSURE TEMP (DEGREES F)	ORIENT- ATION	ULTIMATE STRENGTH (KSI)	YIELD STRENGTH (KSI)	ELONG (%)	RA (%)
NORTHROP	RT	300	LONG	77.7	65.8	9.0	12.3
				77.7	65.9	9.0	11.6
		350	LONG	75.8	70.6	7.0	15.9
				76.1	70.7	7.0	18.9
		375	LONG	71.3	64.7	7.0	18.5
				71.6	64.8	7.0	18.1
		400	LONG	66.9	58.1	7.0	18.5
				66.7	58.0	7.0	18.1

TABLE A24
 COMPRESSION RESULTS AT t/2 LOCATION FOR PECHINEY
 2091-T8X PLATE (0.42" X 39" X 39")

COMPANY	TEST TEMPERATURE (DEGREES F)	ORIENTATION	COMPRESSIVE YIELD STRENGTH (KSI)	COMPRESSIVE MODULUS (KSI)

NORTHROP	RT	LONG	48.6	
			48.3	
			48.6	
GRUMMAN	RT	LONG	48.1	11.9
			50.5	11.5
			48.4	11.1
GENERAL DYNAMICS, TX	RT	LONG	48.6	
			49.2	
AVERAGE			48.8	11.5
STANDARD DEVIATION			0.8	0.4

TABLE A25

COMPRESSION RESULTS AT t/2 LOCATION FOR PECHINEY

2091-T8X PLATE (0.42" X 39" X 39")

COMPANY	TEST TEMPERATURE (DEGREES F)	ORIENTATION	COMPRESSIVE YIELD STRENGTH (KSI)	COMPRESSIVE MODULUS (KSI)
NORTHROP	RT	L TRANS	57.6	
			57.4	
			57.5	
GRUMMAN	RT	L TRANS	58.3	11.9
			58.2	11.2
			58.9	11.6
GENERAL DYNAMICS. TX	RT	L TRANS	57.5	
			60.9	
AVERAGE			58.3	11.5
STANDARD DEVIATION			1.2	0.3

TABLE A26

COMPRESSION RESULTS AT t/2 LOCATION FOR PECHINEY

2091-T8X PLATE (0.42" X 39" X 39")

COMPANY	TEST TEMPERATURE (DEGREES F)	ORIENTATION	COMPRESSIVE YIELD STRENGTH (KSI)	COMPRESSIVE MODULUS (KSI)
GRUMMAN	RT	45	49.5	11.3
			48.6	11.4
			49.6	10.8
		AVERAGE	49.2	11.2
		STANDARD DEVIATION	0.6	0.3

TABLE A27
RIVET SHEAR RESULTS FOR PECHINEY
2091-T8X PLATE (0.42" X 39" X 39")

COMPANY	ORIENTATION	SHEAR STRENGTH (KSI)
NORTHROP	L-S	35.9
		35.9
		35.9
GRUMMAN	L-S	36.4
		36.0
		37.8
AVERAGE		36.6
STANDARD DEVIATION		1.0

TABLE A28
RIVET SHEAR RESULTS FOR PECHINEY
2091-T8X PLATE (0.42" X 39" X 39")

COMPANY	ORIENTATION	SHEAR STRENGTH (KSI)
NORTHROP	T-S	33.5
		33.5
		33.9
GRUMMAN	T-S	34.6
		35.9
		37.2
AVERAGE		34.6
STANDARD DEVIATION		1.5

TABLE A29
SLOTTED SHEAR RESULTS FOR PECHINEY
2091-T8X PLATE (0.42" X 39" X 39")

COMPANY	ORIENTATION	SHEAR STRENGTH (KSI)
GENERAL	LONG	41.3
DYNAMICS, TX		40.9
	AVERAGE	41.1
	STANDARD DEVIATION	0.3

TABLE A30
SLOTTED SHEAR RESULTS FOR PECHINEY
2091-T8X PLATE (0.42" X 39" X 39")

COMPANY	ORIENTATION	SHEAR STRENGTH (KSI)
GENERAL	L TRANS	42.6
DYNAMICS, TX		43.4
	AVERAGE	43.0
	STANDARD DEVIATION	0.6

TABLE A31
BEARING RESULTS FOR PECHINEY
2091-T8X PLATE (0.42" X 39" X 39")

COMPANY	ORIENTATION	e/D	BEARING		BEARING	
			ULT.	STR.	YIELD	STR.
				(KSI)		(KSI)
NORTHROP	LONG	1.5		93.0		73.0
				89.6		71.8
				92.6		73.7
GRUMMAN	LONG	1.5		92.9		71.9
				93.8		73.0
				93.4		72.1
GENERAL DYNAMICS, TX	LONG	1.5		117.0		93.0
				112.0		91.4
AVERAGE				98.0		77.5
STANDARD DEVIATION				10.3		9.1

TABLE A32
BEARING RESULTS FOR PETCHINEY
2091-T8X PLATE (0.42" X 39" X 39")

COMPANY	ORIENTATION	e/D	BEARING	
			ULT. STR. (KSI)	YIELD STR. (KSI)
NORTHROP	L TRANS	1.5	99.3	75.5
			98.9	76.0
			97.9	74.2
GRUMMAN	L TRANS	1.5	94.9	73.0
			91.9	70.1
			92.8	71.0
GENERAL DYNAMICS, TX	L TRANS	1.5	97.0	79.1
			97.8	80.5
AVERAGE			96.3	74.9
STANDARD DEVIATION			2.8	3.6

TABLE A33
BEARING RESULTS FOR PECHINEY
2091-T8X PLATE (0.42' X 39' X 39')

COMPANY	ORIENTATION	e/D	BEARING		BEARING	
			ULT.	STR.	YIELD	STR.
			(KSI)		(KSI)	
NORTHROP	LONG	2.0		119.4		86.8
				118.9		87.8
				118.6		86.4
GRUMMAN	LONG	2.0		113.0		85.6
				115.5		86.9
				114.2		87.1
GENERAL DYNAMICS. TX	LONG	2.0		123.0		91.3
				122.0		94.0
AVERAGE				118.1		88.2
STANDARD DEVIATION				3.6		2.9

TABLE A34

BEARING RESULTS FOR PECHINEY

2091-T8X PLATE (0.42" X 39" X 39")

COMPANY	ORIENTATION	e/D	BEARING	
			ULT. STR. (KSI)	YIELD STR. (KSI)
NORTHROP	L TRANS	2.0	123.9	90.7
			124.2	94.2
			124.1	92.1
GRUMMAN	L TRANS	2.0	115.6	88.2
			117.5	89.5
			114.9	88.9
GENERAL DYNAMICS, TX	L TRANS	2.0	99.3	82.7
			103.0	85.3
AVERAGE			115.3	89.0
STANDARD DEVIATION			9.6	3.7

TABLE A35
FRACTURE TOUGHNESS RESULTS FOR PECHINEY
2091-T8X PLATE (0.42" X 39" X 39")

COMPANY	ORIENTATION	KIC (KSI in ^{0.5})	Kq (KSI in ^{0.5})	COMMENT
NORTHROP	L-T	27.0		VALID
		28.0		VALID
GRUMMAN	L-T		40.1	INVALID(1)
			43.2	INVALID(1,2)
			39.5	INVALID(1,2)
GENERAL DYNAMICS, TX	L-T		29.9	INVALID(2,3,4)
			29.0	INVALID(2,3,4)
	AVERAGE	27.5	36.3	
	STANDARD DEVIATION	0.7	6.5	

- (1): $2.5(Kq)^2 / (YS)^2 > B$
(2): $P_{max}/P_q > 1.10$
(3): INSUFFICIENT THICKNESS
(4): CRACK CURVATURE > 5%

TABLE A36
FRACTURE TOUGHNESS RESULTS FOR PECHINEY
2091-T8X PLATE (0.42" X 39" X 39")

COMPANY	ORIENTATION	KIC	Kq	COMMENT
		(KSI in ^{-0.5})	(KSI in ^{-0.5})	

NORTHROP	T-L	29.8		VALID
		28.5		VALID
GRUMMAN	T-L		40.5	INVALID(1)
			43.2	INVALID(1,2)
			38.2	INVALID(1,2)
GENERAL DYNAMICS. TX	T-L		27.1	INVALID(2,3)
			27.0	INVALID(2,3,4)
	AVERAGE	29.2	35.2	
	STANDARD DEVIATION	0.9	7.6	

- (1): $2.5(Kq)^2 / (YS)^2 > B$
(2): $P_{max}/P_q > 1.10$
(3): INSUFFICIENT THICKNESS
(4): CRACK CURVATURE > 5%

TABLE A37

General Dynamics, Texas

Pechiney 2091-T8X Plate

(0.42" X 39" X 39")

Results of R-Curve Tests

	$K_{R25}, \text{ksi-in}^{\frac{1}{2}}$
L-T	48.3
L-T	50.2
T-L	43.2
T-L	43.2

TABLE A38
SMOOTH FATIGUE RESULTS WITH R=0.1 AND Kt=1.0 FOR
PECHINEY 2091-T8X PLATE (0.42" X 39" X 39")

COMPANY	ORIENTATION	STRESS (KSI)	CYCLES
NORTHROP	LONG	60.0	31,299
		50.0	84,556
		45.0	135,397
		45.0	140,237
		40.0	242,930
		37.5	1,386,890
		37.5	934,697
		35.0	2,000,000 *

(*): INDICATES RUN-OUT TEST

Pechiney 2091-T8X Plate (0.42" X 39" X 39")

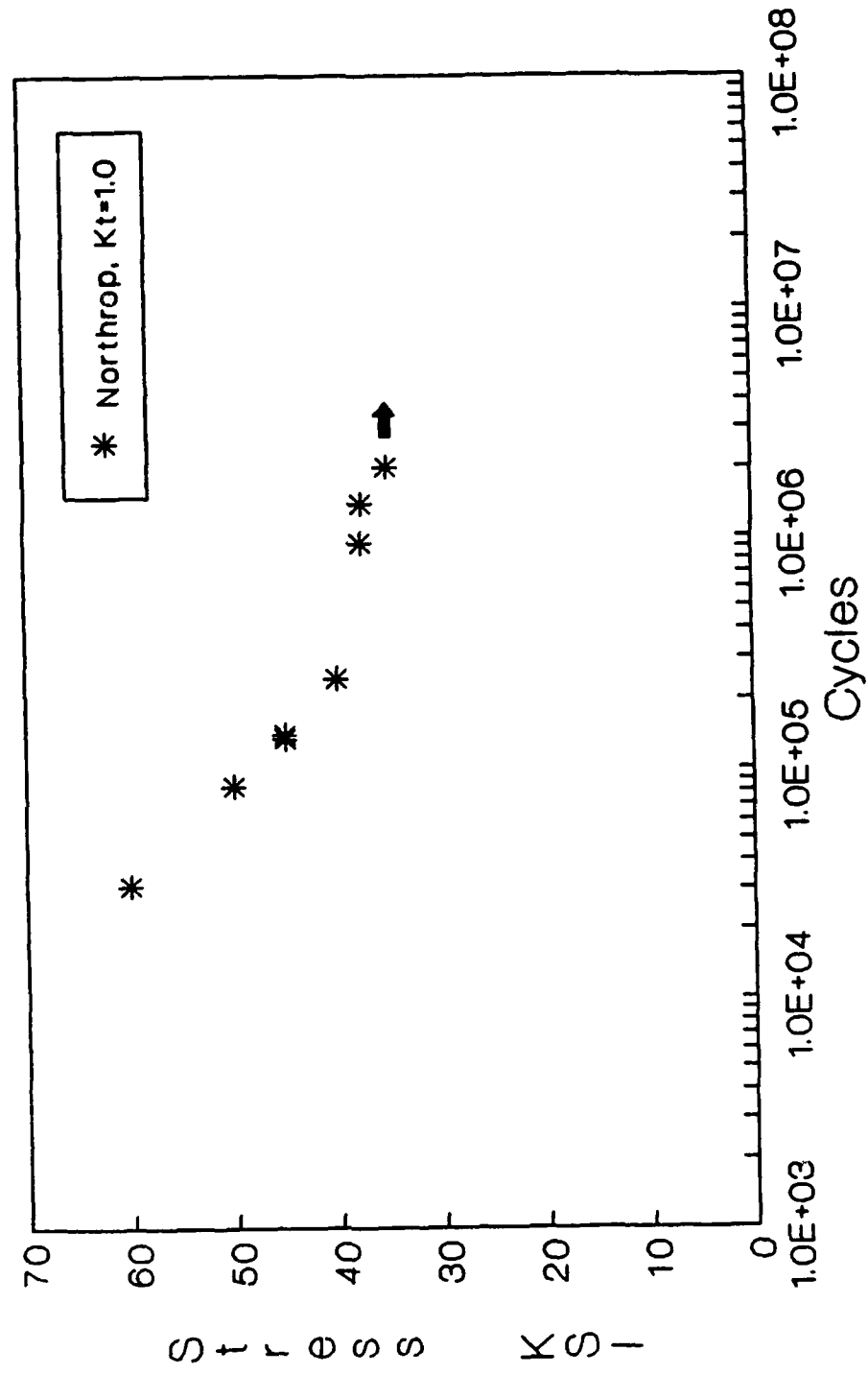


Figure A11 Fatigue Results for 2091-T8X 0.42" Plate (R=0.1, Kt=1.0). Northrop.

TABLE A39
 NOTCHED FATIGUE RESULTS WITH R=0.1 AND Kt=3.0 FOR
 PECHINEY 2091-T8X PLATE (0.42" X 39" X 39")

COMPANY	ORIENTATION	STRESS (KSI)	CYCLES
NORTHROP	LONG	45.0	13,635
		40.0	26,179
		35.0	48,930
		30.0	216,536
		27.5	257,234
		27.5	193,418
		25.0	474,737 *
		23.0	940,075

(*): INDICATES SLANT FAILURE

Pechiney 2091-T8X Plate (0.42" X 39" X 39")

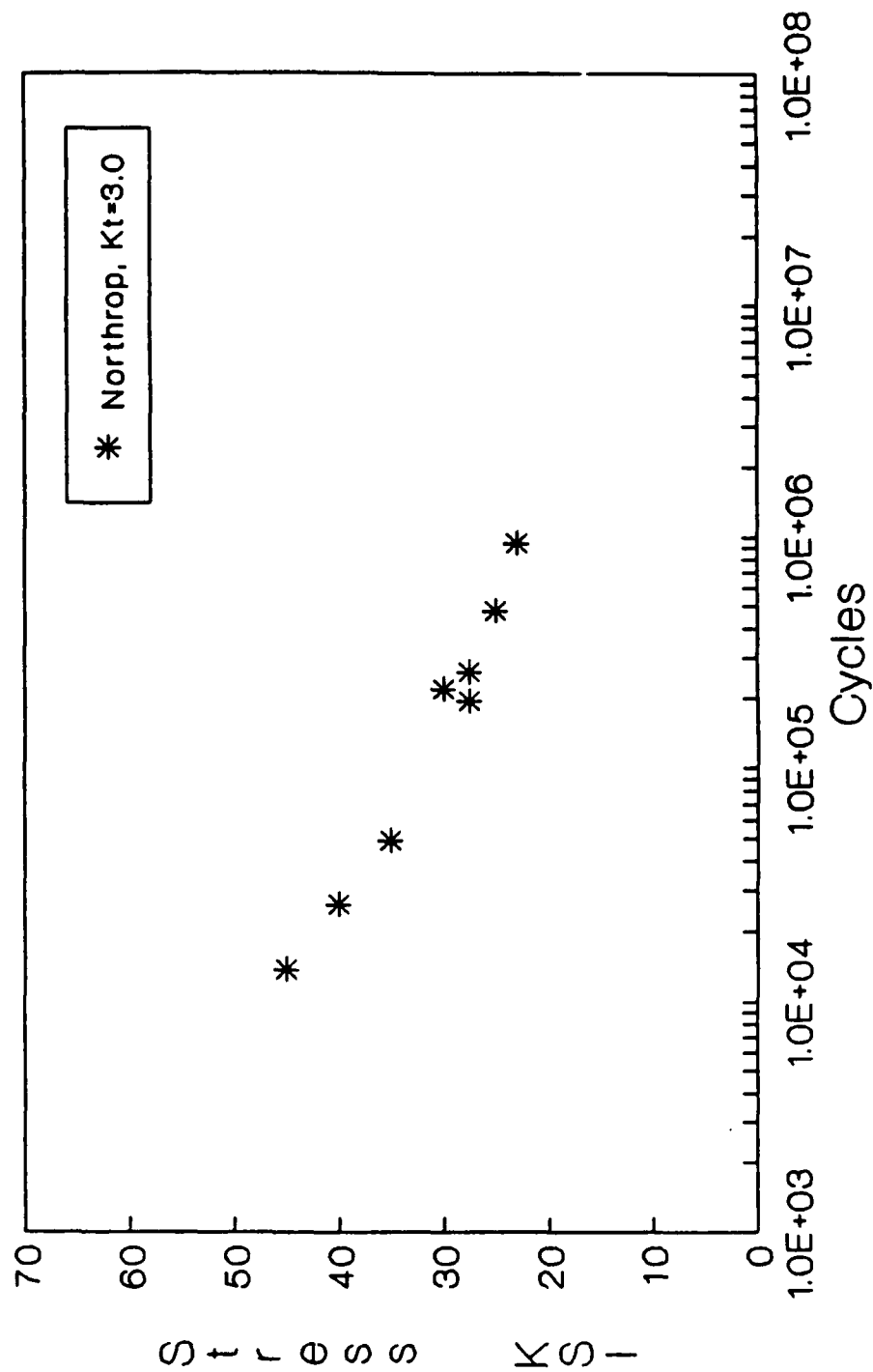


Figure A12 Fatigue Results for 2091-T8X 0.42" Plate (R=0.1, Kt=3.0). Northrop.

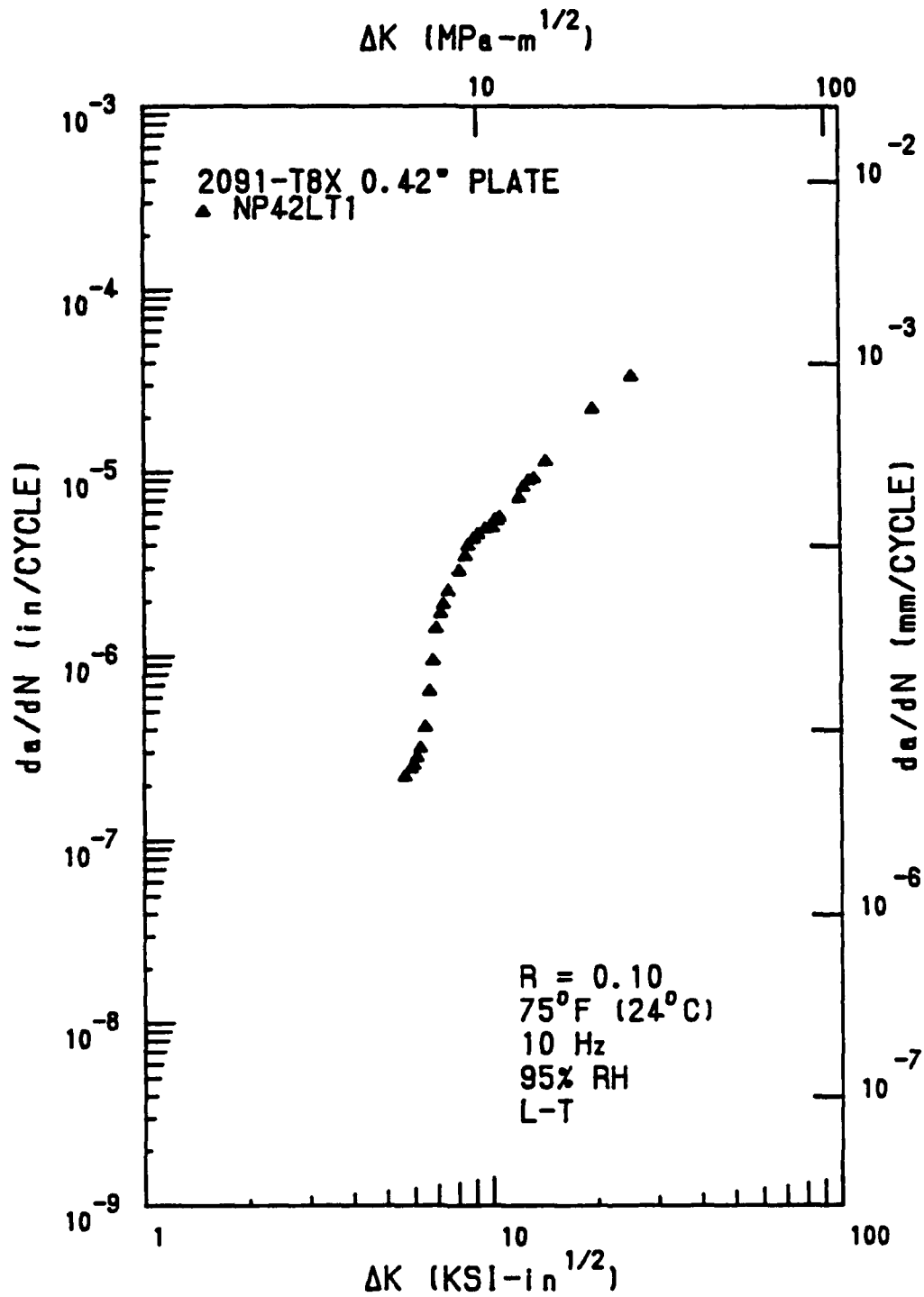


Figure A13 Fatigue Crack Growth Rate Data for Pechiney 2091-T8X 0.42" Plate (L-T Orientation). Northrop.

TABLE A40

Fatigue Crack Growth Rate Data
Associated with Figure A13

Seven Point Incremental Polynomial Method per ASTM E647

02-10-1989

Specimen Number: NP42LT1 Specimen Type: CT

B= 0.2530 in W= 3.0090 in An= 0.0000

Pmax= 0.550 kips Pmin= 0.055 kips

R= 0.10 Frequency= 10.00 hz.

Test Temperature= 75 F Environment= 95% RH

PT	CYCLES	Amax	Aavg	MCC	Delta K	da/dN
1	0.00	0.6860				
2	110.00	0.7073				
3	260.00	0.7385				
4	370.00	0.7610	0.7618	0.999873	5.60	.2206E-06
5	577.00	0.8110	0.8100	0.999899	5.85	.2428E-06
6	657.00	0.8295	0.8294	0.999733	5.95	.2558E-06
7	762.00	0.8560	0.8568	0.998942	6.09	.2802E-06
8	860.00	0.8830	0.8830	0.998830	6.23	.3150E-06
9	956.00	0.9130	0.9147	0.990732	6.41	.4086E-06
10	1036.00	0.9435	0.9511	0.972252	6.61	.6409E-06
11	1071.00	0.9625	0.9735	0.972984	6.74	.9437E-06
12	1101.00	0.9925	1.0009	0.991457	6.90	.1406E-05
13	1124.00	1.0320	1.0330	0.997454	7.09	.1691E-05
14	1136.00	1.0580	1.0554	0.998488	7.22	.1901E-05
15	1156.00	1.1005	1.0971	0.997670	7.49	.2241E-05
16	1190.00	1.1730	1.1791	0.997498	8.04	.2885E-05
17	1205.00	1.2205	1.2239	0.998194	8.36	.3456E-05
18	1212.00	1.2500	1.2473	0.999542	8.53	.3926E-05
19	1222.00	1.2860	1.2888	0.999041	8.86	.4289E-05
20	1229.00	1.3190	1.3206	0.998878	9.12	.4543E-05
21	1240.00	1.3775	1.3725	0.998727	9.57	.4861E-05
22	1250.00	1.4225	1.4240	0.999389	10.05	.4939E-05
23	1255.00	1.4370	1.4383	0.998825	10.20	.5449E-05
24	1256.00	1.4535	1.4523	0.999989	10.35	.5377E-05
25	1259.00	1.4700	1.4697	0.999983	10.52	.5618E-05
26	1278.00	1.5910	1.5909	0.999978	11.93	.7186E-05
27	1282.00	1.6195	1.6188	0.999055	12.31	.8224E-05
28	1286.00	1.6510	1.6524	0.999458	12.78	.8977E-05
29	1290.00	1.6835	1.6822	0.996456	13.23	.9208E-05
30	1297.00	1.7625	1.7456	0.991133	14.24	.1144E-04
31	1312.00	1.9435	1.9699	0.986259	19.42	.2214E-04
32	1318.00	2.0830	2.1283	0.977265	25.28	.3549E-04
33	1320.00	2.1750				
34	1321.00	2.2400				
35	1322.00	2.3240				

* - DATA VIOLATES SIZE REQUIREMENTS

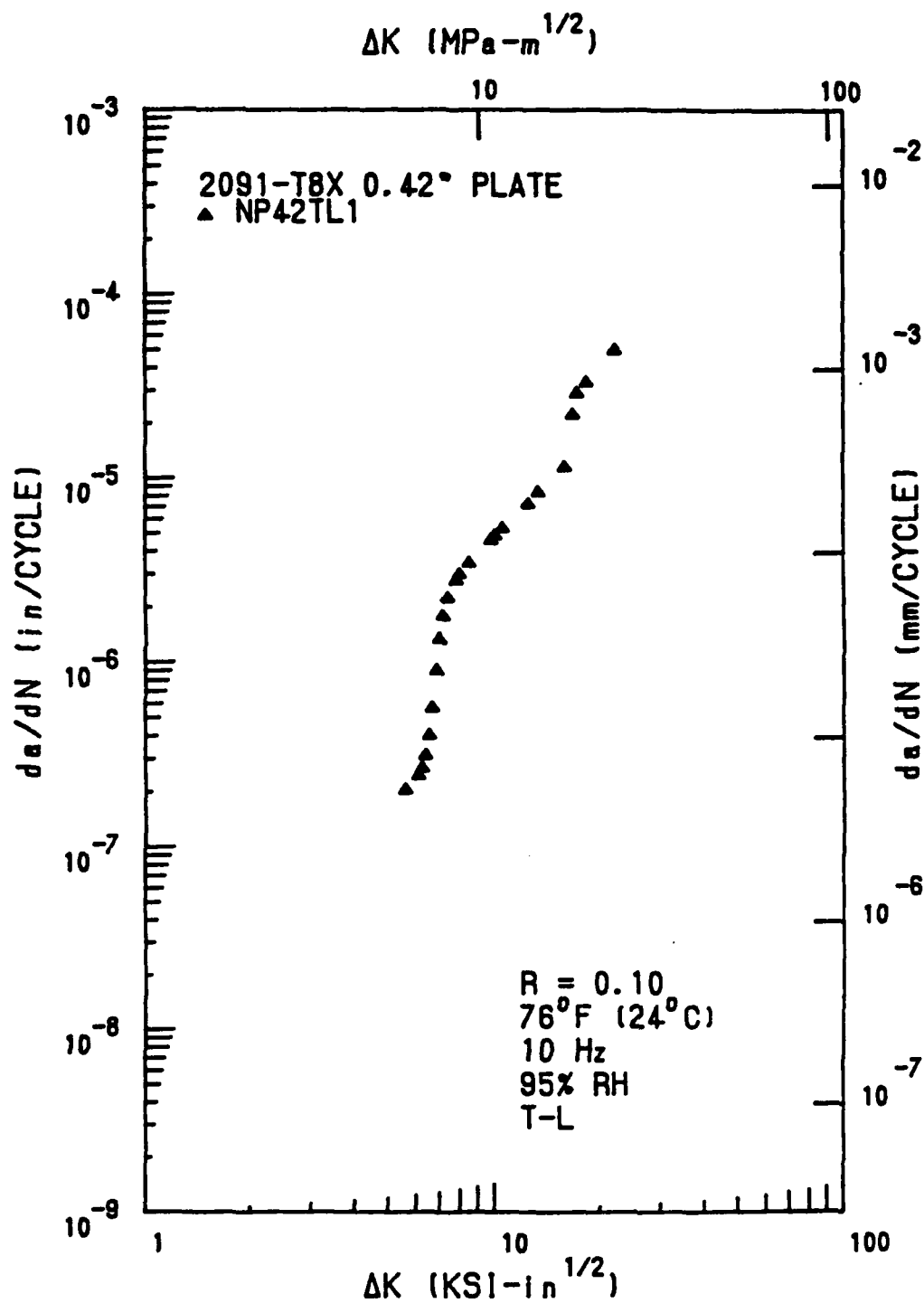


Figure A14 Fatigue Crack Growth Rate Data for Pechiney 2091-T8X 0.42" Plate (T-L Orientation). Northrop.

TABLE A41

Fatigue Crack Growth Rate Data
Associated with Figure A14

Seven Point Incremental Polynomial Method per ASTM E647

02-10-1989

Specimen Number: NP42TL1 Specimen Type: CT

B= 0.2530 in W= 3.0090 in An= 0.0000

Pmax= 0.500 kips Pmin= 0.050 kips

R= 0.10 Frequency= 10.00 hz.

Test Temperature= 76 F Environment= 95% RH

PT	CYCLES	Amax	Aavg	MCC	Delta K	da/dN
1	0.00	0.6280				
2	1280.00	0.8080				
3	1450.00	0.8370				
4	1585.00	0.8625	0.8647	0.999893	5.58	.2042E-06
5	2055.00	0.9690	0.9673	0.999906	6.09	.2428E-06
6	2170.00	0.9955	0.9962	0.999109	6.24	.2669E-06
7	2265.00	1.0200	1.0233	0.993956	6.39	.3128E-06
8	2355.00	1.0440	1.0484	0.993095	6.53	.3997E-06
9	2425.00	1.0725	1.0774	0.991288	6.69	.5594E-06
10	2475.00	1.1035	1.1088	0.978290	6.87	.8988E-06
11	2495.00	1.1190	1.1240	0.980810	6.96	.1326E-05
12	2520.00	1.1465	1.1549	0.995230	7.15	.1767E-05
13	2540.00	1.1910	1.1900	0.999308	7.37	.2212E-05
14	2565.00	1.2560	1.2547	0.999315	7.81	.2765E-05
15	2572.00	1.2758	1.2764	0.999977	7.96	.2981E-05
16	2595.00	1.3505	1.3488	0.999622	8.51	.3448E-05
17	2634.00	1.4960	1.4986	0.999617	9.85	.4574E-05
18	2639.50	1.5210	1.5235	0.999455	10.10	.4851E-05
19	2649.00	1.5715	1.5682	0.999400	10.59	.5307E-05
20	2675.00	1.7145	1.7174	0.997564	12.54	.7175E-05
21	2682.20	1.7685	1.7703	0.995364	13.38	.8341E-05
22	2695.50	1.8725	1.9005	0.987147	15.94	.1148E-04
23	2698.25	1.9220	1.9375	0.969562	16.82	.2213E-04
24	2699.35	1.9475	1.9546	0.995890	17.25	.2907E-04
25	2701.00	1.9935	1.9956	0.999860	18.38	.3332E-04
26	2704.00	2.1135	2.1099	0.996875	22.24	.4978E-04
27	2705.00	2.1605				
28	2707.00	2.2720				
29	2708.00	2.3720				

* - DATA VIOLATES SIZE REQUIREMENTS

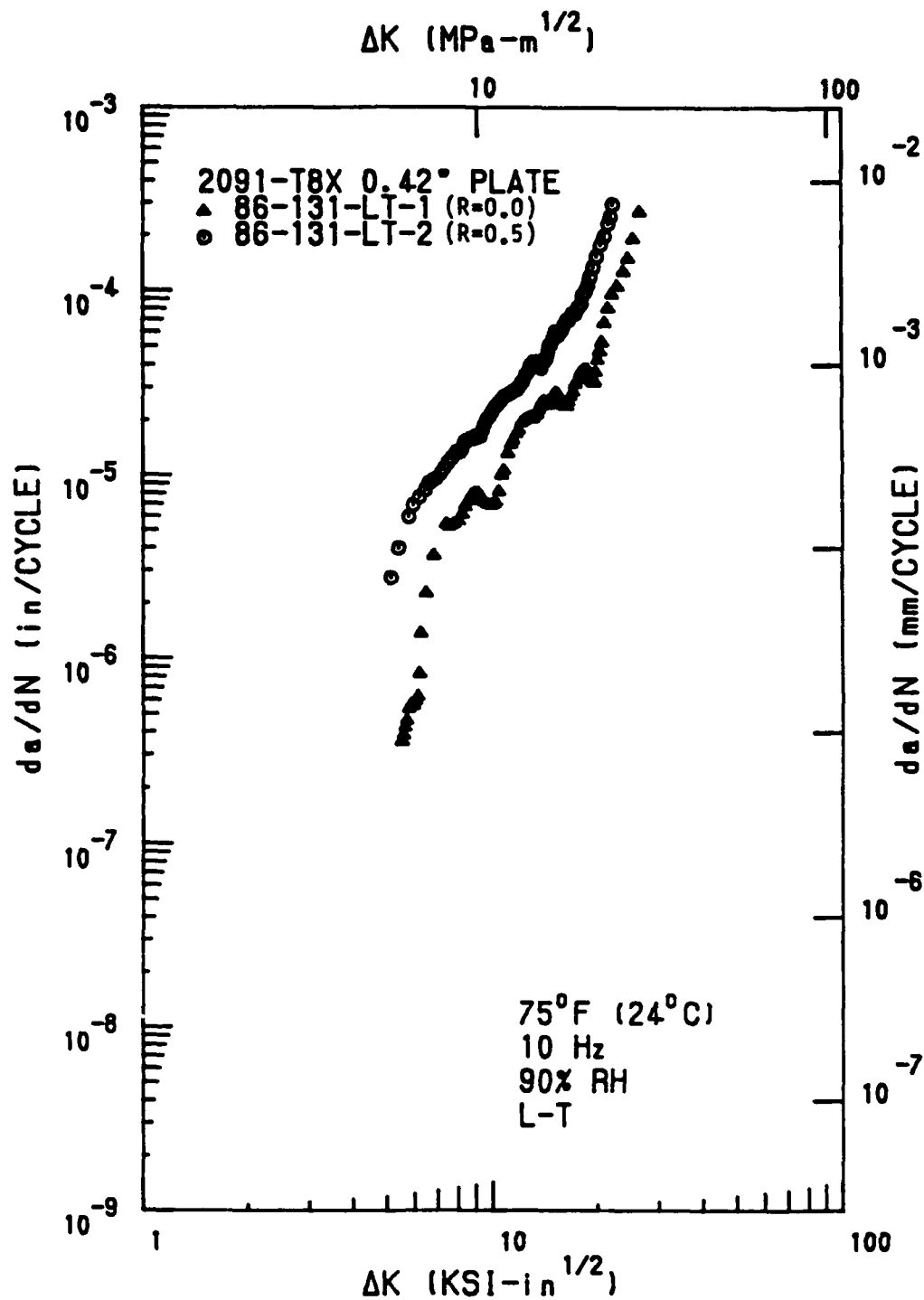


Figure A15 Fatigue Crack Growth Rate Data for Pechiney 2091-T8X 0.42" Plate (L-T Orientation). Grumman.

TABLE A42

Fatigue Crack Growth Rate Data Associated with Figure A15

Seven Point Incremental Polynomial Method per ASTM E647

1-07-1988

Specimen Number: 1 Specimen Type: CCT
76-131-LT-1 $\beta = 0.2510$ in $W = 3.7570$ in $R = 0.0000$ $P_{max} = 6.258$ kips $P_{min} = 0.000$ kips $R = 0.00$ Frequency = 10.00 Hz.

Test Temperature = 75 F Environment = 90% RH

PT	CYCLES	Area ²	Area	MCC	Delta K	d _{cr} /dN
1	0.00	0.3750				
2	100.00	0.4130				
3	125.00	0.4230				
4	150.00	0.4280	0.4293	0.993070	5.49	-3509E-06
5	175.00	0.4350	0.4359	0.994133	5.54	-3814E-06
6	200.00	0.4450	0.4459	0.995104	5.60	-4186E-06
7	225.00	0.4580	0.4584	0.993770	5.68	-4557E-06
8	250.00	0.4730	0.4698	0.989179	5.76	-5286E-06
9	275.00	0.4830	0.4838	0.989264	5.84	-5572E-06
10	300.00	0.4930	0.4985	0.985594	5.94	-5500E-06
11	325.00	0.5180	0.5119	0.985675	6.02	-5809E-06
12	350.00	0.5280	0.5274	0.985314	6.11	-6143E-06
13	375.00	0.5380	0.5394	0.975956	6.18	-8171E-06
14	400.00	0.5500	0.5500	0.963793	6.25	-1353E-05
15	425.00	0.5750	0.5848	0.982328	6.46	-2233E-05
16	450.00	0.6350	0.6466	0.993047	6.81	-3590E-05
17	475.00	0.7500	0.7500	0.997940	7.39	-5334E-05
18	480.00	0.7850	0.7782	0.996031	7.54	-5181E-05
19	487.00	0.8250	0.8194	0.998323	7.76	-5355E-05
20	495.00	0.8630	0.8642	0.997329	7.99	-5509E-05
21	503.00	0.9030	0.9068	0.998029	8.22	-6035E-05
22	508.00	0.9380	0.9359	0.997254	8.37	-6702E-05
23	514.00	0.9750	0.9783	0.998123	8.59	-7215E-05
24	518.00	1.0100	1.0091	0.998413	8.75	-7713E-05
25	522.00	1.0450	1.0412	0.998083	8.91	-7890E-05
26	527.00	1.0780	1.0840	0.998472	9.13	-7921E-05
27	531.00	1.1180	1.1158	0.998533	9.30	-7550E-05
28	536.00	1.1550	1.1523	0.998540	9.48	-7115E-05
29	542.00	1.1930	1.1925	0.994702	9.69	-6909E-05
30	548.00	1.2280	1.2300	0.997253	9.89	-6816E-05
31	554.00	1.2650	1.2709	0.997368	10.10	-6910E-05
32	557.00	1.2980	1.2919	0.996996	10.21	-7116E-05
33	563.00	1.3380	1.3350	0.993909	10.43	-8092E-05
34	568.00	1.3700	1.3744	0.991370	10.64	-9918E-05
35	570.00	1.3900	1.3924	0.996834	10.74	-1047E-05
36	575.00	1.4480	1.4496	0.997611	11.05	-1301E-04
37	578.00	1.5000	1.4950	0.998418	11.28	-1485E-04
38	580.00	1.5200	1.5236	0.998567	11.45	-1539E-04
39	583.00	1.5700	1.5720	0.998111	11.72	-1669E-04
40	585.00	1.6080	1.6047	0.998757	11.90	-1739E-04
41	587.00	1.6400	1.6417	0.998662	12.12	-1910E-04
42	589.00	1.6800	1.6804	0.997808	12.34	-1970E-04
43	591.00	1.7180	1.7203	0.998652	12.58	-2011E-04
44	592.00	1.7480	1.7416	0.996933	12.70	-2035E-04
45	593.00	1.7600	1.7620	0.995848	12.83	-2031E-04
46	594.00	1.7800	1.7821	0.994735	12.95	-2050E-04
47	595.00	1.8030	1.8015	0.997713	13.07	-2014E-04
48	596.00	1.8250	1.8235	0.999795	13.21	-2096E-04
49	597.00	1.8450	1.8443	0.999626	13.34	-2107E-04
50	598.00	1.8650	1.8644	0.999178	13.47	-2164E-04
51	599.00	1.8850	1.8860	0.999408	13.61	-2264E-04
52	600.00	1.9080	1.9091	0.999509	13.76	-2357E-04
53	601.00	1.9250	1.9227	0.999591	13.92	-2486E-04
54	602.00	1.9600	1.9602	0.999148	14.10	-2514E-04
55	603.00	1.9850	1.9862	0.999299	14.27	-2646E-04
56	604.00	2.0130	2.0102	0.999139	14.44	-2646E-04
57	605.00	2.0330	2.0321	0.999400	14.59	-2543E-04
58	606.00	2.0550	2.0572	0.995600	14.77	-2646E-04
59	607.00	2.0800	2.0847	0.994563	14.97	-2714E-04
60	608.00	2.1200	2.1147	0.995204	15.19	-2789E-04
61	609.00	2.1700	2.1643	0.997517	15.41	-2768E-04
62	610.00	2.1950	2.1716	0.997587	15.62	-2639E-04
63	611.00	2.1950	2.1952	0.999899	15.81	-2832E-04
64	612.00	2.2200	2.2192	0.999809	16.00	-2804E-04
65	613.00	2.2430	2.2429	0.999782	16.19	-2371E-04
66	614.00	2.2650	2.2660	0.999781	16.39	-2364E-04
67	615.00	2.2900	2.2881	0.997997	16.57	-2311E-04
68	616.00	2.3130	2.3137	0.998539	16.79	-2671E-04
69	617.00	2.3380	2.3418	0.998314	17.04	-2829E-04
70	618.00	2.3750	2.3700	0.997528	17.30	-3125E-04
71	619.00	2.4030	2.4039	0.996892	17.61	-3311E-04
72	620.00	2.4330	2.4374	0.996757	17.94	-3582E-04
73	621.00	2.4800	2.4736	0.996256	18.30	-3705E-04
74	622.00	2.5080	2.5136	0.994674	18.71	-3716E-04
75	623.00	2.5580	2.5521	0.994646	19.12	-3405E-04
76	623.50	2.5700	2.5685	0.991572	19.31	-3208E-04
77	624.00	2.5830	2.5859	0.991366	19.50	-3171E-04
78	624.50	2.5980	2.5967	0.996676	19.63	-3214E-04
79	625.00	2.6130	2.6136	0.997546	19.82	-3614E-04
80	625.50	2.6300	2.6323	0.998068	20.05	-4186E-04
81	626.00	2.6580	2.6551	0.997722	20.33	-4664E-04
82	626.50	2.6780	2.6803	0.998454	20.64	-5193E-04
83	627.00	2.7100	2.7036	0.983642	20.95	-6586E-04
84	627.50	2.7350	2.7267	0.992482	21.39	-7945E-04
85	628.00	2.7480	2.7808	0.992475	22.01	-9461E-04
86	628.50	2.8450	2.8337	0.986284	22.82	-1044E-03
87	629.00	2.8980	2.8920	0.986808	23.78	-1258E-03
88	629.50	2.9280	2.9323	0.977779	24.50	-1479E-03
89	629.60	2.9530	2.9718	0.984816	25.25	-1897E-03
90	629.90	3.0280	3.0299	0.994657	26.46	-2666E-03
91	630.00	3.0430				
92	630.10	3.0930				
93	630.20	3.1180				

* - DATA VIOLATES SIZE REQUIREMENTS

TABLE A43

Fatigue Crack Growth Rate Data Associated with Figure A15

Seven Point Incremental Polynomial Method per ASTM E647

1-07-1988

Specimen Number: 86-131-LT-2 Specimen Type: CCT

 $\delta = 0.2500$ in $W = 3.7590$ in $A_w = 0.0000$ $f_{max} = 12.991$ kips $P_{min} = 6.496$ kips $\lambda = 0.50$ Frequency = 10.00 Hz.

Test Temperature = 75 F Environment = 90% RH

PT	CYCLES	Amesse2	Area	MCC	Delta K	da/dN
1	0.00	0.1660				
2	50.00	0.2130				
3	100.00	0.2430				
4	150.00	0.3210	0.3477	0.948439	5.13	.2702E-05
5	162.50	0.3460	0.3812	0.983353	5.38	.3948E-05
6	175.00	0.4310	0.4344	0.992519	5.74	.5838E-05
7	180.00	0.4610	0.4622	0.998007	5.94	.7919E-05
8	185.00	0.4960	0.4974	0.999810	6.18	.7494E-05
9	190.00	0.5360	0.5366	0.999737	6.43	.8211E-05
10	193.00	0.5630	0.5621	0.999370	6.59	.8884E-05
11	196.00	0.5860	0.5897	0.998953	6.75	.9188E-05
12	199.00	0.6160	0.6177	0.998889	6.92	.9512E-05
13	202.00	0.6310	0.6449	0.998984	7.10	.1000E-04
14	205.00	0.6760	0.6772	0.998671	7.27	.1047E-04
15	208.00	0.7080	0.7090	0.998634	7.46	.1148E-04
16	211.00	0.7430	0.7436	0.999122	7.66	.1221E-04
17	214.00	0.7830	0.7829	0.999396	7.88	.1314E-04
18	216.00	0.8130	0.8106	0.996943	8.03	.1313E-04
19	218.00	0.8360	0.8371	0.997654	8.18	.1382E-04
20	220.00	0.8660	0.8631	0.996837	8.32	.1477E-04
21	222.00	0.8880	0.8934	0.995546	8.48	.1523E-04
22	224.00	0.9260	0.9263	0.994385	8.64	.1563E-04
23	226.00	0.9660	0.9587	0.994334	8.84	.1588E-04
24	227.50	0.9810	0.9835	0.995275	8.97	.1609E-04
25	229.00	1.0030	1.0037	0.995742	9.09	.1596E-04
26	230.50	1.0280	1.0280	0.998612	9.21	.1617E-04
27	232.00	1.0560	1.0543	0.999721	9.35	.1748E-04
28	233.50	1.0810	1.0805	0.998869	9.49	.1883E-04
29	235.00	1.1080	1.1092	0.999172	9.65	.1993E-04
30	236.50	1.1380	1.1404	0.998224	9.81	.2067E-04
31	238.00	1.1760	1.1728	0.996891	9.99	.2192E-04
32	239.50	1.2080	1.2065	0.996958	10.17	.2314E-04
33	241.00	1.2380	1.2415	0.999043	10.36	.2414E-04
34	242.50	1.2780	1.2772	0.999711	10.55	.2524E-04
35	244.00	1.3180	1.3171	0.999391	10.77	.2635E-04
36	245.50	1.3580	1.3593	0.999642	11.00	.2713E-04
37	247.00	1.4030	1.4003	0.999380	11.23	.2770E-04
38	248.00	1.4280	1.4282	0.999275	11.38	.2794E-04
39	249.00	1.4530	1.4539	0.998907	11.54	.2868E-04
40	250.00	1.4860	1.4842	0.999074	11.70	.2879E-04
41	251.00	1.5130	1.5140	0.999318	11.87	.2979E-04
42	252.00	1.5460	1.5439	0.999036	12.04	.3107E-04
43	253.00	1.5730	1.5741	0.999509	12.22	.3232E-04
44	254.00	1.6060	1.6072	0.999598	12.41	.3443E-04
45	255.00	1.6430	1.6424	0.999693	12.62	.3629E-04
46	256.00	1.6800	1.6791	0.999788	12.83	.3820E-04
47	257.00	1.7170	1.7161	0.999883	13.04	.4011E-04
48	258.00	1.7540	1.7531	0.999978	13.25	.4202E-04
49	259.00	1.7910	1.7901	0.999973	13.46	.4393E-04
50	260.00	1.8280	1.8271	0.999968	13.67	.4584E-04
51	261.00	1.8650	1.8641	0.999963	13.88	.4775E-04
52	262.00	1.9020	1.9011	0.999958	14.09	.4966E-04
53	263.00	1.9390	1.9381	0.999953	14.30	.5157E-04
54	264.00	1.9760	1.9751	0.999948	14.51	.5348E-04
55	265.00	2.0130	2.0121	0.999943	14.72	.5539E-04
56	266.00	2.0500	2.0491	0.999938	14.93	.5730E-04
57	267.00	2.0870	2.0861	0.999933	15.14	.5921E-04
58	268.00	2.1240	2.1231	0.999928	15.35	.6112E-04
59	269.00	2.1610	2.1601	0.999923	15.56	.6303E-04
60	270.00	2.1980	2.1971	0.999918	15.77	.6494E-04
61	271.00	2.2350	2.2341	0.999913	15.98	.6685E-04
62	272.00	2.2720	2.2711	0.999908	16.19	.6876E-04
63	273.00	2.3090	2.3081	0.999903	16.40	.7067E-04
64	274.00	2.3460	2.3451	0.999898	16.61	.7258E-04
65	275.00	2.3830	2.3821	0.999893	16.82	.7449E-04
66	276.00	2.4200	2.4191	0.999888	17.03	.7640E-04
67	277.00	2.4570	2.4561	0.999883	17.24	.7831E-04
68	278.00	2.4940	2.4931	0.999878	17.45	.8022E-04
69	279.00	2.5310	2.5301	0.999873	17.66	.8213E-04
70	280.00	2.5680	2.5671	0.999868	17.87	.8404E-04
71	281.00	2.6050	2.6041	0.999863	18.08	.8595E-04
72	282.00	2.6420	2.6411	0.999858	18.29	.8786E-04
73	283.00	2.6790	2.6781	0.999853	18.50	.8977E-04
74	284.00	2.7160	2.7151	0.999848	18.71	.9168E-04
75	285.00	2.7530	2.7521	0.999843	18.92	.9359E-04
76	286.00	2.7900	2.7891	0.999838	19.13	.9550E-04
77	287.00	2.8270	2.8261	0.999833	19.34	.9741E-04
78	288.00	2.8640	2.8631	0.999828	19.55	.9932E-04
79	289.00	2.9010	2.9001	0.999823	19.76	.1014E-03
80	290.00	2.9380	2.9371	0.999818	19.97	.1095E-03
81	291.00	2.9750	2.9741	0.999813	20.18	.1176E-03
82	292.00	3.0120	3.0111	0.999808	20.39	.1257E-03
83	293.00	3.0490	3.0481	0.999803	20.60	.1338E-03
84	294.00	3.0860	3.0851	0.999798	20.81	.1419E-03
85	295.00	3.1230	3.1221	0.999793	21.02	.1500E-03
86	296.00	3.1600	3.1591	0.999788	21.23	.1581E-03
87	297.00	3.1970	3.1961	0.999783	21.44	.1662E-03
88	298.00	3.2340	3.2331	0.999778	21.65	.1743E-03
89	299.00	3.2710	3.2701	0.999773	21.86	.1824E-03
90	300.00	3.3080	3.3071	0.999768	22.07	.1905E-03
91	301.00	3.3450	3.3441	0.999763	22.28	.1986E-03
92	302.00	3.3820	3.3811	0.999758	22.49	.2067E-03
93	303.00	3.4190	3.4181	0.999753	22.70	.2148E-03
94	304.00	3.4560	3.4551	0.999748	22.91	.2229E-03
95	305.00	3.4930	3.4921	0.999743	23.12	.2310E-03
96	306.00	3.5300	3.5291	0.999738	23.33	.2391E-03
97	307.00	3.5670	3.5661	0.999733	23.54	.2472E-03
98	308.00	3.6040	3.6031	0.999728	23.75	.2553E-03
99	309.00	3.6410	3.6401	0.999723	23.96	.2634E-03
100	310.00	3.6780	3.6771	0.999718	24.17	.2715E-03

* - DATA VIOLATES SIZE REQUIREMENTS

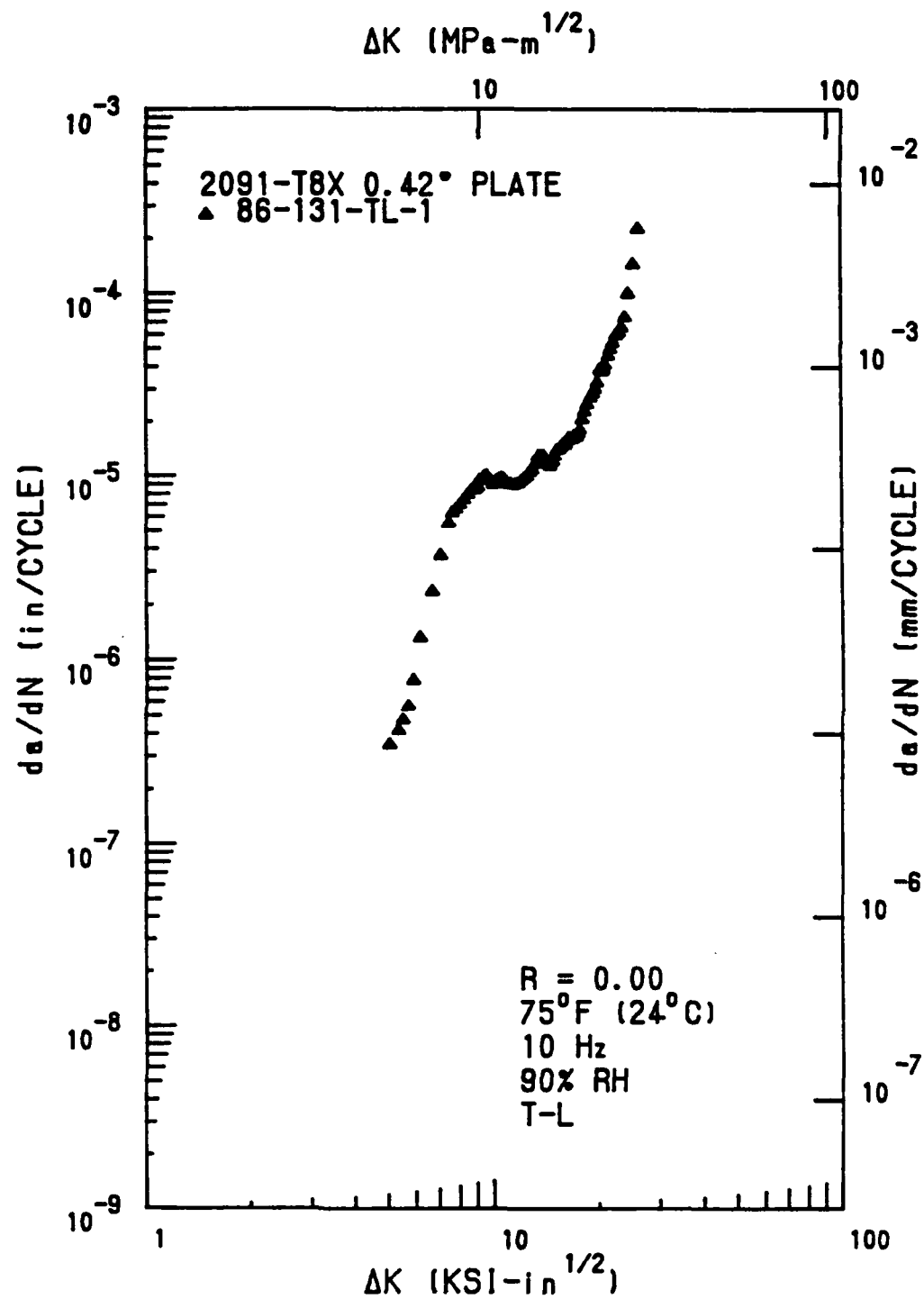


Figure A16 Fatigue Crack Growth Rate Data for Pechiney 2091-T8X 0.42" Plate (T-L Orientation). Grumman.

TABLE A44

Fatigue Crack Growth Rate Data Associated with Figure A16

Seven Point Incremental Polynomial Method per ASTM E647

1-14-1988

Specimen Number: 86-131-1L-1 Specimen Type: CCT

B = 0.2500 in W = 3.7540 in An = 0.0000

Pmax = 6.765 kips Pmin = 0.000 kips

R = 0.00 Frequency = 10.00 Hz

Test Temperature = 75 F Environment = 90% RH

CT	CYCLES	Area2	Area	MCC	Delta K	da/dN
1	0.00	0.2210				
2	101.00	0.2460				
3	225.00	0.2730				
4	325.00	0.2960	0.2066	0.999057	5.02	.345E-06
5	425.00	0.3230	0.3430	0.999641	5.22	.412E-06
6	475.00	0.3640	0.3646	0.998716	5.49	.467E-06
7	525.00	0.3860	0.3876	0.996682	5.66	.526E-06
8	575.00	0.4120	0.4112	0.971974	5.84	.584E-06
9	625.00	0.4480	0.4488	0.950143	6.11	.715E-05
10	675.00	0.4930	0.5254	0.959589	6.63	.233E-05
11	700.00	0.5680	0.5879	0.976200	7.03	.364E-05
12	715.00	0.6460	0.6469	0.998410	7.40	.547E-05
13	720.00	0.6730	0.6732	0.999727	7.56	.621E-05
14	725.00	0.7060	0.7065	0.999812	7.76	.690E-05
15	730.00	0.7410	0.7297	0.999720	7.96	.750E-05
16	735.00	0.7760	0.7756	0.999795	8.17	.807E-05
17	740.00	0.8110	0.8126	0.999602	8.39	.884E-05
18	745.00	0.8530	0.8523	0.999457	8.62	.927E-05
19	747.50	0.8750	0.8727	0.999198	8.74	.974E-05
20	750.00	0.8980	0.8928	0.999243	8.86	.971E-05
21	752.50	0.9160	0.9160	0.997085	8.98	.942E-05
22	755.00	0.9280	0.9263	0.995186	9.09	.942E-05
23	757.50	0.9560	0.9627	0.990407	9.24	.912E-05
24	760.00	0.9860	0.9873	0.992226	9.38	.979E-05
25	762.50	1.0210	1.0122	0.994419	9.52	.993E-05
26	767.50	1.0560	1.0626	0.995740	9.80	.973E-05
27	770.00	1.0860	1.0841	0.995452	9.92	.892E-05
28	772.50	1.1060	1.1046	0.997105	10.04	.897E-05
29	775.00	1.1280	1.1282	0.997157	10.17	.978E-05
30	777.50	1.1480	1.1503	0.999777	10.29	.940E-05
31	780.00	1.1760	1.1752	0.998758	10.43	.964E-05
32	782.50	1.2010	1.2004	0.998969	10.57	.970E-05
33	785.00	1.2260	1.2257	0.999913	10.71	.951E-05
34	787.50	1.2480	1.2479	0.999098	10.84	.930E-05
35	790.00	1.2710	1.2712	0.998665	10.97	.803E-05
36	792.50	1.2910	1.2924	0.998656	11.09	.886E-05
37	795.00	1.3180	1.3146	0.998751	11.22	.887E-05
38	798.00	1.3360	1.3415	0.998660	11.37	.884E-05
39	802.00	1.3780	1.3762	0.999732	11.79	.900E-05
40	806.00	1.4130	1.4119	0.999072	11.99	.926E-05
41	810.00	1.4660	1.4687	0.995277	12.21	.962E-05
42	814.00	1.4860	1.4853	0.999644	12.45	.970E-05
43	818.00	1.5270	1.5252	0.999311	12.67	.104E-04
44	822.00	1.5660	1.5653	0.999726	12.91	.108E-04
45	825.50	1.6040	1.6040	0.999748	13.15	.116E-04
46	829.00	1.6360	1.6402	0.998831	13.41	.124E-04
47	832.50	1.6830	1.6805	0.999092		
48	835.00	1.7110	1.7119	0.995622	13.62	.127E-04
49	837.50	1.7480	1.7495	0.996952	13.85	.128E-04
50	840.00	1.7880	1.7816	0.996705	14.07	.129E-04
51	842.50	1.8280	1.8124	0.996459	14.27	.117E-04
52	845.00	1.8410	1.8193	0.995681	14.46	.112E-04
53	847.00	1.8580	1.8590	0.997644	14.59	.116E-04
54	849.00	1.8930	1.8840	0.996607	14.77	.119E-04
55	851.00	1.9060	1.9065	0.996025	14.92	.127E-04
56	853.00	1.9280	1.9241	0.996057	15.13	.126E-04
57	855.00	1.9560	1.9625	0.994868	15.33	.129E-04
58	857.00	1.9760	1.9910	0.994779	15.54	.141E-04
59	858.50	2.0130	2.0117	0.994258	15.70	.145E-04
60	860.00	2.0310	2.0252	0.994250	15.89	.149E-04
61	861.50	2.0560	2.0523	0.994007	16.04	.146E-04
62	863.00	2.0810	2.0787	0.993926	16.22	.142E-04
63	864.50	2.1010	2.1025	0.993742	16.41	.161E-04
64	866.00	2.1260	2.1270	0.993700	16.61	.159E-04
65	867.50	2.1500	2.1507	0.993289	16.89	.157E-04
66	869.00	2.1700	2.1743	0.993289	17.09	.164E-04
67	870.50	2.1960	2.1992	0.992763	17.22	.162E-04
68	872.00	2.2110	2.2224	0.992763	17.42	.162E-04
69	873.50	2.2370	2.2480	0.992794	17.65	.178E-04
70	875.00	2.2510	2.2748	0.992794	17.89	.170E-04
71	876.50	2.2680	2.3037	0.992621	18.19	.202E-04
72	878.00	2.2860	2.3060	0.992621	18.41	.227E-04
73	879.50	2.3060	2.3089	0.992580	18.52	.268E-04
74	880.50	2.3260	2.3089	0.992571	19.20	.283E-04
75	881.50	2.3460	2.4291	0.992484	19.51	.292E-04
76	882.50	2.3660	2.4665	0.992457	19.81	.253E-04
77	883.50	2.3810	2.5004	0.992457	20.13	.284E-04
78	884.00	2.3910	2.5210	0.992322	20.42	.271E-04
79	884.50	2.5410	2.5408	0.996498	20.65	.281E-04
80	885.00	2.5660	2.5590	0.992459	21.87	.406E-04
81	886.00	2.5960	2.6005	0.992459	21.78	.452E-04
82	886.50	2.6180	2.6221	0.992487	21.66	.474E-04
83	887.00	2.6570	2.6472	0.996650	21.99	.523E-04
84	887.50	2.6760	2.6777	0.991857	22.41	.495E-04
85	888.00	2.7060	2.7082	0.998892	22.84	.605E-04
86	888.50	2.7260	2.7290	0.997805	23.25	.647E-04
87	889.00	2.7710	2.7694	0.997141	23.76	.723E-04
88	889.50	2.8010	2.8020	0.987227	24.20	.999E-04
89	890.00	2.8310	2.8050	0.986227	24.19	.143E-03
90	890.50	2.8610	2.8610	0.986227	24.19	.143E-03
91	890.60	2.9610	2.9610	0.986227	24.19	.143E-03
92	890.80	3.0680	3.0680	0.986227	24.19	.143E-03

* DATA VIOLATES SIZE REQUIREMENTS

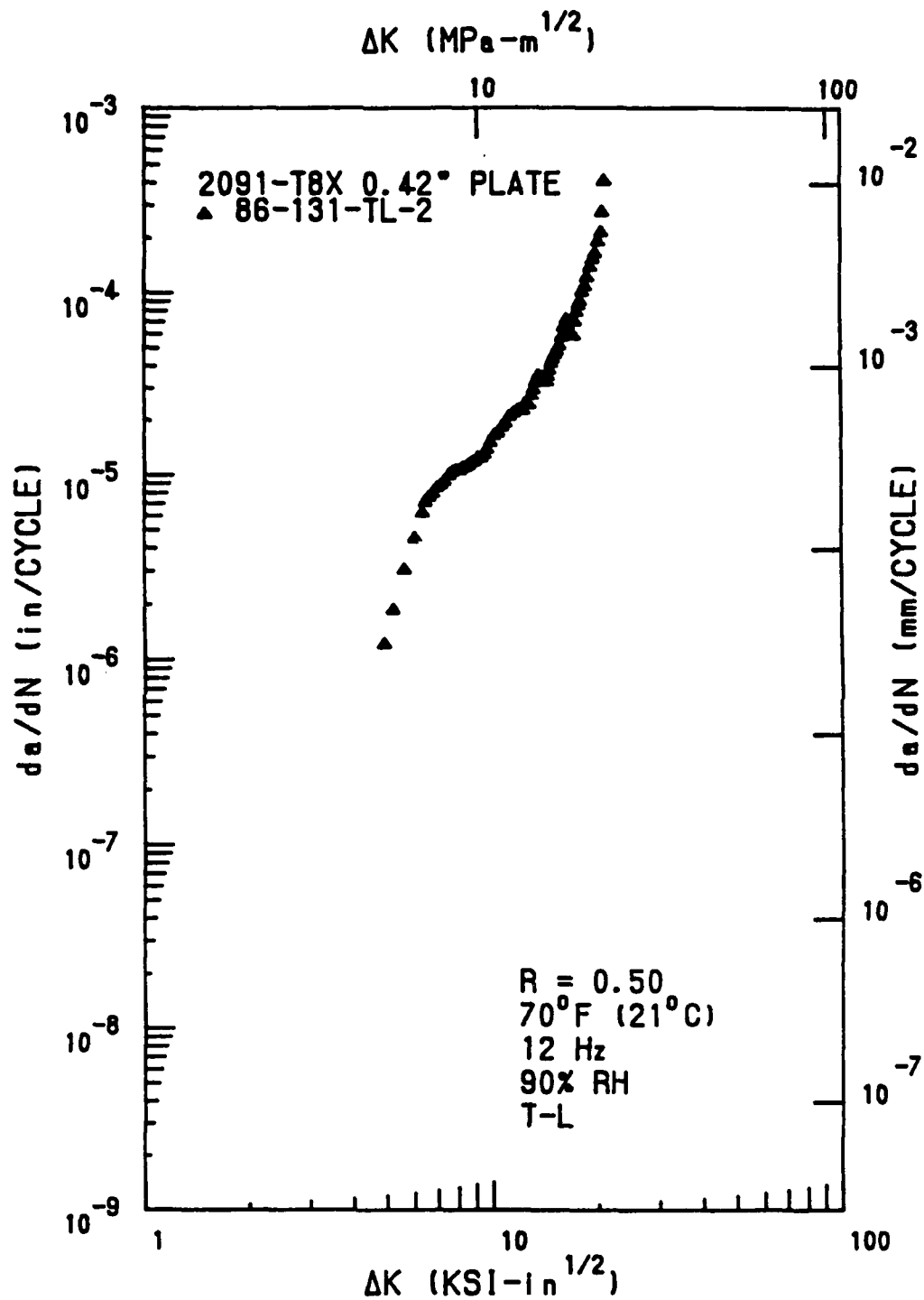


Figure A17 Fatigue Crack Growth Rate Data for Pechiney 2091-T8X 0.42" Plate (T-L Orientation). Grumman.

Fatigue Crack Growth Rate Data Associated with Figure A17

Seven Point Incremental Polynomial Method per ASTM E647

11-14-1968

Specimen Number: 06-151-7L-2 Specimen Type: C53

B= 0.2500 in W= 3.7590 in An= 0.0000

Peak= 14.433 kilos Pain= 7.210 tips

R= 0.50
Frequency= 12.00 Hz.

Test Temperature= 70 F Environment= 90% RH

PT	CYCLES	Ames2	Area	MCE	Delta K	da/dN
1	0.00	0.1910				
2	50.00	0.2090				
3	100.00	0.2390				
4	125.00	0.2530	0.2548	0.971287	4.89	-1310E-05
5	150.00	0.2780	0.2872	0.961194	5.18	-1847E-04
6	175.00	0.3210	0.3334	0.987310	5.39	-3040E-05
7	190.00	0.3740	0.3840	0.993097	6.00	-4459E-05
8	197.50	0.4180	0.4206	0.997124	6.29	-6156E-05
9	200.50	0.4340	0.4381	0.998832	6.52	-7046E-05
10	203.50	0.4580	0.4597	0.998034	6.39	-7488E-05
11	204.50	0.4880	0.4841	0.998035	6.77	-7905E-05
12	209.50	0.5080	0.5084	0.997851	6.94	-8452E-05
13	212.50	0.5330	0.5339	0.997992	7.12	-8741E-05
14	215.50	0.5580	0.5594	0.999343	7.30	-9194E-05
15	218.50	0.5910	0.5987	0.999481	7.50	-9881E-05
16	221.50	0.6110	0.6142	0.999508	7.67	-1032E-04
17	223.00	0.6410	0.6413	0.999486	7.85	-1053E-04
18	226.00	0.6680	0.6679	0.999294	8.02	-1051E-04
19	228.50	0.6940	0.6945	0.999265	8.19	-1083E-04
20	231.00	0.7210	0.7209	0.999290	8.34	-1101E-04
21	233.50	0.7460	0.7484	0.999486	8.54	-1121E-04
22	236.00	0.7780	0.7746	0.999486	8.71	-1163E-04
23	238.50	0.8080	0.8074	0.999027	8.90	-1183E-04
24	241.00	0.8360	0.8369	0.998235	9.08	-1237E-04
25	243.50	0.8700	0.8681	0.997960	9.27	-1234E-04
26	246.00	0.8950	0.8984	0.997426	9.46	-1296E-04
27	248.50	0.9340	0.9309	0.997602	9.65	-1380E-04
28	251.00	0.9610	0.9450	0.998209	9.84	-1499E-04
29	253.50	1.0050	1.0048	0.998365	10.10	-1632E-04
30	256.00	1.0460	1.0478	0.997434	10.35	-1694E-04
31	258.50	1.0940	1.0932	0.999193	10.62	-1817E-04
32	261.00	1.1410	1.1378	0.998649	10.89	-1911E-04
33	263.50	1.1810	1.1848	0.998329	11.17	-2079E-04
34	266.00	1.2340	1.2377	0.997216	11.49	-2176E-04
35	268.50	1.2940	1.2953	0.995795	11.83	-2268E-04
36	271.00	1.3460	1.3559	0.997131	12.20	-2353E-04
37	272.00	1.3790	1.3834	0.992412	12.37	-2438E-04
38	273.40	1.4040	1.4115	0.990814	12.54	-2494E-04
39	274.60	1.4360	1.4402	0.985911	12.72	-2496E-04
40	275.80	1.4810	1.4713	0.989726	12.92	-2717E-04
41	277.00	1.5060	1.5032	0.989483	13.12	-2955E-04
42	278.20	1.5240	1.5379	0.990826	13.34	-3232E-04
43	279.40	1.5800	1.5755	0.992678	13.58	-3512E-04
44	280.40	1.6260	1.6221	0.985759	13.89	-3438E-04

* - DATA VIOLATES SIZE REQUIREMENTS

- DATA VIOLATES SIZE REQUIREMENTS

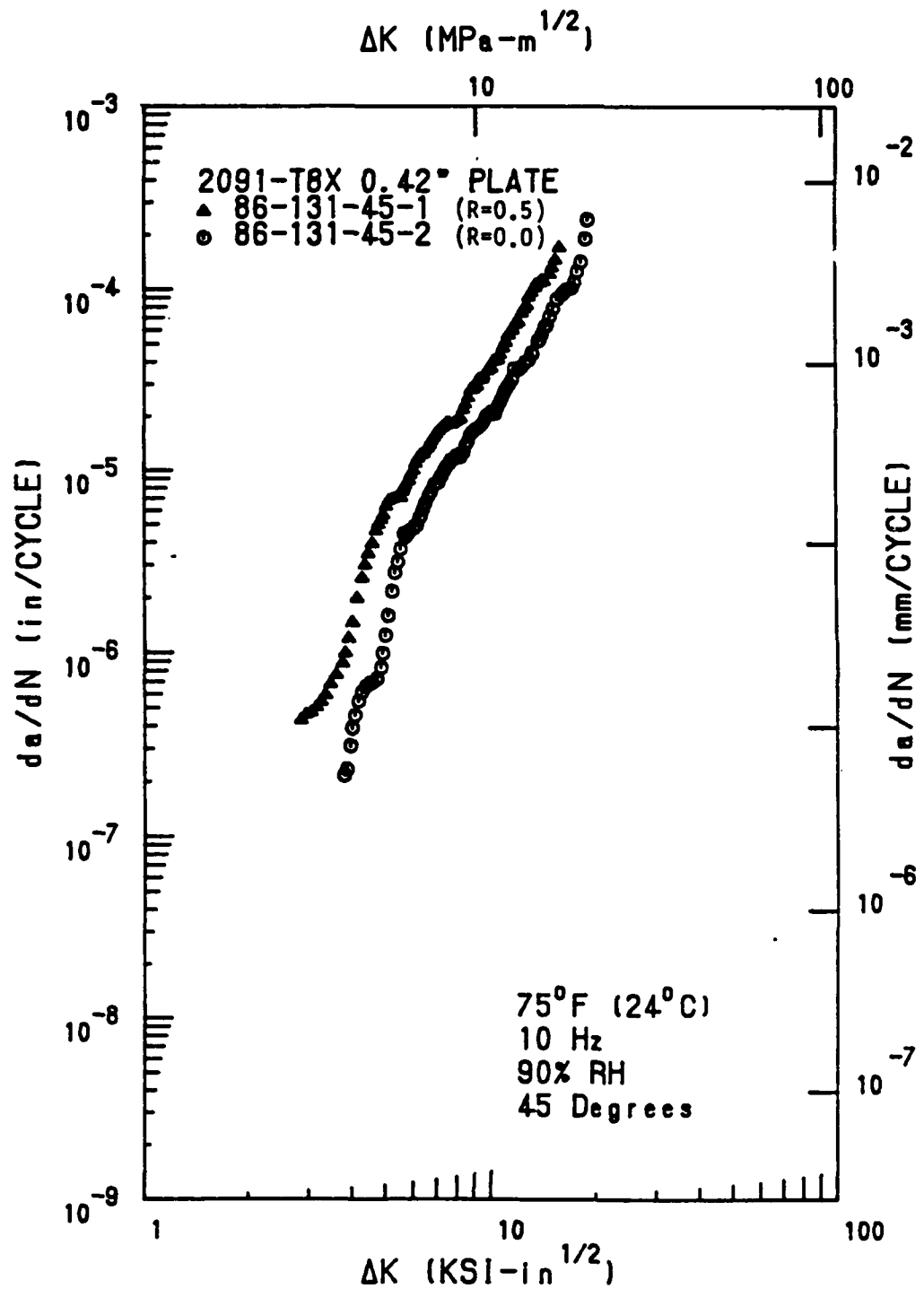


Figure A18 Fatigue Crack Growth Rate Data for Pechiney 2091-T8X 0.42" Plate (45 degrees Orientation). Grumman.

TABLE A46

Fatigue Crack Growth Rate Data Associated with Figure A18

Seven Point Incremental Polynomial Method per ASTM E647

1-15-1988

Specimen Number: 86-131-45-1 Specimen Type: CCT

 $\sigma = 0.2500$ in $M = 3.7530$ in $A_n = 0.0000$ $P_{max} = 7.375$ kips $P_{min} = 3.688$ kips $R = 0.50$ Frequency = 10.00 Hz.

Test Temperature = 75 F Environment = 90% RH

PT	CYCLES	Amplitude	Area	MCC	Delta K	da/dN
1	0.00	0.2750				
2	50.00	0.2900				
3	100.00	0.3130				
4	150.00	0.3330	0.3321	0.999225	2.85	.4284E-06
5	200.00	0.3530	0.3545	0.999409	2.95	.4607E-06
6	250.00	0.3780	0.3780	0.999261	3.05	.4743E-06
7	300.00	0.4030	0.4024	0.999274	3.15	.5037E-06
8	350.00	0.4300	0.4282	0.999130	3.25	.5421E-06
9	400.00	0.4530	0.4547	0.999030	3.35	.5893E-06
10	450.00	0.4850	0.4841	0.998128	3.46	.6733E-06
11	500.00	0.5180	0.5192	0.998159	3.59	.7601E-06
12	550.00	0.5580	0.5622	0.998047	3.74	.8738E-06
13	575.00	0.5880	0.5823	0.996666	3.81	.9944E-06
14	600.00	0.6030	0.6070	0.992261	3.90	.1147E-05
15	625.00	0.6330	0.6350	0.994322	4.00	.1447E-05
16	650.00	0.6710	0.6716	0.998336	4.12	.1867E-05
17	670.00	0.7130	0.7150	0.998613	4.26	.2536E-05
18	680.00	0.7380	0.7402	0.999224	4.34	.2999E-05
19	690.00	0.7730	0.7712	0.999473	4.44	.3433E-05
20	700.00	0.8050	0.8074	0.999472	4.56	.3917E-05
21	710.00	0.8500	0.8493	0.998800	4.69	.4602E-05
22	715.00	0.8730	0.8722	0.999202	4.76	.4970E-05
23	720.00	0.8930	0.8984	0.999183	4.84	.5304E-05
24	725.00	0.9280	0.9234	0.999198	4.92	.5627E-05
25	730.00	0.9550	0.9536	0.997856	5.01	.6279E-05
26	735.00	0.9850	0.9870	0.996167	5.11	.6737E-05
27	740.00	1.0180	1.0223	0.996167	5.22	.6900E-05
28	745.00	1.0450	1.0598	0.996528	5.33	.7003E-05
29	750.00	1.0980	1.0961	0.995982	5.45	.7127E-05
30	755.00	1.1280	1.1317	0.994437	5.55	.7375E-05
31	757.50	1.1430	1.1468	0.997144	5.60	.7598E-05
32	760.00	1.1700	1.1837	0.996977	5.64	.7942E-05
33	762.50	1.1850	1.1875	0.997133	5.72	.8286E-05
34	765.00	1.2100	1.2083	0.996945	5.79	.8733E-05
35	767.50	1.2300	1.2293	0.998447	5.85	.8793E-05
36	770.00	1.2500	1.2523	0.998846	5.92	.9410E-05
37	773.00	1.2830	1.2801	0.999431	6.01	.9993E-05
38	776.00	1.3100	1.3114	0.999339	6.11	.1094E-04
39	778.00	1.3430	1.3462	0.999207	6.21	.1164E-04
40	782.00	1.3830	1.3822	0.998908	6.33	.1212E-04
41	785.00	1.4230	1.4208	0.999693	6.45	.1235E-04
42	787.00	1.4450	1.4454	0.998228	6.53	.1305E-04
43	789.00	1.4700	1.4711	0.998353	6.61	.1332E-04
44	791.00	1.4950	1.4971	0.998890	6.70	.1395E-04
45	793.00	1.5300	1.5249	0.998461	6.79	.1462E-04
46	795.00	1.5530	1.5570	0.998998	6.89	.1527E-04
47	797.00	1.5700	1.5681	0.998967	7.00	.1586E-04
48	799.00	1.6180	1.6187	0.999349	7.10	.1635E-04
49	801.00	1.6530				
50	803.00	1.6880				
51	805.00	1.7300				
52	807.00	1.7625				
53	808.50	1.7880				
54	810.00	1.8200				
55	811.50	1.8450				
56	813.00	1.8480				
57	814.50	1.9000				
58	816.00	1.9300				
59	817.50	1.9571				
60	819.00	1.9900				
61	820.50	2.0150				
62	822.00	2.0750				
63	823.40	2.1080				
64	824.10	2.1250				
65	824.80	2.1500				
66	825.50	2.1650				
67	826.20	2.1950				
68	826.90	2.2150				
69	827.60	2.2430				
70	829.00	2.2780				
71	829.70	2.3080				
72	830.40	2.3380				
73	831.10	2.3650				
74	831.80	2.3880				
75	832.50	2.4150				
76	833.20	2.4500				
77	833.90	2.4800				
78	834.60	2.5100				
79	835.30	2.5480				
80	836.00	2.5930				
81	836.50	2.6200				
82	837.00	2.6600				
83	837.60	2.6900				
84	837.90	2.7200				
85	838.20	2.7380				
86	838.50	2.7700				
87	838.80	2.7947				
88	839.10	2.8200				
89	839.20	2.8400				
90	839.50	2.8680				
91	839.70	2.8900				
92	839.90	2.9180				
93	840.30	2.9530				
94	840.50	2.9800				
95	840.70	3.0130				
96	840.90	3.0350				
97	841.10	3.0730				
98	841.30	3.1080				
99	841.50	3.1650				

* - DATA VIOLATES SIZE REQUIREMENTS

TABLE A47

Fatigue Crack Growth Rate Data Associated with Figure A18

Seven Point Incremental Polynomial Method per ASTM E647

11-16-1988

Specimen Number: 86-131-45-2 Specimen Type: CCT

R = 0.2400 in W = 3.7530 in An = 0.0000

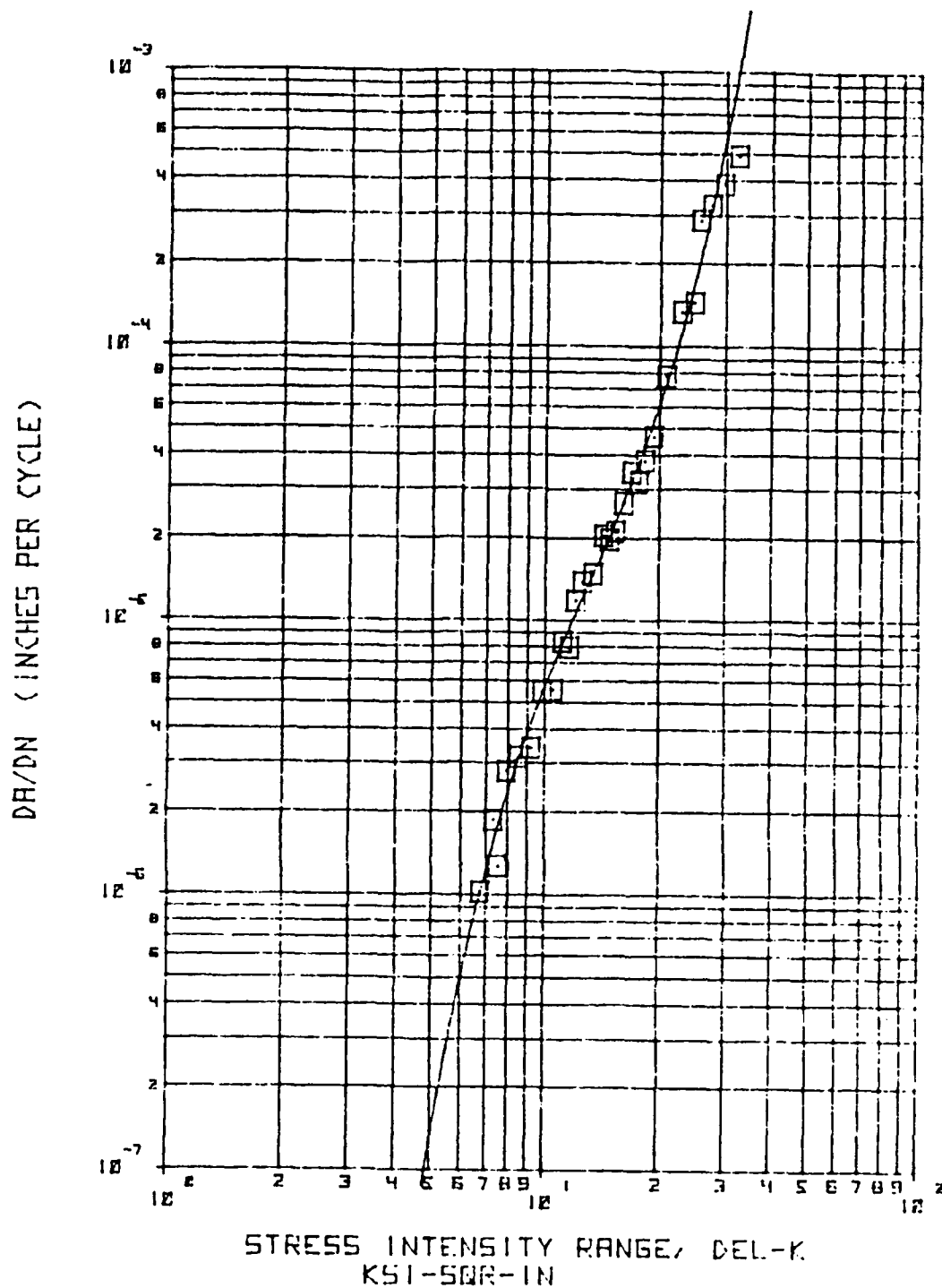
Pmax = 3.637 kips Pmin = 0.000 kips

R = 0.00 Frequency = 10.00 Hz.

Test Temperature = 75 F Environment = 90% RH

PT	CYCLES	Area#2	Area	MCC	Delta K	da/dN				
1	0.00	0.4940		51	1105.00	1.8980	1.8970	0.996348	8.37	.1270E-04
2	75.00	0.5110		52	1107.00	1.9180	1.9224	0.996983	8.47	.1370E-04
3	150.00	0.5280		53	1109.00	1.9510	1.9303	0.997873	8.59	.1470E-04
4	200.00	0.5460		54	1111.00	1.9820	1.9816	0.998691	8.72	.1540E-04
5	300.00	0.5610	0.3405	55	1113.00	2.0160	2.0155	0.999640	8.86	.1620E-04
6	400.00	0.5740	0.5821	56	1115.00	2.0460	2.0471	0.999682	9.00	.1680E-04
7	450.00	0.5960	0.5967	57	1117.00	2.0830	2.0815	0.998529	9.13	.1703E-04
8	500.00	0.6180	0.6169	58	1119.00	2.1130	2.1160	0.998529	9.30	.1746E-04
9	550.00	0.6430	0.6443	59	1121.00	2.1560	2.1515	0.998200	9.47	.1825E-04
10	600.00	0.6730	0.6714	60	1123.00	2.1760	2.1780	0.997823	9.60	.1845E-04
11	650.00	0.7010	0.7043	61	1124.00	2.2060	2.2084	0.997339	9.74	.2004E-04
12	700.00	0.7410	0.7384	62	1125.00	2.2380	2.2385	0.997460	9.89	.2050E-04
13	725.00	0.7580	0.7548	63	1127.00	2.2760	2.2725	0.998930	10.07	.2108E-04
14	775.00	0.7910	0.7916	64	1129.00	2.3130	2.3148	0.998930	10.29	.2061E-04
15	800.00	0.8080	0.8075	65	1130.00	2.3360	2.3345	0.998554	10.39	.2212E-04
16	850.00	0.8410	0.8446	66	1131.00	2.3530	2.3553	0.997940	10.51	.2300E-04
17	875.00	0.8680	0.8637	67	1132.00	2.3760	2.3791	0.997384	10.64	.2407E-04
18	900.00	0.8860	0.8890	68	1133.00	2.4080	2.4037	0.997665	10.78	.2561E-04
19	925.00	0.9160	0.9190	69	1134.00	2.4310	2.4310	0.998650	10.94	.2739E-04
20	950.00	0.9580	0.9609	70	1135.00	2.4540	2.4584	0.998531	11.11	.2886E-04
21	965.00	0.9960	0.9946	71	1136.00	2.4880	2.4869	0.997605	11.29	.3000E-04
22	975.00	1.0230	1.0234	72	1137.00	2.5180	2.5186	0.997599	11.49	.3218E-04
23	985.00	1.0530	1.0539	73	1138.00	2.5530	2.5497	0.995679	11.70	.3671E-04
24	995.00	1.0960	1.0939	74	1139.00	2.5860	2.5910	0.987277	11.98	.3625E-04
25	1000.00	1.1130	1.1182	75	1140.00	2.6230	2.6288	0.983859	12.23	.3757E-04
26	1005.00	1.1430	1.1415	76	1141.00	2.6600	2.6673	0.979011	12.54	.3964E-04
27	1010.00	1.1710	1.1635	77	1142.00	2.6910	2.7079	0.977235	12.87	.4105E-04
28	1020.00	1.2030	1.2100	78	1142.80	2.7360	2.7402	0.972650	13.13	.4482E-04
29	1025.00	1.2310	1.2318	79	1143.00	2.7560	2.7443	0.981183	13.17	.4432E-04
30	1030.00	1.2610	1.2564	80	1144.00	2.7930	2.8002	0.994164	13.66	.5174E-04
31	1035.00	1.2830	1.2837	81	1144.40	2.8210	2.8186	0.994581	13.84	.5318E-04
32	1040.00	1.3110	1.3098	82	1144.80	2.8410	2.8394	0.997718	14.04	.5665E-04
33	1045.00	1.3330	1.3340	83	1145.20	2.8620	2.8636	0.997765	14.28	.6196E-04
34	1050.00	1.3710	1.3698	84	1145.60	2.8860	2.8882	0.996813	14.53	.6366E-04
35	1055.00	1.4010	1.4038	85	1146.00	2.9160	2.9142	0.998254	14.81	.7071E-04
36	1060.00	1.4480	1.4425	86	1146.40	2.9460	2.9435	0.998159	15.14	.7841E-04
37	1066.00	1.4830	1.4885	87	1146.80	2.9710	2.9759	0.997914	15.53	.8821E-04
38	1069.00	1.5160	1.5145	88	1147.20	3.0120	3.0125	0.997132	15.99	.9342E-04
39	1072.00	1.5360	1.5387	89	1147.60	3.0560	3.0321	0.994991	16.25	.9629E-04
40	1075.00	1.5710	1.5673	90	1148.00	3.0910	3.0924	0.999481	16.56	.9991E-04
41	1078.00	1.5910	1.5930	91	1148.20	3.1130	3.1119	0.998147	17.13	.1020E-03
42	1081.00	1.6210	1.6215	92	1148.40	3.1330	3.1334	0.996230	17.43	.1098E-03
43	1084.00	1.6510	1.6515	93	1148.60	3.1580	3.1588	0.996230	17.79	.1262E-03
44	1087.00	1.6860	1.6863	94	1148.80	3.1860	3.1878	0.997183	18.23	.1418E-03
45	1090.00	1.7210	1.7212	95	1149.00	3.2410	3.1878	0.987014	18.77	.1892E-03
46	1093.00	1.7560	1.7541	96	1149.20	3.2910	3.2040	0.978770	19.09	.2419E-03
47	1096.00	1.7830	1.7881	97	1149.40	3.3480				
48	1099.00	1.8280	1.8245	98	1149.50					
49	1101.00	1.8480	1.8478	99	1149.50					
50	1102.00	1.8780	1.8749							

* - DATA VIOLATES SIZE REQUIREMENTS



Material: 2091-T851 Plate
 Age: 335°F - 16 hrs
 Environment: Lab air, Room temperature
 Orientation: L-T
 Stress Ratio: 0.1
 Frequency: 5 Hz

Figure A19 Fatigue Crack Growth Rate Data for 2091-T8X 0.42" Plate (L-T orientation). General Dynamics TX.

TABLE A48

Fatigue Crack Growth Rate Data Associated with Figure A19

PAGE 1

COMPACT TENSION AT H/W=0.486

P34

2091,T335

LT ORIENTATION

LAB AIR,RT

GENERAL DYNAMICS

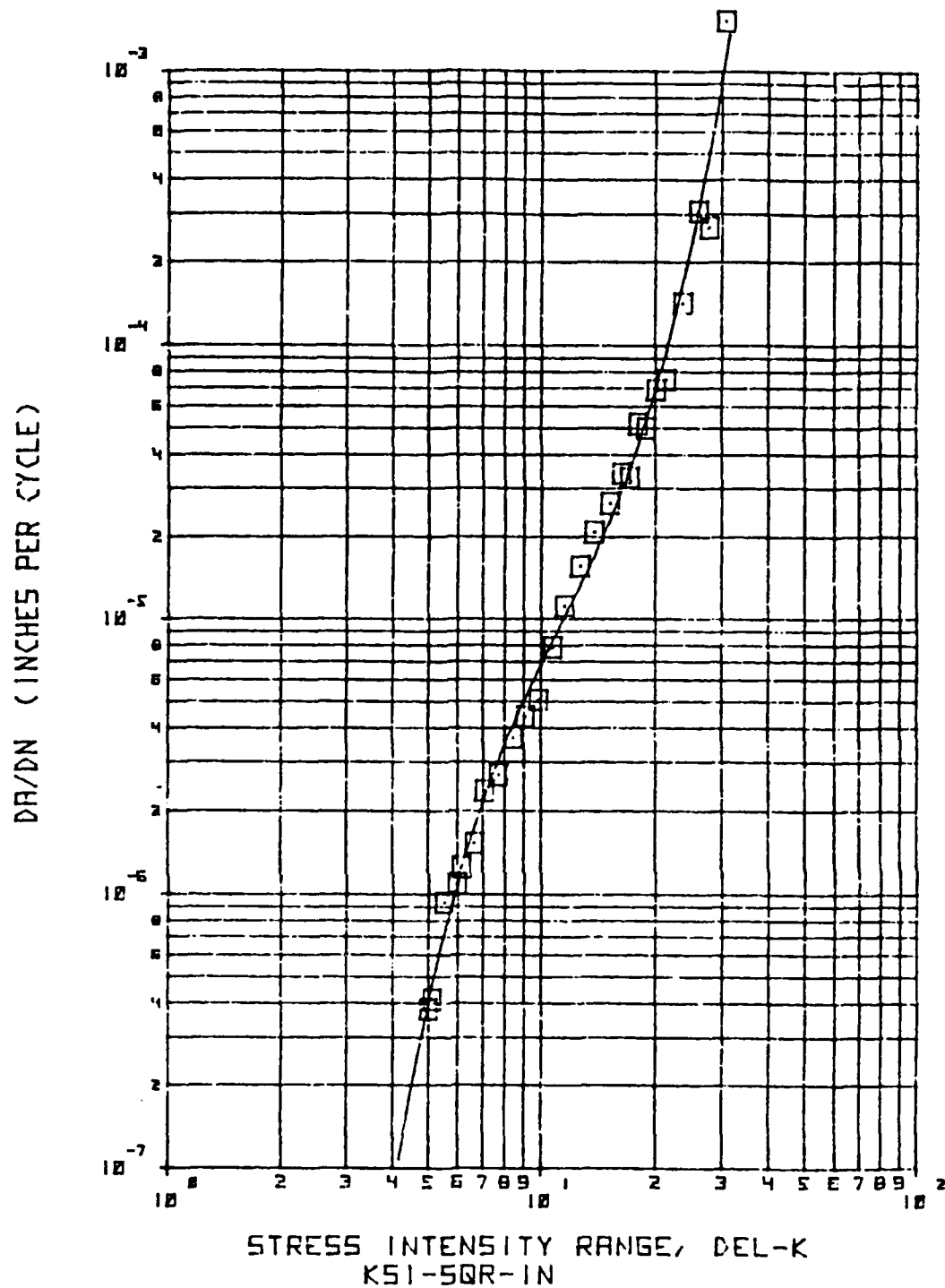
FORT WORTH DIVISION

APR 08,1987

180 CPM

R= 0.1 B= 0.4195 W= 2.5605

NO. OF PTS.	TOTAL CYCLES	AVG. CRACK LENGTH (IN)	DELTA CRACK LENGTH (IN)	LSO FIT DA/DN (IN/CYC)	CORR. COEFF.	AVG. MAX. LOAD (LBS)	AVG. DEL-Y (KSI-SQRT)
9	43358	0.8294	0.0585	1.27E-06	0.984	807	7.51
10	57324	0.8708	0.0505	1.02E-06	0.973	703	6.76
11	35690	0.9239	0.0614	1.87E-06	0.978	729	7.33
10	18067	0.9763	0.0484	2.81E-06	0.997	755	7.94
11	19039	1.0200	0.0576	3.16E-06	0.997	782	8.54
9	13665	1.0683	0.0457	3.41E-06	0.995	807	9.20
6	6680	1.1134	0.0385	5.49E-06	0.992	831	9.85
10	8910	1.1573	0.0516	5.59E-06	0.995	856	10.55
8	4212	1.1837	0.0375	8.36E-06	0.985	882	11.14
7	5913	1.2279	0.0460	7.95E-06	0.998	882	11.60
7	3190	1.2393	0.0396	1.19E-05	0.998	909	12.08
5	3095	1.2801	0.0409	1.39E-05	0.987	909	12.57
13	4622	1.3163	0.0607	1.48E-05	0.995	935	13.41
8	1963	1.3518	0.0391	2.05E-05	0.995	958	14.26
4	1456	1.3837	0.0296	1.98E-05	0.980	958	14.77
7	1746	1.3915	0.0367	2.12E-05	0.997	984	15.32
6	1587	1.4359	0.0455	2.68E-05	0.994	984	16.14
6	807	1.4514	0.0293	3.47E-05	0.979	1011	16.90
6	1137	1.4858	0.0369	3.18E-05	0.999	1010	17.66
9	694	1.4990	0.0304	3.82E-05	0.993	1030	18.33
6	885	1.5372	0.0419	4.69E-05	0.997	1031	19.36
10	742	1.5703	0.0611	7.80E-05	0.991	1057	20.85
8	335	1.6143	0.0469	1.33E-04	0.991	1083	22.89
7	287	1.6588	0.0396	1.44E-04	0.998	1083	24.69
7	107	1.6664	0.0325	2.87E-04	0.991	1110	25.62
7	114	1.7043	0.0376	3.25E-04	0.996	1109	27.44
8	94	1.7346	0.0411	3.88E-04	0.957	1134	29.71
7	110	1.7796	0.0560	4.92E-04	0.988	1135	32.50
8	22	1.7961	0.0492	2.23E-03	0.997	1158	34.31
2	10	1.8430	0.0439	4.39E-03	1.000	1158	37.87



Material: 2091-T851 Plate
 Age: 335°F - 16 hrs
 Environment: Lab air, Room temperature
 Orientation: T-L
 Stress Ratio: 0.1
 Frequency: 5 Hz

Figure A20 Fatigue Crack Growth Rate Data for 2091-T8X 0.42" Plate (T-L orientation). General Dynamics TX.

TABLE A49

Fatigue Crack Growth Rate Data Associated with Figure A20

PAGE 1

COMPACT TENSION AT H/W=0.486

P35

2091, T335

TL ORIENTATION

LAB AIR, RT

GENERAL DYNAMICS

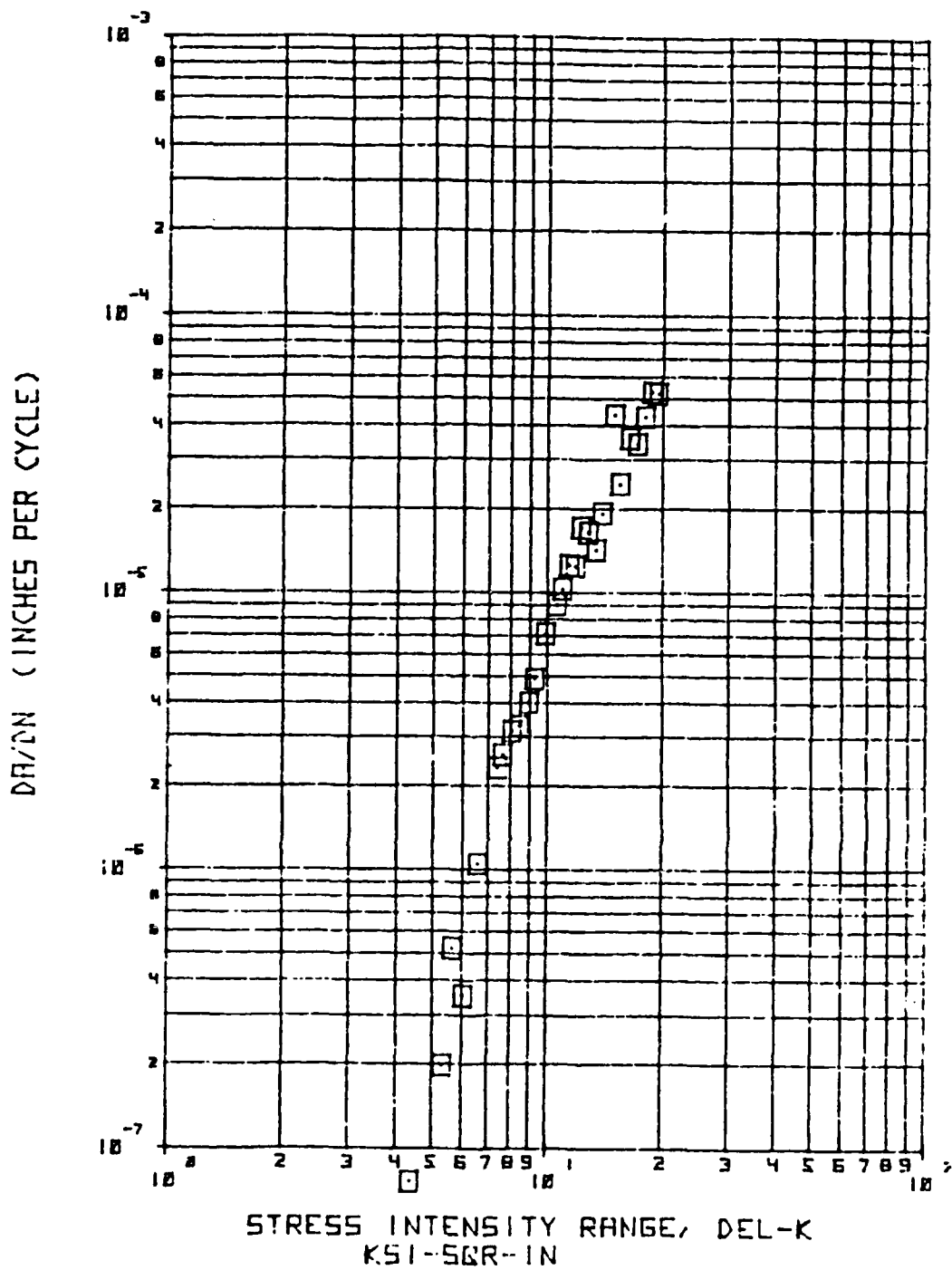
FORT WORTH DIVISION

APR 16, 1987

180 CPM

R= 0.1 B= 0.4185 W= 2.56

NO. OF PTS.	TOTAL CYCLES	AVG. CRACK LENGTH (IN)	DELTA CRACK LENGTH (IN)	LSO FIT DA/DN (IN/CYC)	CORR. COEFF.	AVG. MAX. LOAD (LBS)	AVG. DEL-T (KSI-SQRT)
13	76003	0.7876	0.0270	3.82E-07	0.962	555	5.00
5	68434	0.8190	0.0268	4.15E-07	0.992	554	5.13
10	56211	0.8516	0.0527	9.35E-07	0.967	581	5.52
9	36607	0.8934	0.0351	1.09E-06	0.984	607	5.97
5	22016	0.9311	0.0275	1.26E-06	0.996	607	6.16
6	21234	0.9836	0.0332	1.53E-06	0.990	627	6.65
13	35436	1.0096	0.0734	2.36E-06	0.984	652	7.08
13	21419	1.0664	0.0528	2.69E-06	0.990	675	7.70
8	12207	1.1278	0.0460	3.69E-06	0.987	701	8.43
10	12369	1.1699	0.0566	4.41E-06	0.996	727	9.09
9	10471	1.2200	0.0541	5.07E-06	0.993	754	9.87
8	7161	1.2736	0.0592	7.88E-06	0.997	779	10.74
8	5518	1.3168	0.0622	1.12E-05	0.999	804	11.58
10	3442	1.3753	0.0585	1.57E-05	0.983	828	12.69
13	2648	1.4216	0.0604	2.08E-05	0.989	854	13.81
9	2282	1.4718	0.0620	2.66E-05	0.998	881	15.18
6	1020	1.5047	0.0369	3.43E-05	0.994	906	16.30
4	831	1.5384	0.0275	3.29E-05	1.000	906	17.10
5	556	1.5571	0.0298	5.19E-05	0.992	933	18.08
4	595	1.5870	0.0302	5.00E-05	0.998	934	18.96
5	481	1.6090	0.0329	6.88E-05	1.000	957	20.12
5	525	1.6463	0.0406	7.51E-05	0.998	956	21.40
8	491	1.6879	0.0715	1.42E-04	0.998	982	23.68
4	107	1.7258	0.0325	3.08E-04	0.999	1008	26.05
5	135	1.7579	0.0359	2.68E-04	1.000	1008	27.72
3	30	1.8003	0.0442	1.54E-03	0.979	1030	30.86
2	15	1.8349	0.0358	2.44E-03	1.000	1029	33.18



Material: 2091-T851 Plate
 Age: 335°F - 16 hrs
 Environment: Lab air, Room temperature
 Orientation: T-L
 Stress Ratio: 0.1
 Frequency: 5 Hz

Figure A21 Fatigue Crack Growth Rate Data for 2091-T8X 0.42" Plate (T-L orientation). General Dynamics TX.

TABLE A50

Fatigue Crack Growth Rate Data Associated with Figure A21

PAGE 1

COMPACT TENSION AT H/W=0.486

P36

2091, T335

TL ORIENTATION

LAB AIR, RT

335F FOR 16HRS

180 CPM

R= 0.1 B= 0.4203 N= 2.5515

GENERAL DYNAMICS

FORT WORTH DIVISION

MAR 11, 1987

NO. OF PTS.	TOTAL CYCLES	AVG. CRACK LENGTH (IN)	DELTA CRACK LENGTH (IN)	LSO FIT DA/DN (IN/CYC)	CORR. COEFF.	AVG. MAX. LOAD (LBS)	AVG. DEL-E (KSI-SQRT)
8	418184	0.8105	0.0377	7.60E-08	0.974	476	4.37
10	244850	0.8655	0.0598	1.98E-07	0.957	555	5.33
7	80247	0.8793	0.0389	5.22E-07	0.980	581	5.64
12	193294	0.9094	0.0498	3.53E-07	0.955	607	6.05
8	52395	0.9706	0.0494	1.05E-06	0.980	628	6.59
6	15098	1.0193	0.0331	2.32E-06	0.961	677	7.41
5	12198	1.0568	0.0301	2.59E-06	0.992	677	7.66
9	13313	1.0734	0.0365	3.15E-06	0.978	704	8.08
6	12737	1.1209	0.0405	3.29E-06	0.998	703	8.42
7	7330	1.1483	-0.0278	4.01E-06	0.993	730	8.95
6	7924	1.1868	0.0380	4.90E-06	0.999	730	9.27
9	7718	1.2211	0.0565	7.10E-06	0.999	756	9.92
7	3334	1.2546	0.0319	9.07E-06	0.989	783	10.60
5	2900	1.2874	0.0306	1.03E-05	0.997	782	10.94
6	2699	1.2965	0.0378	1.26E-05	0.986	808	11.41
4	2410	1.3326	0.0293	1.25E-05	0.998	808	11.84
5	1131	1.3392	0.0219	1.72E-05	0.971	831	12.27
6	3105	1.3768	0.0510	1.65E-05	1.000	832	12.81
6	1492	1.3916	0.0226	1.43E-05	0.972	858	13.43
5	1701	1.4222	0.0333	1.93E-05	0.997	858	13.92
5	482	1.4578	0.0235	4.38E-05	0.923	884	14.99
5	1327	1.4835	0.0331	2.46E-05	0.997	883	15.50
6	683	1.5043	0.0275	3.60E-05	0.961	910	16.43
6	1020	1.5362	0.0354	3.43E-05	0.999	910	17.19
7	503	1.5488	0.0274	4.31E-05	0.928	937	18.03
5	465	1.5749	0.0239	5.29E-05	0.997	936	18.75
4	572	1.5994	0.0305	5.23E-05	0.988	936	19.49

APPENDIX B

PECHINEY 2091-T3 AND 2091-T8X (0.063" X 79" X 39")

INTRODUCTION

The Pechiney 2091-T3 0.063-inch sheet was received the second quarter of 1986. Three participants heat treated the 2091-T3 to a T8X temper. Grumman Aircraft Systems and Northrop Corporation achieved the T8 condition by aging the 2091 sheet at 275° F for 12 hours (recommended by the producer of this alloy). General Dynamics Fort Worth Division aged the 2091 sheet at 335° F for 32 hours achieving the T81 condition.

TESTING

Basic mechanical properties (tension, compression, bearing, etc.) were tested according to ASTM standards, unless otherwise specified.

Constant amplitude fatigue crack growth tests were conducted according to ASTM E647 standard. The growth rate $a-N$ data that was generated by the participants (Grumman, McDonnell Aircraft Co., and Northrop) were reduced using a seven-point incremental polynomial method. This involves fitting a second-order polynomial (parabola) to sets of seven successive data points. The data are also checked against size requirements per ASTM E647, Section 7.2. General Dynamics, TX performed constant amplitude fatigue crack growth tests using a K-increasing (load increasing) method.

2091-T3 SHEET
(0.063"x79"x79")

TABLE B1

TENSILE RESULTS FOR PECHINEY

2091-T3 SHEET (0.063" X 79" X 39")

COMPANY	TEST TEMP (DEGREES F)	ORIENT- ATION	ULTIMATE STRENGTH (KSI)	YIELD STRENGTH (KSI)	ELONG (%)	RA (%)	E (MSI)
BOEING	RT	LONG	57.0	41.3	13.0		
			58.1	41.2	20.0		
			58.0	41.2	22.0		
LTV	RT	LONG	58.8		21.5		
			58.6	39.0	21.0		10.7
			58.2	39.4	19.5		11.0
GENERAL DYNAMICS, CALIF.	RT	LONG	56.7	41.1	20.0		10.7
			55.9	40.3	20.0		10.7
			56.5	41.7	18.5		10.7
NORTHROP			58.5	42.3	16.9		
			58.9	42.1	16.9		
			59.0	42.5	16.9		
MCAIR	RT	LONG	57.5	42.6	19.0		12.0
			57.0	42.4	16.0		12.1
			57.5	42.4	23.0		12.2
MARTIN MARIETTA, LOUISIANA	RT	LONG	56.1	39.4	18.0	27.0	
			57.6	40.8	20.0	21.0	
			59.2	42.5	22.0	25.0	
AVERAGE			57.7	41.3	19.1	24.3	11.3
STANDARD DEVIATION			1.0	1.2	2.5	3.1	0.7

TABLE B2
TENSILE RESULTS FOR PECHINEY
2091-T3 SHEET (0.063" X 79" X 39")

COMPANY	TEST TEMP (DEGREES F)	ORIENT- ATION	ULTIMATE STRENGTH (KSI)	YIELD STRENGTH (KSI)	ELONG (%)	RA (%)	E (MSI)
BOEING	RT	L TRANS	60.8	41.5	16.0		
			61.4	41.5	17.0		
			60.8	41.6	16.0		
NORTHROP	RT	L TRANS	62.0	41.9	17.0		
			62.7	41.6	16.8		
			62.0	42.0	17.1		
LTV	RT	L TRANS	61.7	40.0	17.0		10.7
			61.6	39.9	18.5		10.6
			61.9	39.3	16.5		11.0
GENERAL DYNAMICS, CALIF.	RT	L TRANS	60.0	41.3	22.0		10.9
			60.2	41.2	21.0		10.9
			59.7	41.4	20.0		10.9
MCAIR	RT	L TRANS	62.0	42.2	17.0		12.0
			60.5	42.7	17.0		12.0
			60.5	41.9	18.0		12.1
MARTIN MARIETTA, LOUISIANA	RT	L TRANS	60.8	41.2	17.0	27.0	
			60.5	40.8	16.0	21.0	
			60.3	40.9	16.0	24.0	
AVERAGE			61.1	41.3	17.6	24.0	11.2
STANDARD DEVIATION			0.9	0.9	1.8	3.0	0.6

TABLE B3

COMPRESSION RESULTS FOR PECHINEY

2091-T3 SHEET (0.063" X 79" X 39")

COMPANY	TEST TEMPERATURE (DEGREES F)	ORIENTATION	COMPRESSIVE YIELD STRENGTH (KSI)	COMPRESSIVE MODULUS (KSI)
BOEING	RT	LONG	39.4 39.6 39.9	
LTV	RT	LONG	41.4 41.4	10.6 10.6
GENERAL DYNAMICS, CALIF.	RT	LONG	38.7 38.9 39.1	11.7 12.0 12.0
		AVERAGE	39.8	11.4
		STANDARD DEVIATION	1.0	0.7

TABLE B4
 COMPRESSION RESULTS FOR PECHINEY
 2091-T3 SHEET (0.063" X 79" X 39")

COMPANY	TEST TEMPERATURE (DEGREES F)	ORIENTATION	COMPRESSIVE YIELD STRENGTH (KSI)	COMPRESSIVE MODULUS (KSI)

BOEING	RT	L TRANS	44.6	
			44.7	
			44.5	
LTV	RT	L TRANS	45.9	
			45.2	
			45.3	
GENERAL DYNAMICS, CALIF.	RT	L TRANS	42.7	11.8
			44.3	11.5
AVERAGE			44.7	11.7
STANDARD DEVIATION			1.0	0.2

TABLE B5
PUNCH SHEAR RESULTS FOR PECHINEY
2091-T3 SHEET (0.063" X 79" X 39")

COMPANY	ORIENTATION	SHEAR STRENGTH (KSI)
BOEING	S TRANS	36.0
		36.5
		36.0
	AVERAGE	36.2
	STANDARD DEVIATION	0.3

TABLE B6
SLOTTED SHEAR RESULTS FOR PECHINEY
2091-T3 SHEET (0.063" X 39" X 39")

COMPANY	ORIENTATION	SHEAR STRENGTH (KSI)

BOEING	LONG	39.8
		39.0
		36.9
LTV	LONG	38.3
		38.6
		37.9
MCAIR	LONG	38.1
		37.9
		38.2
AVERAGE		38.3
STANDARD DEVIATION		0.8

TABLE B7
SLOTTED SHEAR RESULTS FOR PECHINEY
2091-T3 SHEET (0.063" X 39" X 39")

COMPANY	ORIENTATION	SHEAR STRENGTH (KSI)

BOEING	T - L	36.8
		40.1
		36.4
LTV	T - L	40.0
		40.5
		40.5
MCAIR	T - L	39.2
		37.9
		39.0
AVERAGE		38.9
STANDARD DEVIATION		1.5

TABLE B8
BEARING RESULTS FOR PECHINEY
2091-T3 SHEET (0.063" X 79" X 39")

COMPANY	ORIENTATION	e/D	BEARING		BEARING	
			ULT.	STR. (KSI)	YIELD	STR. (KSI)
BOEING	LONG	1.5		88.9		61.4
				90.2		63.0
				90.3		63.5
LTV	LONG	1.5		90.4		58.9
				88.5		61.2
				89.3		61.4
GENERAL DYNAMICS, CALIF.	LONG	1.5		88.6		66.6
				88.1		64.0
				90.0		64.0
AVERAGE				89.4		62.7
STANDARD DEVIATION				0.9		2.2

TABLE B9
BEARING RESULTS FOR PECHINEY
2091-T3 SHEET (0.063" X 79" X 39")

COMPANY	ORIENTATION	e/D	BEARING		BEARING	
			ULT.	STR.	YIELD	STR.
			(KSI)		(KSI)	
BOEING	L TRANS	1.5		92.9		62.6
				93.1		63.3
				93.1		63.3
LTV	L TRANS	1.5		91.0		60.5
				92.1		59.7
				92.2		61.8
GENERAL DYNAMICS, CALIF.	L TRANS	1.5		90.3		65.7
				88.5		62.3
				87.9		64.0
AVERAGE				91.2		62.6
STANDARD DEVIATION				2.0		1.8

TABLE B10
BEARING RESULTS FOR PECHINEY
2091-T3 SHEET (0.063" X 79" X 39")

COMPANY	ORIENTATION	e/D	BEARING		BEARING	
			ULT.	STR. (KSI)	YIELD	STR. (KSI)
BOEING	LONG	2.0		115.2		75.6
				115.8		76.1
				115.3		76.2
LTV	LONG	2.0		111.6		77.3
				111.0		76.4
				112.5		76.9
GENERAL DYNAMICS, CALIF.	LONG	2.0		115.6		76.8
				114.3		73.2
MCAIR	LONG	2.0				73.5
						73.9
AVERAGE				113.9		75.6
STANDARD DEVIATION				1.9		

TABLE B11
BEARING RESULTS FOR PECHINEY
2091-T3 SHEET (0.063" X 79" X 39")

COMPANY	ORIENTATION	e/D	BEARING	
			ULT. STR. (KSI)	BEARING YIELD STR. (KSI)
BOEING	L TRANS	2.0	118.8	76.5
			115.2	75.4
LTV	L TRANS	2.0	111.1	75.9
			114.1	78.8
			116.0	75.1
GENERAL DYNAMICS, CALIF.	L TRANS	2.0	120.6	76.8
			115.9	81.8
			111.7	80.3
MCAIR	L TRANS	2.0		76.5
				72.7
AVERAGE			115.4	77.0
STANDARD DEVIATION			3.2	2.7

TABLE B12

General Dynamics, CA

ASTM E561 R Curve CCT Al-Li B-5-LT-1

W = 3.994 in $F_{ty} = 41.10$ ksi
 B = 0.0644 in $P_{max} = 7540$ lb
 a = 1.255 in
 a/2 = 0.6275 in

Loads				Load	a (half)	a plastic	a eff	K
a eff	5000	7540	10000					
0.6	28	43	57	0	0.6275	0.0000	0.6275	0
0.6	29	44	58	200	0.7225	0.0002	0.7227	1
0.7	30	45	59	600	0.7225	0.0014	0.7239	4
0.7	30	46	61	1000	0.7225	0.0038	0.7263	6
0.7	31	47	62	1400	0.7225	0.0075	0.7300	9
0.7	32	48	64	1800	0.7225	0.0124	0.7349	12
0.8	33	49	65	2200	0.7225	0.0186	0.7411	14
0.8	33	51	67	2600	0.7225	0.0259	0.7484	17
0.8	34	52	69	2800	0.7250	0.0302	0.7552	18
0.8	35	53	70	3200	0.7250	0.0395	0.7645	21
0.9	36	54	72	3600	0.7250	0.0499	0.7749	24
0.9	37	55	73	4000	0.7275	0.0619	0.7894	27
0.9	38	57	75	4400	0.7275	0.0750	0.8025	30
0.9	38	58	77	4600	0.7275	0.0819	0.8094	32
1.0	39	59	78	4800	0.7300	0.0896	0.8196	33
1.0	40	60	80	5200	0.7300	0.1052	0.8352	37
1.0	41	62	82	5600	0.7300	0.1220	0.8520	40
1.0	42	63	84	5800	0.7300	0.1309	0.8609	42
1.1	43	65	86	6000	0.7450	0.1440	0.8890	45
1.1	44	66	88	6200	0.7450	0.1538	0.8988	46
1.1	45	68	90	6400	0.7600	0.1685	0.9285	49
				6800	0.7600	0.1902	0.9502	53
				7000	0.7700	0.2053	0.9753	56
				7200	0.7700	0.2172	0.9872	58
				7400	0.7850	0.2359	1.0209	62

$$K_c = 61.8 \text{ Ksi} \sqrt{\text{in}}$$

ASTM E561 R-Curve Chart
Alum-Li, Spec. B-5-LT-1

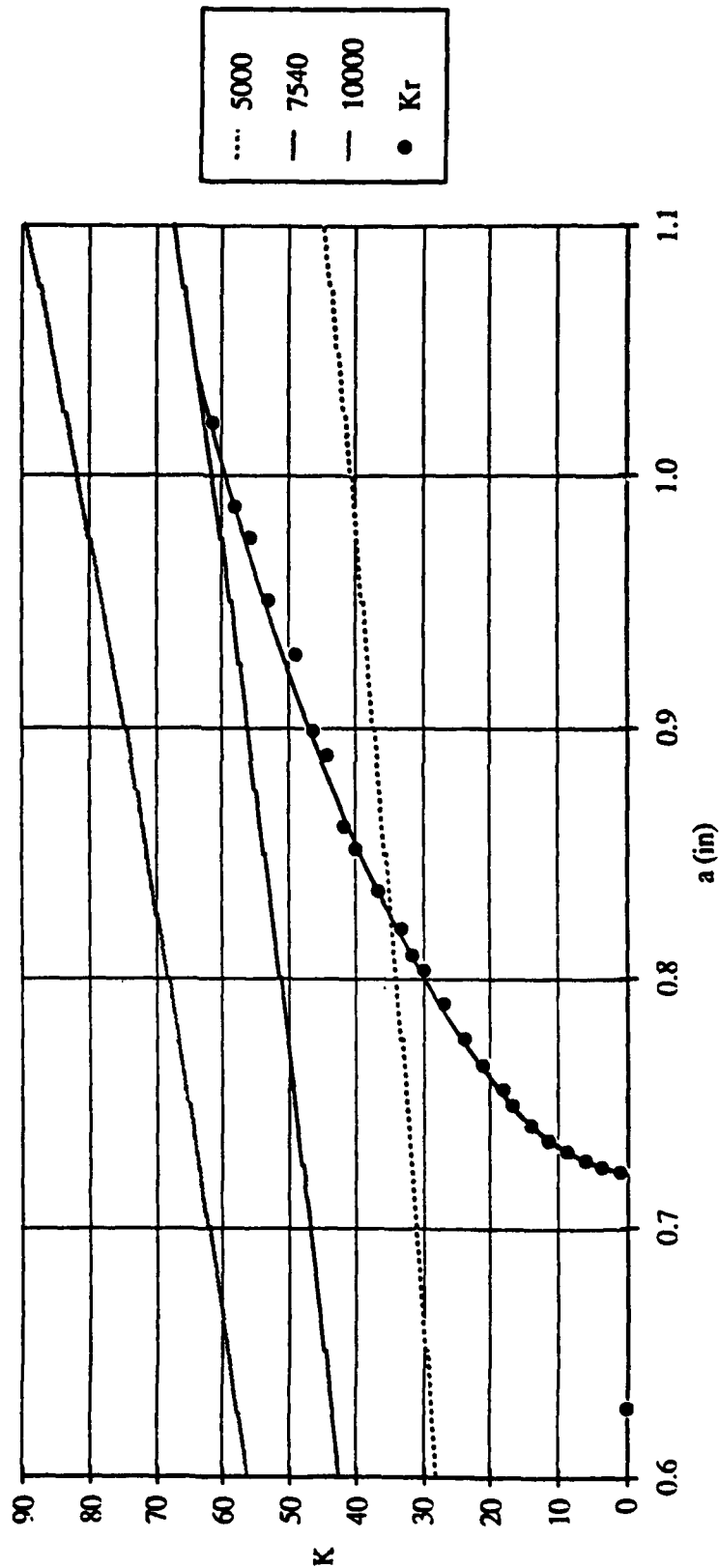


Figure B1 R-Curve Results for 2091-T3 0.063" Sheet (Lr) General Dynamics, CA.

TABLE B13

General Dynamics, CA

ASTM E561 R Curve CCT Al-Li B-5-LT-2

W = 3.995 in F_{ty} = 41.10 ksi
 B = 0.0647 in P_{max} = 7250 lb
 a = 1.255 in
 a/2 = 0.6275 in

a eff	Loads			Load	a (half)	a plastic	a eff	K
	5000	7250	10000					
0.6	28	41	56	0	0.6275	0.0000	0.6275	0
0.6	29	42	58	200	0.7250	0.0002	0.7252	1
0.7	30	43	59	600	0.7250	0.0014	0.7264	4
0.7	30	44	61	1000	0.7250	0.0038	0.7288	6
0.7	31	45	62	1400	0.7250	0.0075	0.7325	9
0.7	32	46	64	1800	0.7250	0.0124	0.7374	12
0.8	33	47	65	2200	0.7250	0.0185	0.7435	14
0.8	33	48	67	2600	0.7250	0.0258	0.7508	17
0.8	34	49	68	2800	0.7250	0.0299	0.7549	18
0.8	35	51	70	3200	0.7250	0.0391	0.7641	21
0.9	36	52	71	3600	0.7250	0.0494	0.7744	24
0.9	36	53	73	4000	0.7275	0.0613	0.7888	27
0.9	37	54	75	4200	0.7275	0.0676	0.7951	29
0.9	38	55	76	4400	0.7300	0.0746	0.8046	30
1.0	39	57	78	4600	0.7300	0.0815	0.8115	32
1.0	40	58	80	4800	0.7300	0.0887	0.8187	33
1.0	41	59	82	5200	0.7300	0.1041	0.8341	37
1.0	42	60	83	5600	0.7300	0.1208	0.8508	40
1.1	43	62	85	5800	0.7300	0.1296	0.8596	42
1.1	44	63	87	6000	0.7300	0.1387	0.8687	44
1.1	45	65	89	6200	0.7325	0.1488	0.8813	46
				6400	0.7325	0.1585	0.8910	47
				6800	0.7375	0.1806	0.9181	52
				7000	0.7450	0.1941	0.9391	54
				7200	0.7550	0.2092	0.9642	57

$$K_c = 56.9 \text{ Ksi} \sqrt{in}$$

ASTM E561 R-Curve Chart
Alum-Li, Spec. B-5-LT-2

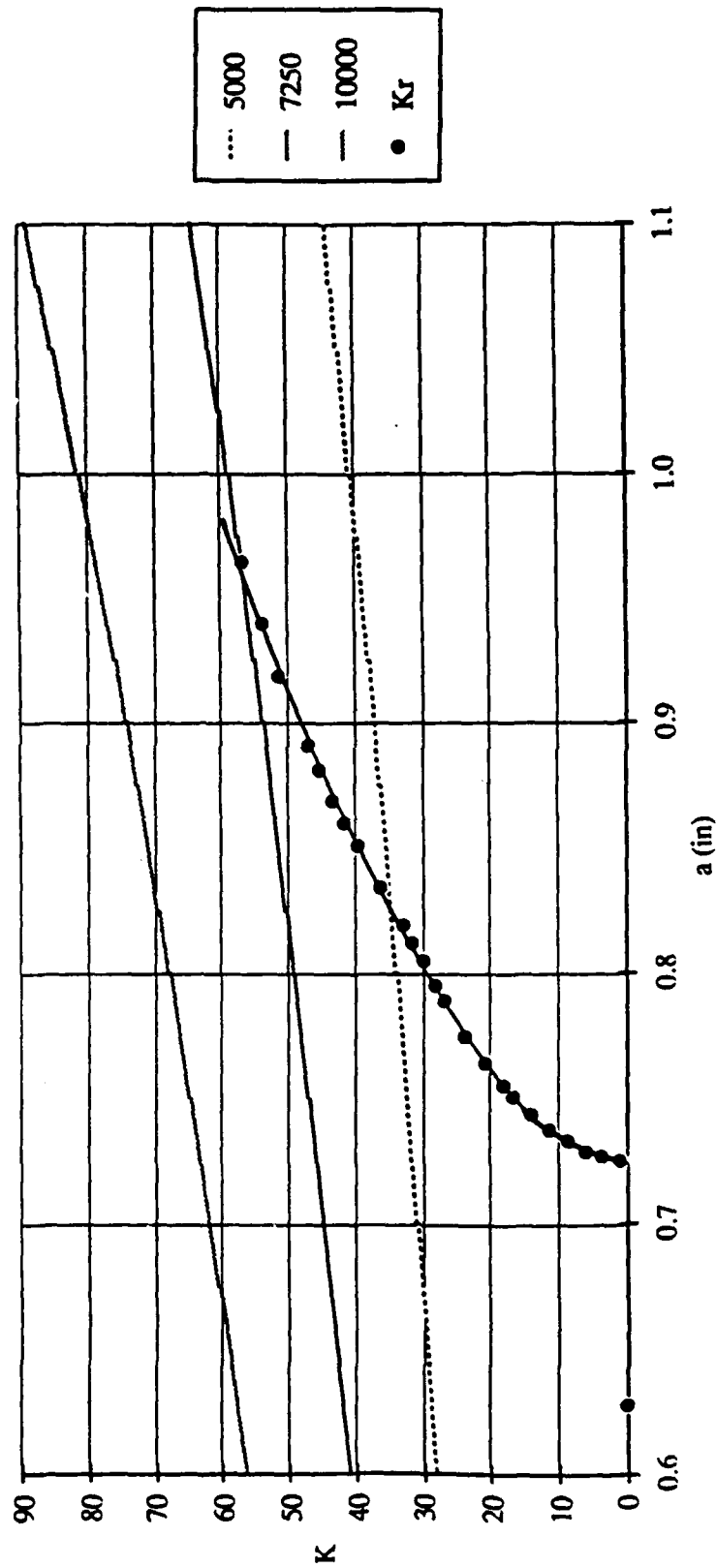


Figure B2 R-Curve Results for 2091-T3 0.063" Sheet (LT). General Dynamics, CA.

TABLE B14

General Dynamics, CA

ASTM E561 R Curve

CCT Al-Li B-5-LT-3

W = 3.992 in

F_{ty} = 41.10 ksi

B = 0.0642 in

P_{max} = 5875 lb

a = 1.2600 in

a/2 = 0.6300 in

a eff	Loads			Load	a (half)	a plastic	a eff	K
	4000	5875	8000					
0.6	23	33	45	0	0.6300	0.0000	0.6300	0
0.6	23	34	47	200	0.7275	0.0002	0.7277	1
0.7	24	35	48	600	0.7275	0.0014	0.7289	4
0.7	24	36	49	1000	0.7275	0.0039	0.7314	6
0.7	25	37	50	1400	0.7275	0.0076	0.7351	9
0.7	26	38	51	1800	0.7275	0.0126	0.7401	12
0.8	26	39	53	2000	0.7275	0.0156	0.7431	13
0.8	27	40	54	2200	0.7275	0.0189	0.7464	14
0.8	28	40	55	2600	0.7275	0.0264	0.7539	17
0.8	28	41	56	3000	0.7275	0.0351	0.7626	20
0.9	29	42	58	3400	0.7275	0.0451	0.7726	23
0.9	29	43	59	3800	0.7275	0.0563	0.7838	26
0.9	30	44	60	4200	0.7275	0.0688	0.7963	29
0.9	31	45	62	4400	0.7275	0.0755	0.8030	30
1.0	31	46	63	4600	0.7275	0.0825	0.8100	32
1.0	32	47	64	4800	0.7275	0.0899	0.8174	34
1.0	33	48	66	5000	0.7275	0.0975	0.8250	35
				5200	0.7275	0.1055	0.8330	37
				5400	0.7275	0.1137	0.8412	39
				5600	0.7275	0.1223	0.8498	40
				5800	0.7275	0.1312	0.8587	42

~~K_c = 42.1 Ksi√in~~ Specimen failed
in doubler region

ASTM E561 R-Curve Chart
Alum-Li, Spec. B-5-LT-3

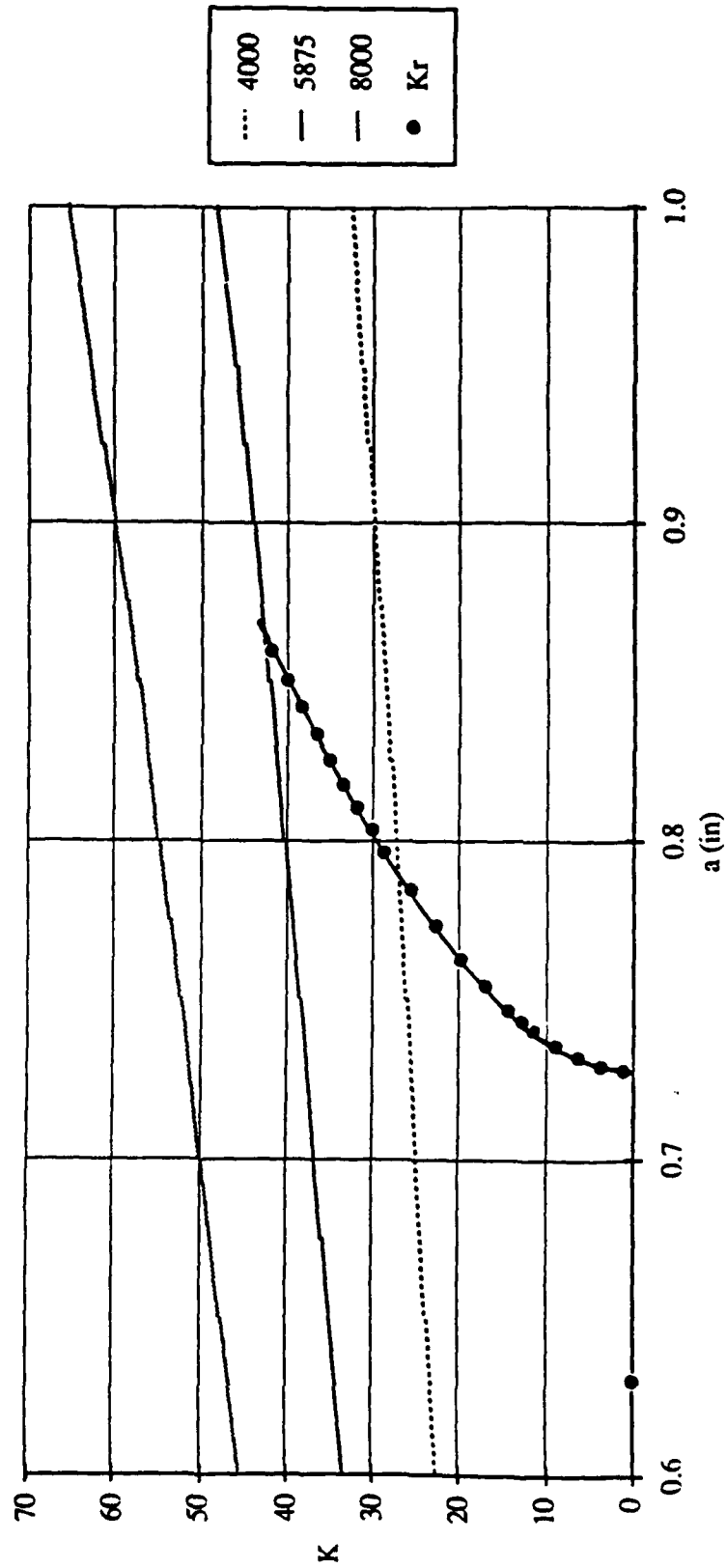


Figure 83 R-Curve Results for 2091-T3 0.063" Sheet (LT). General Dynamics, CA.

TABLE B15

General Dynamics, CA

ASTM E561 R Curve

CCT Al-Li B-5-TL-1

W = 3.995 in F_{ty} = 41.10 ksi
 B = 0.0649 in P_{max} = 7290 lb
 a = 1.25 in
 a/2 = 0.625 in

a eff	Loads			Load	a (half)	a plastic	a eff	K
	5000	7290	10000					
0.6	28	41	56	0	0.6250	0.0000	0.6250	0
0.6	29	42	58	200	0.7400	0.0002	0.7402	1
0.7	30	43	59	600	0.7400	0.0014	0.7414	4
0.7	30	44	60	1000	0.7400	0.0039	0.7439	6
0.7	31	45	62	1400	0.7400	0.0076	0.7476	9
0.7	32	46	63	1600	0.7425	0.0100	0.7525	10
0.8	32	47	65	2000	0.7425	0.0157	0.7582	13
0.8	33	48	66	2400	0.7425	0.0226	0.7651	16
0.8	34	50	68	2800	0.7425	0.0307	0.7732	19
0.8	35	51	70	3200	0.7425	0.0401	0.7826	21
0.9	36	52	71	3600	0.7425	0.0508	0.7933	24
0.9	36	53	73	4000	0.7425	0.0627	0.8052	27
0.9	37	54	74	4400	0.7425	0.0759	0.8184	30
0.9	38	55	76	4600	0.7425	0.0829	0.8254	32
1.0	39	57	78	4800	0.7450	0.0907	0.8357	34
1.0	40	58	80	5000	0.7475	0.0989	0.8464	35
1.0	41	59	81	5200	0.7525	0.1079	0.8604	37
1.0	42	61	83	5600	0.7525	0.1252	0.8777	41
1.1	43	62	85	6000	0.7525	0.1437	0.8962	44
1.1	44	63	87	6200	0.7550	0.1542	0.9092	47
1.1	45	65	89	6400	0.7575	0.1650	0.9225	49
				6600	0.7575	0.1755	0.9330	51
				6800	0.7625	0.1881	0.9506	53
				7000	0.7625	0.1993	0.9618	55
				7200	0.7950	0.2238	1.0188	60

$$K_c = 59.6 \text{ Ksi} \sqrt{\text{in}}$$

ASTM E561 R-Curve Chart
Alum-Li, Spec. B-5-TL-1

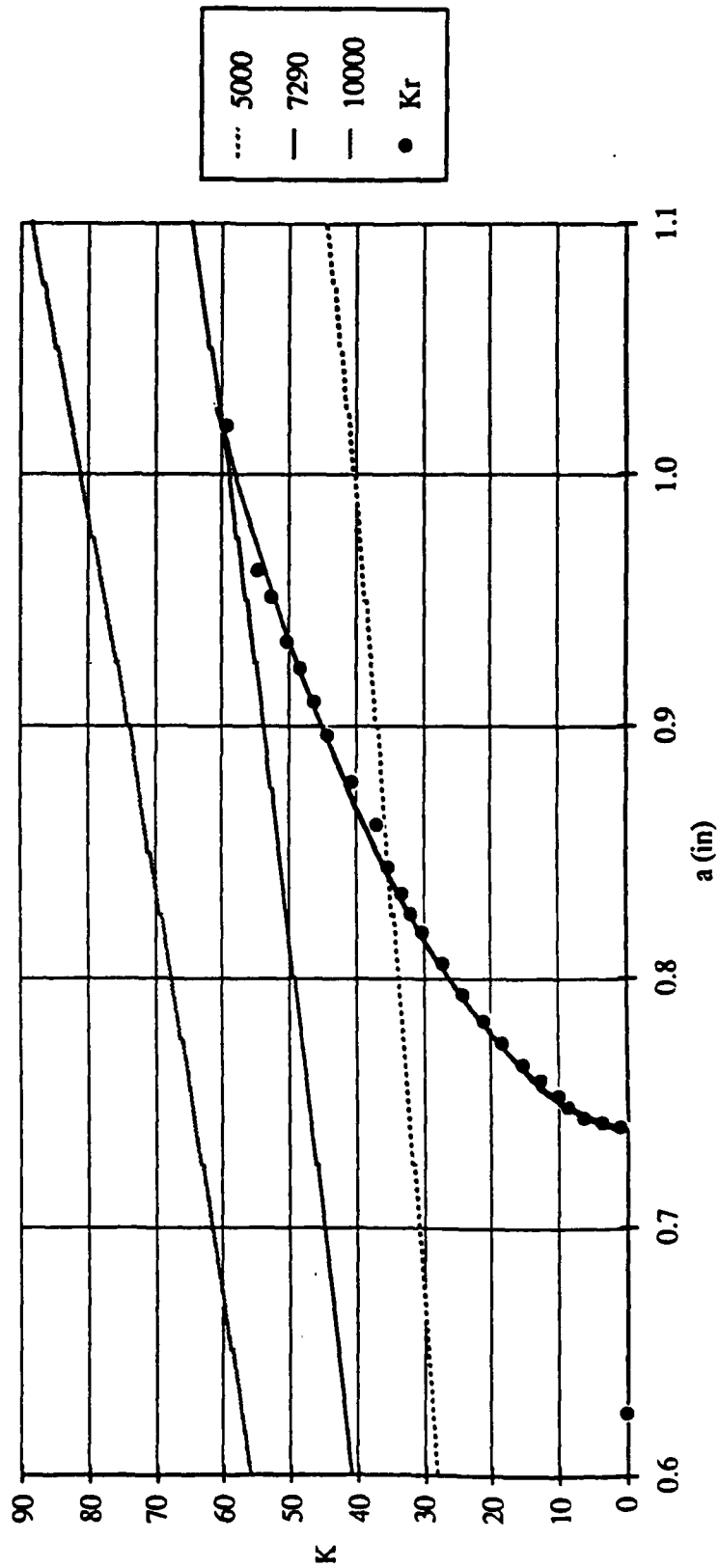


Figure B4 R-Curve Results for 2091-T3 0.063" Sheet (TL). General Dynamics, CA.

TABLE B16

General Dynamics, CA

ASTM E561 R Curve

CCT Al-Li B-5-TL-2

W = 3.992 in Fty = 41.10 ksi
 B = 0.0646 in Pmax = 7450 lb
 a = 1.2550 in
 a/2 = 0.6275 in

a eff	Loads			Load	a (half)	a plastic	a eff	K
	5000	7450	10000					
0.6	28	42	56	0	0.6275	0.0000	0.6275	0
0.6	29	43	58	200	0.7275	0.0002	0.7277	1
0.7	30	44	59	400	0.7275	0.0006	0.7281	3
0.7	30	45	61	600	0.7325	0.0014	0.7339	4
0.7	31	46	62	1000	0.7325	0.0039	0.7364	6
0.7	32	48	64	1400	0.7325	0.0076	0.7401	9
0.8	33	49	65	1800	0.7325	0.0126	0.7451	12
0.8	33	50	67	2200	0.7325	0.0188	0.7513	14
0.8	34	51	68	2600	0.7325	0.0263	0.7588	17
0.8	35	52	70	3000	0.7325	0.0350	0.7675	20
0.9	36	53	72	3400	0.7325	0.0450	0.7775	23
0.9	37	55	73	3600	0.7425	0.0513	0.7938	24
0.9	37	56	75	3800	0.7425	0.0572	0.7997	26
0.9	38	57	77	4000	0.7450	0.0637	0.8087	28
1.0	39	58	78	4200	0.7450	0.0702	0.8152	29
1.0	40	60	80	4400	0.7525	0.0781	0.8306	31
1.0	41	61	82	4600	0.7525	0.0854	0.8379	33
1.0	42	62	84	4800	0.7550	0.0934	0.8484	34
1.1	43	64	86	5400	0.7550	0.1183	0.8733	39
1.1	44	65	88	5600	0.7575	0.1278	0.8853	41
1.1	45	67	90	6000	0.7575	0.1467	0.9042	45
				6200	0.7600	0.1573	0.9173	47
				6400	0.7600	0.1677	0.9277	49
				6600	0.7675	0.1808	0.9483	52
				6800	0.7725	0.1937	0.9662	54
				7000	0.7800	0.2081	0.9881	57
				7200	0.7875	0.2232	1.0107	59
				7400	0.8025	0.2423	1.0448	63

$$K_c = 63.0 \text{ Ksi} \sqrt{\text{in}}$$

ASTM E561 R-Curve Chart
Alum-Li, Spec. B-5-TL-2

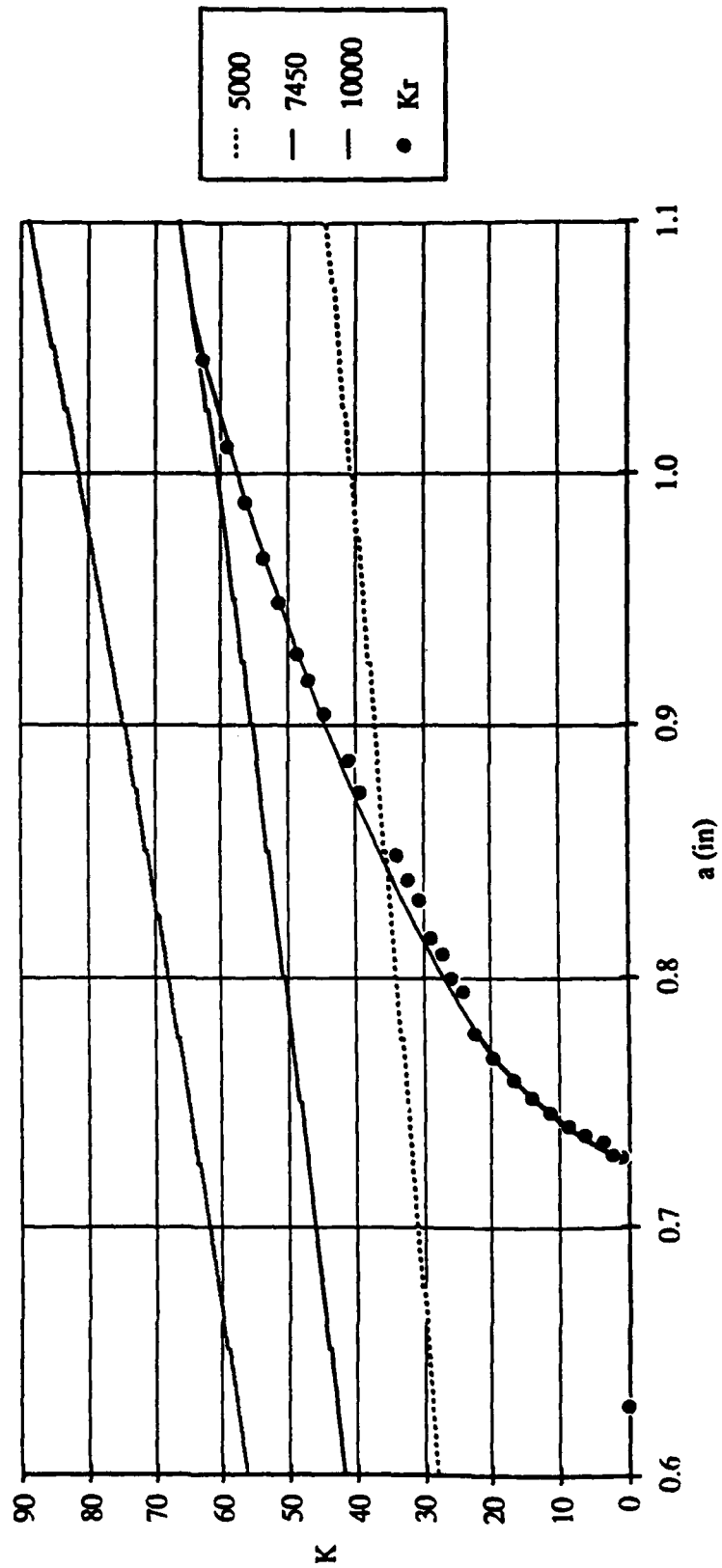


Figure B5 R-Curve Results for 2091-T3 0.063" Sheet (TL). General Dynamics, CA

TABLE B17

General Dynamics, CA

ASTM E561 R Curve

CCT Al-Li B-5-TL-3

$W = 3.996$ in $F_{ty} = 41.10$ ksi
 $B = 0.0642$ in $P_{max} = 7290$ lb
 $a = 1.2500$ in
 $a/2 = 0.6250$ in

a eff	Loads			Load	a (half)	a plastic	a eff	K
	5000	7290	10000					
0.6	28	41	57	0	0.6250	0.0000	0.6250	0
0.6	29	42	58	200	0.7250	0.0002	0.7252	1
0.7	30	43	60	600	0.7250	0.0014	0.7264	4
0.7	31	45	61	1000	0.7250	0.0039	0.7289	6
0.7	31	46	63	1400	0.7250	0.0076	0.7326	9
0.7	32	47	64	1800	0.7250	0.0125	0.7375	12
0.8	33	48	66	2000	0.7250	0.0155	0.7405	13
0.8	34	49	67	2400	0.7250	0.0223	0.7473	16
0.8	34	50	69	2800	0.7250	0.0304	0.7554	18
0.8	35	51	70	3200	0.7250	0.0397	0.7647	21
0.9	36	52	72	3600	0.7250	0.0502	0.7752	24
0.9	37	54	74	3800	0.7250	0.0559	0.7809	26
0.9	38	55	75	4200	0.7250	0.0683	0.7933	29
0.9	38	56	77	4600	0.7250	0.0820	0.8070	32
1.0	39	57	79	4800	0.7250	0.0892	0.8142	33
1.0	40	59	80	5200	0.7250	0.1047	0.8297	37
1.0	41	60	82	5600	0.7250	0.1215	0.8465	40
1.0	42	61	84	5800	0.7250	0.1303	0.8553	42
1.1	43	63	86	6000	0.7250	0.1394	0.8644	44
1.1	44	64	88	6400	0.7250	0.1586	0.8836	47
1.1	45	66	90	6600	0.7250	0.1687	0.8937	49
				6800	0.7250	0.1791	0.9041	51
				7000	0.7250	0.1898	0.9148	53
				7200	0.7250	0.2008	0.9258	55

$$K_c = 55.4 \text{ Ksi} \sqrt{\text{in}}$$

ASTM E561 R-Curve Chart
Alum-Li, Spec. B-5-TL-3

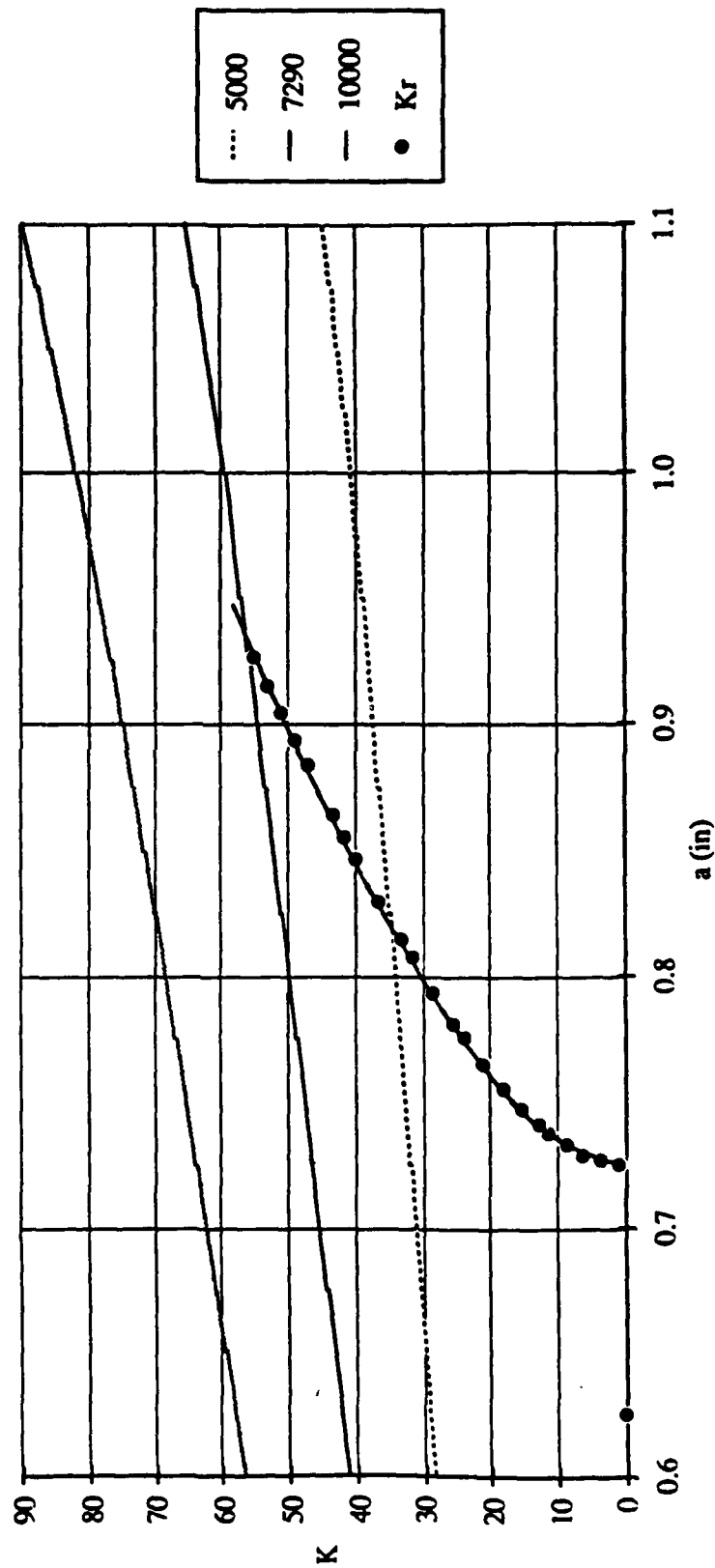


Figure B6 R-Curve Results for 2091-T3 0.063" Sheet (TL). General Dynamics, CA.

TABLE B18

MCAIR

R-CURVE TOUGHNESS DATA FOR PECHINEY 2091
ALUMINUM LITHIUM ALLOY

SPECIMEN IDENTIFICATION	ORIENTATION	SLOT LENGTH 2a, (IN)	PRECRACK LENGTH 2a, (IN)	FINAL CRACK LENGTH 2a, (IN)	LOAD AT FAILURE (LB)	PLANE STRESS FRACTURE TOUGHNESS, K _{IC} (KSI(IN) ^{0.5})
1	LT-L	1.9915	2.1006	2.2480	10,900	57.0
2		1.9945	2.1000	2.2566	10,980	57.4
AVERAGE		-----	-----	-----	10,940	57.2
3	L-LT	1.9925	2.0993	2.2120	10,940	57.1
4		1.9965	2.1015	2.1815	10,900	55.9
AVERAGE		-----	-----	-----	10,920	56.5

DATA COLLECTED AND REDUCED PER ASTM STANDARD TEST METHOD E561-81.

The four toughness specimens were tested in accordance with ASTM Standard Test Method E561-81. The specimens were precracked to a total crack length, 2a, equal to 35% of the width, as is required per the standard. A stress ratio of 0.1 was used for precracking. The specimens were statically failed using a loading rate of 3000 pound/minute. Cathetometers were used to monitor crack length during static loading to determine the final crack length, at failure, which is required for toughness calculations. Table B18 presents toughness test data. All four specimens had a plane stress toughness value in the range of 56 to 57 ksi(in)^{0.5}. It should be noted that no plastic zone corrections were incorporated into the toughness calculations.

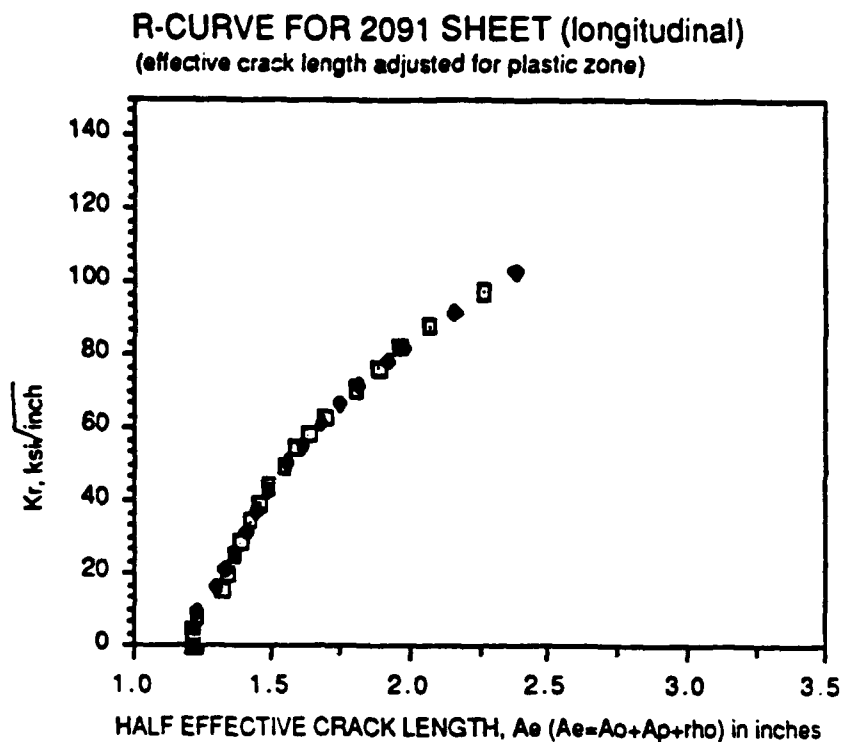


Figure B7 R-Curve Results for 2091-T3 0.063" Sheet (longitudinal).
Martin Marietta, IA.

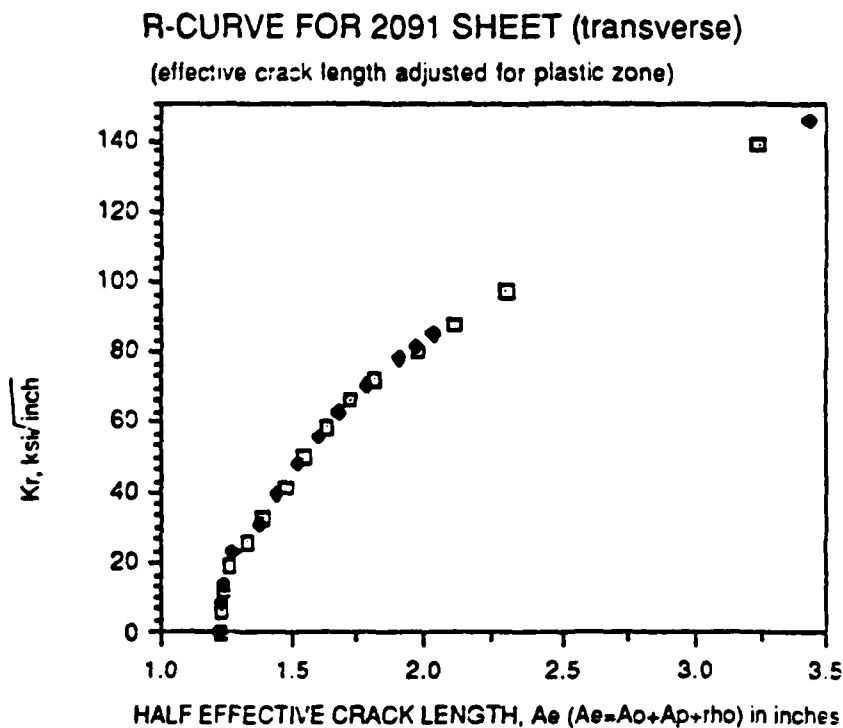


Figure B8 R-Curve Results for 2091-T3 0.063" Sheet (transverse).
Martin Marietta

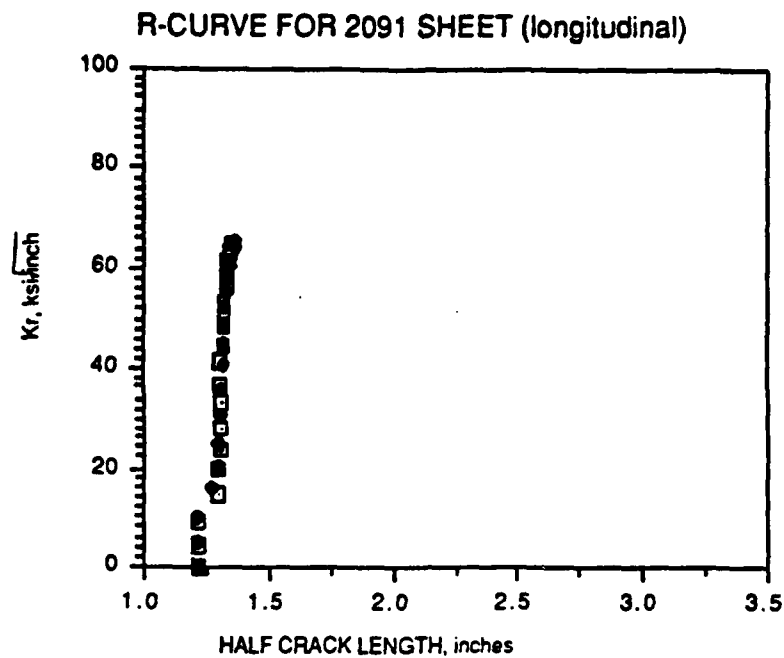


Figure B9 R-Curve Results for 2091-T3 0.063" Sheet (longitudinal).
Martin Marietta, LA.

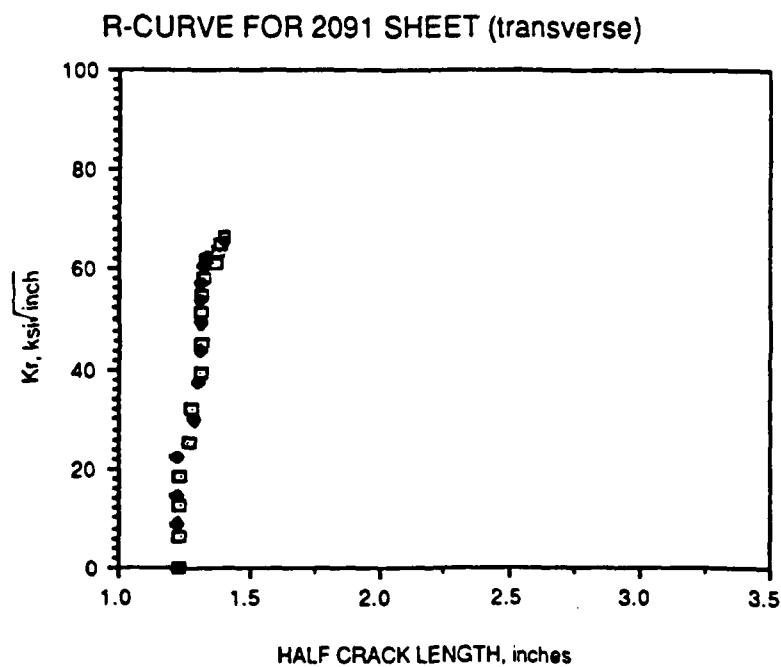


Figure B10 R-Curve Results for 2091-T3 0.063" Sheet (transverse).
Martin Marietta, LA.

TABLE B19

Martin Marietta, IA

DATA FOR SPECIMEN NO. 4, 2091

LONGITUDINAL SHEET

Load, kips	Half Crack Length (c) inch	Half Crack Length, (c + rho) inch	Corresponding Fracture Toughness, ksi $\sqrt{\text{inch}}$	
			Not Adjusted	Adjusted for Plasticity
0.0	1.215	1.215	0.0	0.0
1.17	1.215	1.217	4.81	4.55
2.54	1.220	1.229	10.47	9.86
3.71	1.270	1.294	15.69	15.85
4.79	1.295	1.336	20.51	20.87
5.76	1.300	1.361	24.73	25.35
7.08	1.310	1.406	30.54	31.71
8.21	1.310	1.442	35.42	37.24
9.38	1.315	1.493	40.56	43.31
10.41	1.320	1.560	45.13	50.26
11.28	1.320	1.615	48.90	55.05
12.07	1.325	1.680	52.45	61.05
12.70	1.330	1.756	55.30	66.92
13.29	1.330	1.821	57.90	71.84
13.78	1.340	1.919	60.33	78.02
14.12	1.345	1.986	61.97	82.10
14.51	1.365	2.159	64.30	91.36
14.80	1.370	2.381	65.74	103.09

Thickness = .063 inch
 Yield = 40.9 ksi
 Specimen width = 8.00 inch

TABLE B20

Martin Marietta, LA

DATA FOR SPECIMEN NO. 5 2091

LONGITUDINAL SHEET

Load, kips	Half Crack Length (c) inch	Half Crack Length, (c + rho) inch	Corresponding Fracture Toughness, ksi $\sqrt{\text{inch}}$	
			Not Adjusted	Adjusted for Plasticity
0.0	1.220	1.220	0.0	0.0
1.06	1.220	1.222	4.37	4.12
2.09	1.220	1.226	8.62	8.12
3.48	1.295	1.317	14.90	15.04
4.67	1.300	1.340	20.05	20.36
5.55	1.305	1.362	23.88	24.48
6.53	1.310	1.390	28.17	29.09
7.62	1.310	1.442	32.67	34.33
8.52	1.310	1.453	36.76	38.80
9.54	1.310	1.494	41.16	44.03
10.32	1.315	1.549	44.63	49.59
11.14	1.315	1.599	48.17	54.60
11.74	1.315	1.640	50.77	58.47
12.39	1.320	1.699	53.71	63.08
13.19	1.330	1.809	57.46	70.97
13.71	1.335	1.891	59.77	76.77
14.71	1.335	1.974	61.88	81.95
14.52	1.340	2.076	63.57	87.94
14.79	1.355	2.262	65.22	97.62

Thickness = .063 inch

Yield = 40.9 ksi

Specimen Width = 8.00 inch

TABLE B21

Martin Marietta, LA

DATA FOR SPECIMEN NO. 6 2091

TRANSVERSE SHEET

Load, kips	Half Crack Length (c) inch	Half Crack Length, (c + rho) inch	Corresponding Fracture Toughness, ksi $\sqrt{\text{inch}}$	
			Not Adjusted	Adjusted for Plasticity
0.0	1.215	1.215	0.0	0.0
2.19	1.215	1.222	9.01	8.49
3.50	1.220	1.238	14.43	13.60
5.47	1.220	1.271	22.56	23.05
7.00	1.282	1.373	29.79	30.90
8.75	1.295	1.445	37.47	39.65
10.16	1.300	1.521	43.61	48.23
11.43	1.300	1.605	49.19	56.11
12.43	1.305	1.680	53.49	62.77
13.31	1.305	1.781	57.28	70.74
13.95	1.320	1.906	60.48	78.51
14.21	1.327	1.965	61.83	81.87
14.42	1.330	2.028	62.82	85.66
14.62	1.395	3.433	65.73	146.00

Thickness = .063 inch
 Yield = 40.9 ksi
 Specimen width = 8.00 inch

TABLE B22

Martin Marietta, LA

DATA FOR SPECIMEN NO. 7, 2091

TRANSVERSE SHEET

Load, kips	Half Crack Length (c) inch	Half Crack Length, (c + rho) inch	Corresponding Fracture Toughness, ksi $\sqrt{\text{inch}}$	
			Not Adjusted	Adjusted for Plasticity
0.0	1.225	1.225	0.0	0.0
1.52	1.225	1.228	6.28	5.92
3.00	1.225	1.238	12.40	11.68
4.51	1.225	1.259	18.65	18.92
7.00	1.260	1.324	25.20	25.94
7.50	1.275	1.380	31.81	33.16
9.11	1.305	1.470	39.20	41.69
10.51	1.305	1.547	45.23	50.43
11.86	1.305	1.635	51.04	58.91
12.74	1.310	1.729	54.96	66.33
13.40	1.320	1.817	58.09	72.27
13.69	1.360	1.977	61.40	80.55
14.28	1.375	2.107	63.58	87.73
14.56	1.390	2.299	65.30	97.73
14.77	1.400	3.245	66.56	139.00

Thickness = .063 inch

Yield = 40.9 ksi

Specimen width = 8.00 inch

TABLE B23

FATIGUE RESULTS WITH $R=0.1$ AND $K_t=1.0$ FOR
PECHINEY 2091-T3 SHEET (0.063" X 79" X 39")

COMPANY	ORIENTATION	STRESS (KSI)	CY-LES
GENERAL DYNAMICS, CALIF.	LONG	21.8	10,000,000 *
		25.0	1,888,000
		27.0	10,140,000 *
		30.0	303,000
		32.0	363,000
		35.0	143,000
		38.0	122,000

(*) : INDICATES A RUN-OUT TEST

Pechiney 2091-T3 Sheet (0.063" X 79" X 39")

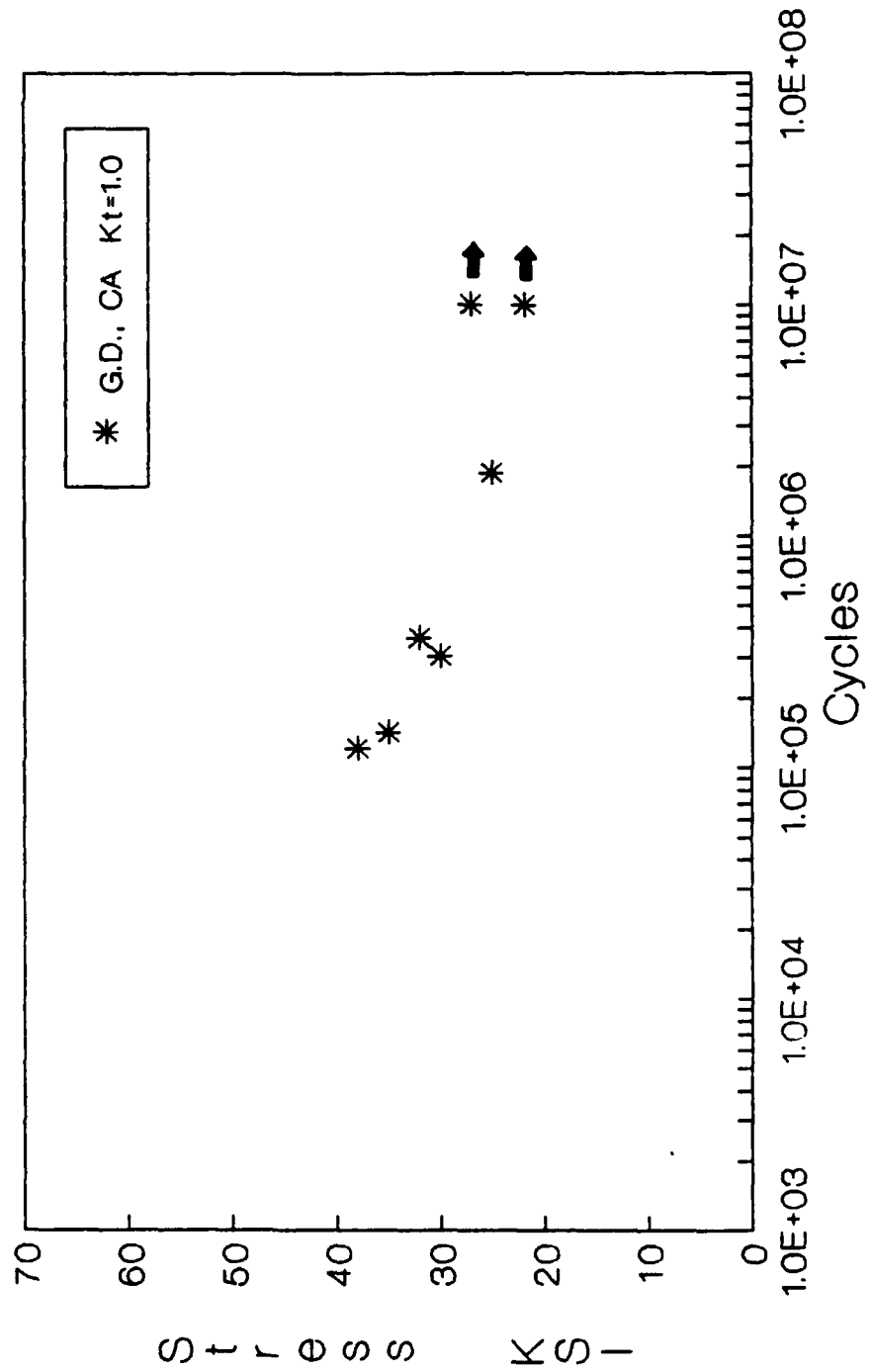


Figure B11 Fatigue Results for 2091-T3 0.063" Sheet ($R=0.1$, $K_t=1.0$, and longitudinal). General Dynamics, CA

TABLE B24

FATIGUE RESULTS WITH $R=0.1$ AND $K_t=3.0$ FOR
PECHINEY 2091-T3 SHEET (0.063" X 79" X 39")

COMPANY	ORIENTATION	STRESS (KSI)	CYCLES

GENERAL DYNAMICS, CALIF.	LONG	10.0	10,000,000 *
		12.0	319,000
		13.0	10,330,000 *
		13.5	193,000
		14.5	158,000
		16.0	163,000
		20.0	47,000
		25.0	15,000

(*): INDICATES A RUN-OUT TEST

TABLE B25
FATIGUE RESULTS WITH R=0.1 AND Kt=2.8 FOR
PECHINEY 2091-T3 SHEET (0.063" X 79" X 39")

COMPANY	ORIENTATION	STRESS (KSI)	CYCLES
LTV	LONG	15.4	1,000,000 *
		15.4	410,760
		15.5	700,100
		16.5	192,020
		16.5	236,950
		18.5	202,250
		18.7	203,450 *
		19.0	155,800
		22.1	83,190
		22.4	76,450
		22.4	49,000

(*): INDICATES A RUN-OUT TEST

(*): INDICATES SPECIMEN FAILED IN GRIP

Pechiney 2091-T3 Sheet (0.063" X 79" X 39")

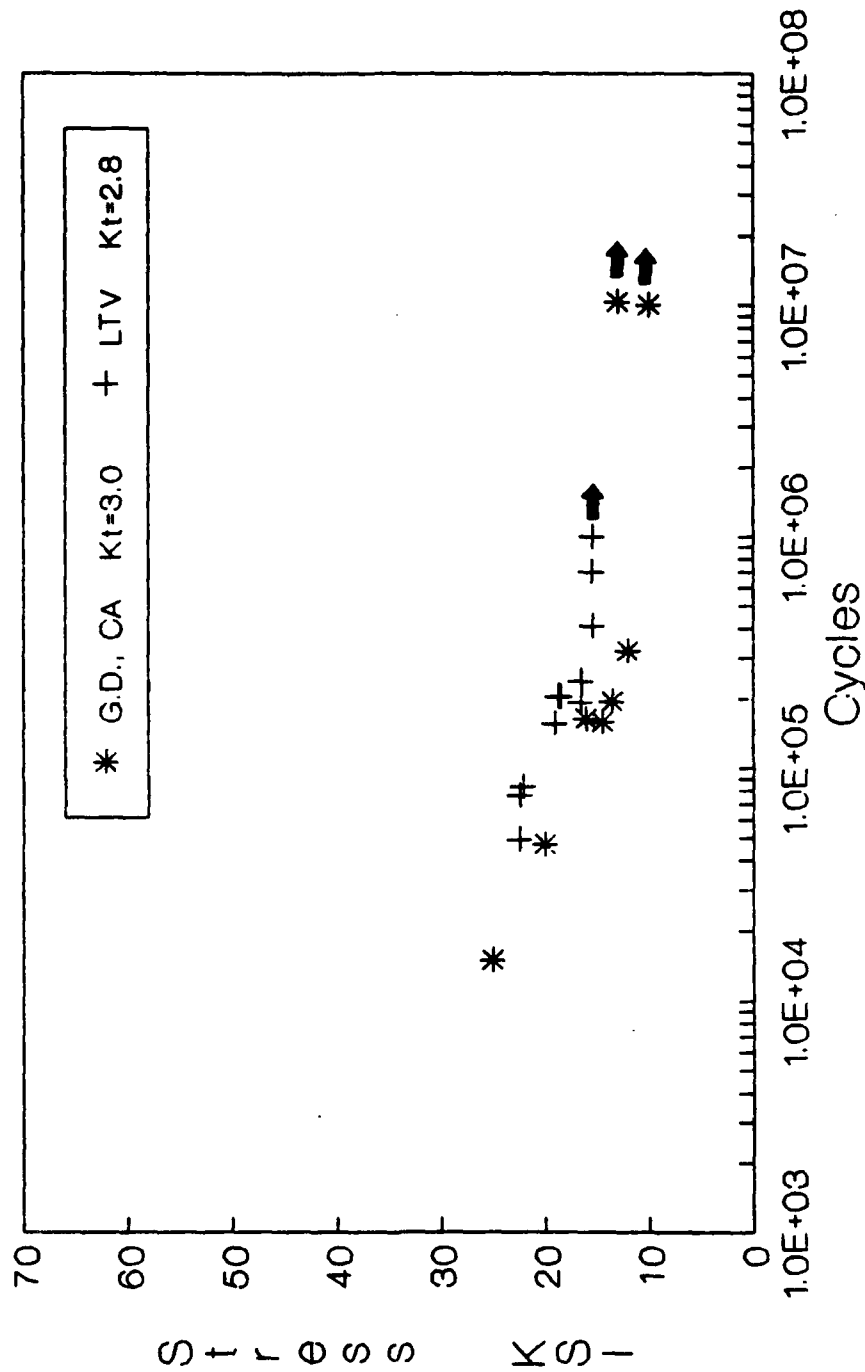


Figure B12 Fatigue Results for 2091-T3 0.063" Sheet ($R=0.1$, $K_t \geq 2.8$, and Longitudinal).
General Dynamics, CA and LTV.

TABLE B26

FATIGUE RESULTS WITH $R=0.1$ AND $K_t=2.8$ FOR
PECHINEY 2091-T3 SHEET (0.063" X 79" X 39")

COMPANY	ORIENTATION	STRESS (KSI)	CYCLES

LTV	L TRANS	15.5	1,500,000 *
		16.0	369,700
		18.7	94,490
		18.7	138,430
		22.1	84,900
		22.5	52,100

(*): INDICATES A RUN-OUT TEST

Pechiney 2091-T3 Sheet (0.063" X 79" X 39")

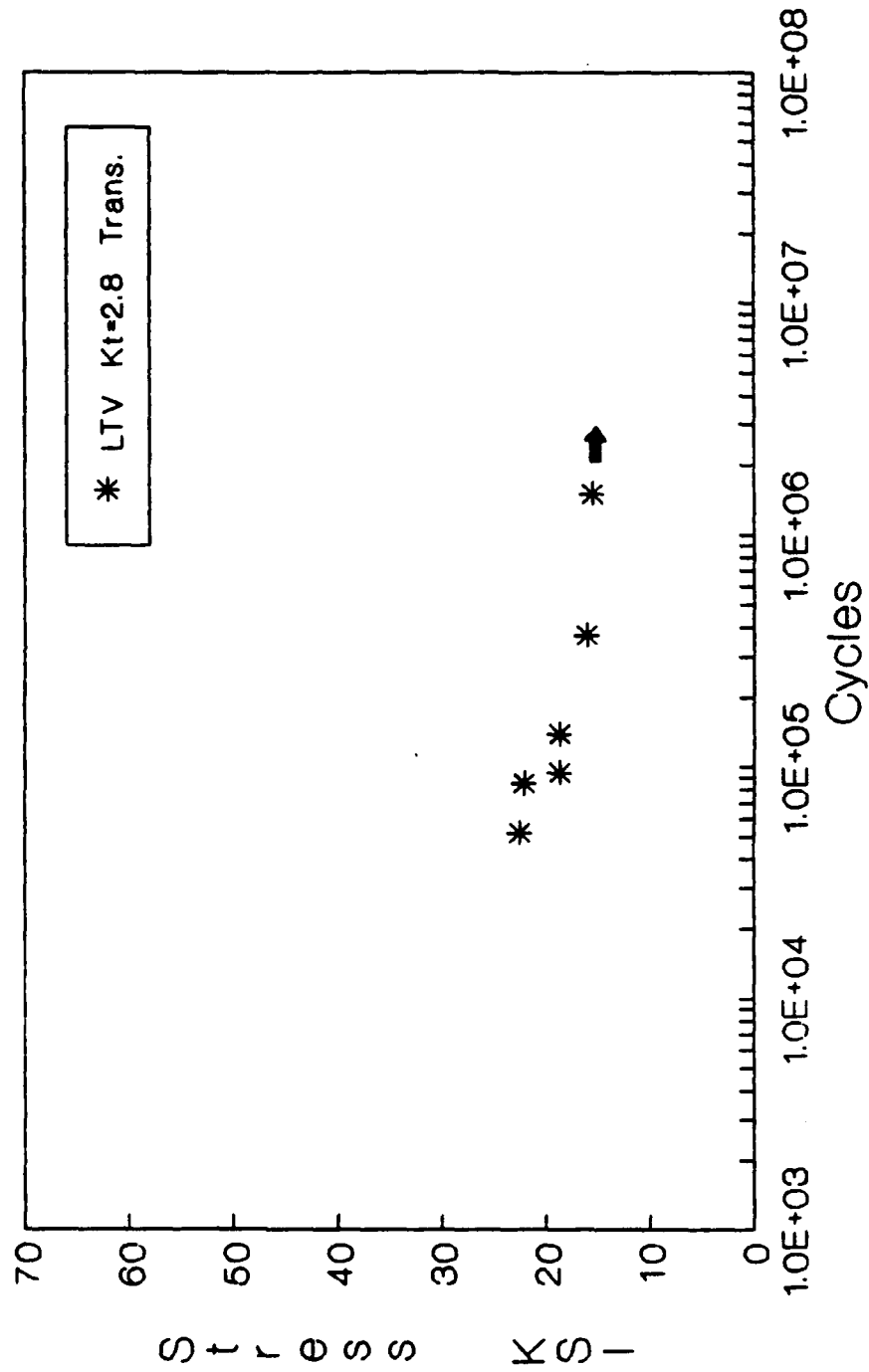


Figure B13 Fatigue Results for 2091-T3 0.063" Sheet ($R=0.1$, $K_t=2.8$, and Transverse). LTV.

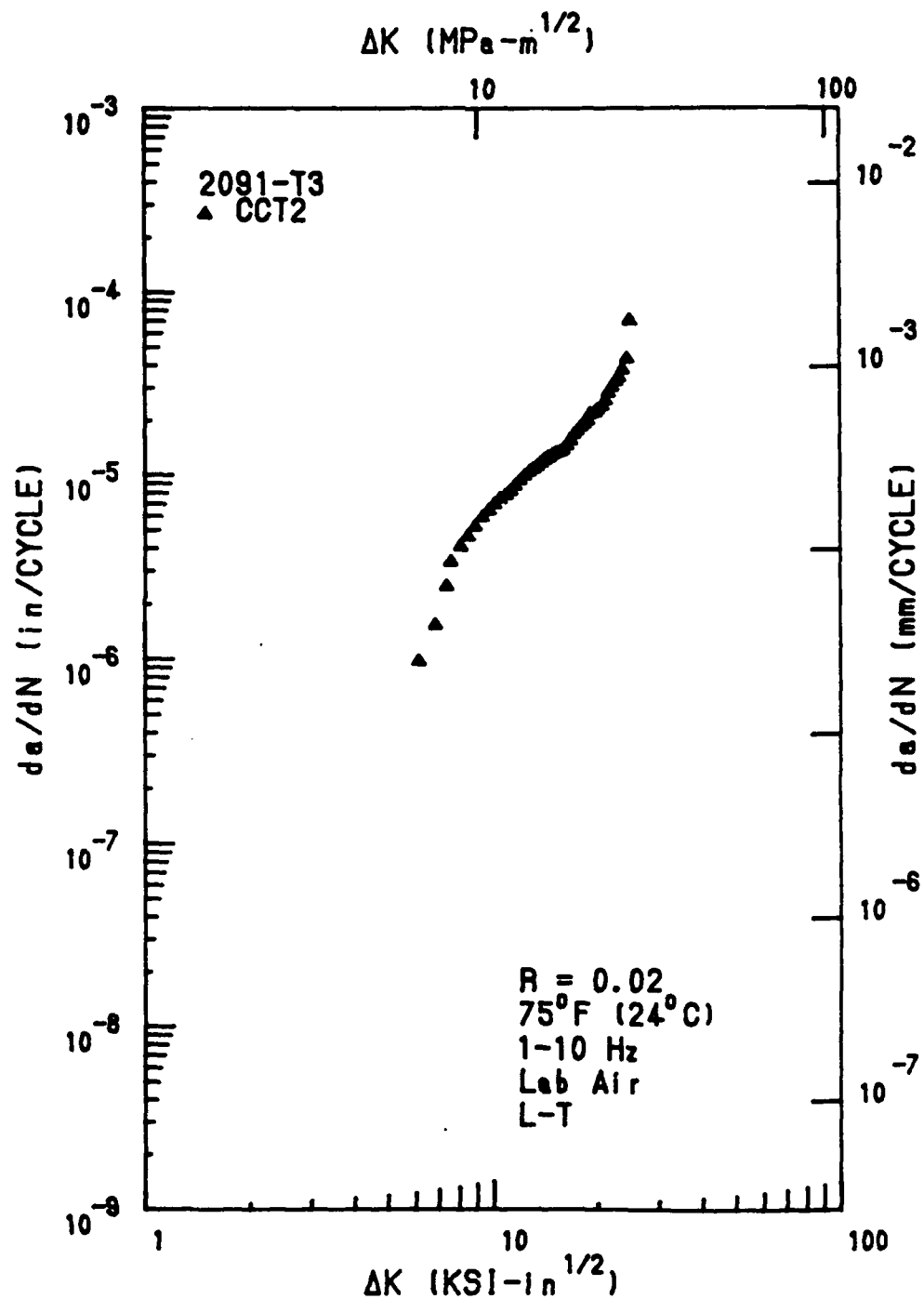


Figure B14 Fatigue Crack Growth Rate Data for Pechinev 2091-T3
0.063" Sheet (L-T Orientation). McDonnell Aircraft IA.

TABLE B27A

Fatigue Crack Growth Rate Data Associate with Figure B14

Seven Point Incremental Polynomial Method per ASTM E647

05-24-1989

Specimen Number: CCT2 Specimen Type: CCT

B = 0.0636 in W = 3.9120 in An = 0.0000

Pmax = 12400.000 lbs Pmin = 48.000 lbs

R = 0.02 Frequency = 0.00 Hz. 1-10 Hz

Test Temperature = 75 F Environment = LAB AIR

PT	CYCLES	2a/mm	Avg	MCC	Delta K	da/dN
1	0.00	0.1410				
2	70.00	0.1610				
3	180.00	0.2000				
4	280.00	0.2500	0.2647	0.973260	6.11	.9778E-06
5	335.00	0.3030	0.3281	0.966404	6.82	.1539E-05
6	365.00	0.3620	0.3800	0.981514	7.35	.2490E-05
7	376.00	0.4000	0.4016	0.998027	7.56	.3379E-05
8	391.00	0.4520	0.4537	0.999719	8.05	.4090E-05
9	401.50	0.5000	0.4998	0.999702	8.46	.4636E-05
10	411.50	0.5500	0.5477	0.999601	8.88	.5241E-05
11	421.50	0.6000	0.6028	0.999543	9.34	.5911E-05
12	429.50	0.6500	0.6515	0.999482	9.73	.6398E-05
13	436.50	0.7000	0.6978	0.999468	10.10	.6891E-05
14	443.50	0.7500	0.7490	0.999877	10.49	.7391E-05
15	450.50	0.8000	0.8022	0.999878	10.90	.7778E-05
16	456.50	0.8500	0.8490	0.999891	11.25	.8186E-05
17	462.50	0.9000	0.8991	0.999886	11.61	.8692E-05
18	468.50	0.9510	0.9526	0.999807	12.01	.9328E-05
19	473.50	1.0000	0.9997	0.999949	12.35	.9865E-05
20	478.50	1.0500	1.0508	0.999833	12.72	.1036E-04
21	483.00	1.1000	1.0995	0.999910	13.07	.1076E-04
22	487.50	1.1500	1.1485	0.999802	13.42	.1119E-04
23	492.00	1.1990	1.1994	0.999766	13.78	.1164E-04
24	496.50	1.2500	1.2520	0.999883	14.16	.1211E-04
25	500.30	1.3000	1.2991	0.999780	14.50	.1246E-04
26	504.30	1.3510	1.3503	0.999818	14.88	.1298E-04
27	508.00	1.4000	1.4000	0.999798	15.24	.1320E-04
28	512.00	1.4510	1.4527	0.999787	15.63	.1399E-04
29	515.30	1.5000	1.4967	0.999640	15.96	.1373E-04
30	519.50	1.5500	1.5513	0.999307	16.37	.1451E-04
31	522.80	1.6010	1.6022	0.999423	16.77	.1549E-04
32	526.00	1.6510	1.6519	0.999943	17.15	.1668E-04

* - DATA VIOLATES SIZE REQUIREMENTS

† Denotes that Data Point is Invalid per ASTM STANDARD TEST METHOD E 647-83, PARAGRAPH 8.6.4

‡ Denotes that DATA POINT IS INVALID PER ASTM STANDARD TEST METHOD E 647-83, PARAGRAPH 7.2.2.

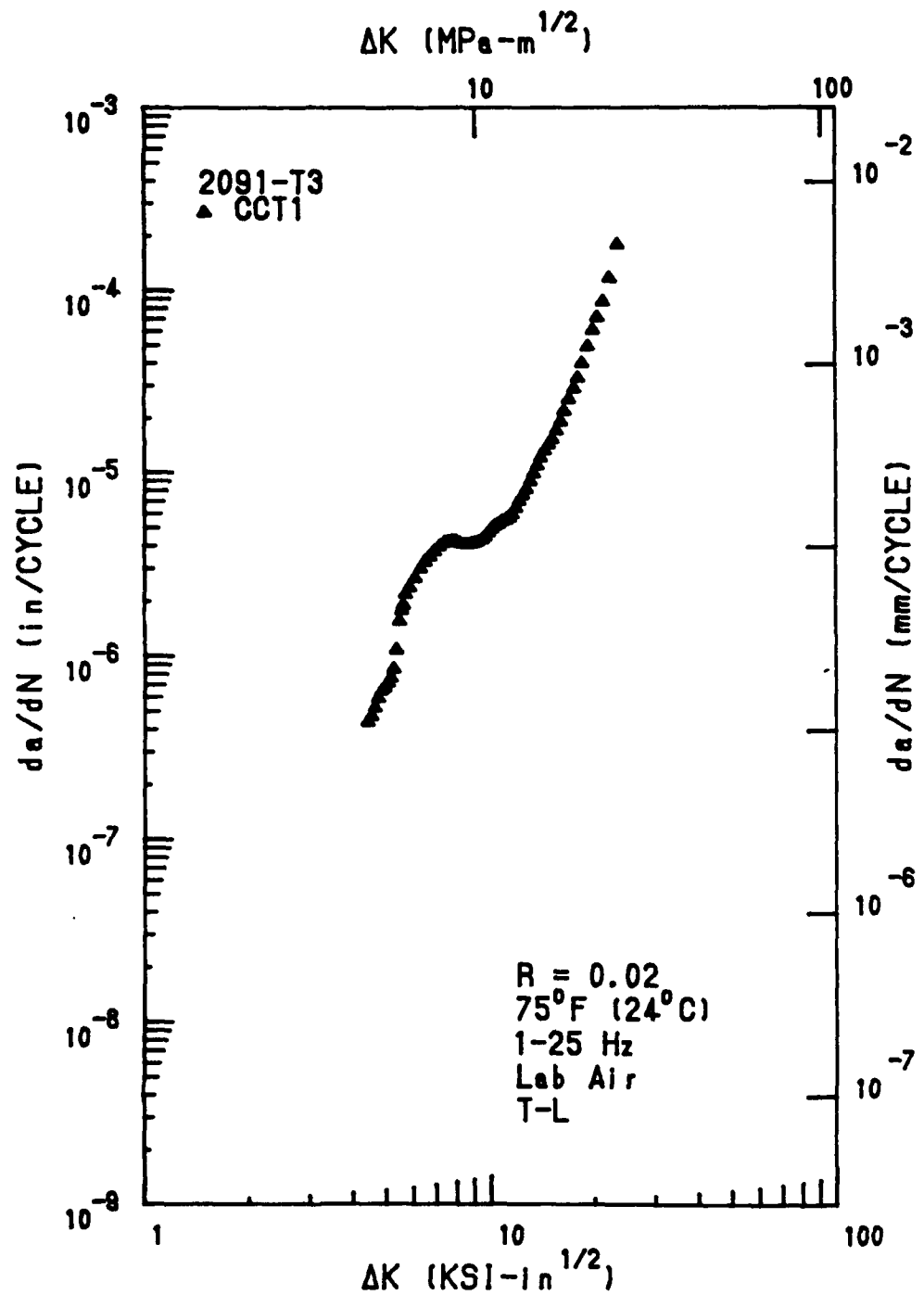


Figure B15 Fatigue Crack Growth Rate Data for Pechiney 2091-T3
0.063" Sheet (T-L Orientation). McDonnell Aircraft LA.

TABLE B27B

Fatigue Crack Growth Rate Data Associated with Figure B15

Seven Point Incremental Polynomial Method per ASTM E647

05-24-1989

Specimen Number: CCT1 Specimen Type: CCT

B = 0.0710 in W = 3.9140 in An = 0.0000

Pmax = 21550.000 lbs Pmin = 31.000 lbs

R = 0.02 Frequency = 0.00 Hz. 1-25 Hz

Test Temperature = 75 F Environment = LAB AIR

PT	CYCLES	2-Point	ΔK	MCC	Delta K	da/dN
1	0.00	0.7500				
2	56.00	0.3700				
3	106.00	0.3900				
4	150.00	0.4100	0.4090	0.999848	4.41	.4351E-06
5	198.00	0.4300	0.4305	0.999727	4.53	.4670E-06
6	239.00	0.4500	0.4495	0.999740	4.63	.5195E-06
7	280.00	0.4700	0.4709	0.998823	4.74	.5855E-06
8	315.00	0.4900	0.4922	0.998786	4.85	.6416E-06
9	340.00	0.5110	0.5091	0.998070	4.94	.6670E-06
10	368.00	0.5300	0.5292	0.998978	5.04	.7099E-06
11	398.00	0.5510	0.5508	0.998246	5.13	.7540E-06
12	426.00	0.5700	0.5709	0.996725	5.25	.8441E-06
13	451.00	0.5910	0.5922	0.990044	5.35	.1075E-05
14	474.00	0.6130	0.6186	0.989092	5.47	.1546E-05
15	484.00	0.6300	0.6334	0.994159	5.54	.1771E-05
16	492.00	0.6500	0.6484	0.995252	5.61	.1888E-05
17	500.00	0.6700	0.6660	0.998870	5.69	.2179E-05
18	516.00	0.7000	0.7012	0.998969	5.85	.2358E-05
19	536.00	0.7500	0.7501	0.999727	6.07	.2643E-05
20	554.00	0.8000	0.8000	0.999915	6.29	.2989E-05
21	584.00	0.8500	0.8497	0.999856	6.50	.3258E-05
22	594.00	0.9000	0.9010	0.999814	6.72	.3473E-05
23	597.00	0.9500	0.9476	0.999764	6.92	.3695E-05
24	611.00	1.0000	1.0002	0.999680	7.14	.3946E-05
25	624.00	1.0500	1.0531	0.999512	7.36	.4115E-05
26	635.00	1.1000	1.1000	0.998925	7.56	.4155E-05
27	646.00	1.1510	1.1482	0.999459	7.74	.4214E-05
28	658.00	1.2000	1.1994	0.999734	7.97	.4202E-05
29	671.00	1.2510	1.2522	0.999726	8.19	.4122E-05
30	683.00	1.3000	1.3008	0.999903	8.39	.4058E-05
31	695.00	1.3500	1.3496	0.999904	8.60	.4044E-05
32	707.00	1.4000	1.3985	0.999917	8.81	.4082E-05
33	720.00	1.4500	1.4512	0.999870	9.03	.4112E-05
34	732.00	1.5000	1.4999	0.999909	9.24	.4181E-05
35	744.00	1.5500	1.5501	0.999984	9.46	.4289E-05
36	756.00	1.6000	1.6001	0.999958	9.68	.4448E-05

* - DATA VIOLATES SIZE REQUIREMENTS

37 767.00 1.6500 1.6491 0.999852 9.90 .4662E-05
 38 778.00 1.7000 1.7012 0.999887 10.14 .4893E-05
 39 788.00 1.7500 1.7514 0.999804 10.38 .5070E-05
 40 797.00 1.8000 1.7983 0.999717 10.60 .5189E-05
 41 806.50 1.8500 1.8488 0.999671 10.85 .5389E-05
 42 816.00 1.9000 1.9005 0.999648 11.11 .5494E-05
 43 825.50 1.9500 1.9523 0.999742 11.37 .5662E-05
 44 833.50 2.0010 1.9977 0.999712 11.61 .5904E-05
 45 842.50 2.0500 2.0513 0.999295 11.90 .6375E-05
 46 850.50 2.1020 2.1029 0.999277 12.19 .6942E-05
 47 857.50 2.1500 2.1518 0.999816 12.47 .7457E-05
 48 863.50 2.2000 2.1986 0.999820 12.74 .8065E-05
 49 869.50 2.2500 2.2479 0.999182 13.05 .8892E-05
 50 875.50 2.3000 2.3028 0.999180 13.39 .9842E-05
 51 880.50 2.3500 2.3524 0.999659 13.72 .1085E-04
 52 884.50 2.4000 2.3985 0.999637 14.02 .1201E-04
 53 889.00 2.4520 2.4539 0.999541 14.43 .1315E-04
 54 892.60 2.5010 2.5030 0.999535 14.80 .1412E-04
 55 895.60 2.5500 2.5454 0.999418 15.13 .1518E-04
 56 899.20 2.6000 2.6021 0.999056 15.59 .1691E-04
 57 902.20 2.6510 2.6532 0.999063 16.03 .1893E-04
 58 904.70 2.7010 2.7003 0.999434 16.45 .2174E-04
 59 907.00 2.7510 2.7522 0.999329 16.95 .2524E-04
 60 909.00 2.8010 2.8043 0.999671 17.48 .2883E-04
 61 910.50 2.8500 2.8482 0.999296 17.95 .3297E-04
 62 912.00 2.9000 2.8992 0.997024 18.53 .3924E-04
 63 913.40 2.9500 2.9533 0.996342 19.24 .4917E-04
 64 914.40 3.0010 3.0057 0.998617 19.89 .6012E-04
 65 915.10 3.0500 3.0479 0.999773 20.49 .7067E-04
 66 915.80 3.1000 3.1000 0.997087 21.30 .8669E-04
 67 916.40 3.1500 3.1552 0.983215 22.22 .1161E-03
 68 916.90 3.2010 3.2199 0.966572 23.44 .1787E-03
 69 917.20 3.2510
 70 917.30 3.3000
 71 917.40 3.3510
 72 917.50 3.4000
 73 917.60 3.4500
 74 917.70 3.5000
 75 917.80 3.5500
 76 917.90 3.6000
 77 918.00 3.6500
 78 918.10 3.7000
 79 918.20 3.7500
 80 918.30 3.8000
 81 918.40 3.8500
 82 918.50 3.9000
 83 918.60 3.9500
 84 918.70 4.0000
 85 918.80 4.0500
 86 918.90 4.1000
 87 919.00 4.1500
 88 919.10 4.2000
 89 919.20 4.2500
 90 919.30 4.3000
 91 919.40 4.3500
 92 919.50 4.4000
 93 919.60 4.4500
 94 919.70 4.5000
 95 919.80 4.5500
 96 919.90 4.6000
 97 920.00 4.6500
 98 920.10 4.7000
 99 920.20 4.7500
 100 920.30 4.8000

2091-T8X SHEET
(0.063"x79"x79")

TABLE B28
TENSILE RESULTS FOR PECHINEY
2091-T8X SHEET (0.063" X 79" X 39")

COMPANY	TEST TEMPERATURE (DEGREES F)	ORIENT- ATION	ULTIMATE STRENGTH (KSI)	YIELD STRENGTH (KSI)	ELONG (%)	RA (%)	MODULUS (MSI)
NORTHROP	RT	LONG	62.9	47.5	15.6		11.1
			63.0	47.4	16.5		11.1
			63.1	47.7	18.3		10.5
GRUMMAN	RT	LONG	61.8	47.3	15.5		10.9
			61.8	47.7	16.5		11.2
			62.8	47.3	15.5		11.6
GENERAL DYNAMICS, TEXAS	RT	LONG	65.6	49.7	14.1		
			64.7	49.1	14.1		
		AVERAGE	63.2	48.0	15.8		11.1
		STANDARD DEVIATION	1.3	0.9	1.4		0.4

TABLE B29
TENSILE RESULTS FOR PECHINEY
2091-T8X SHEET (0.063' X 79' X 39')

COMPANY	TEST TEMPERATURE (DEGREES F)	ORIENT- ATION	ULTIMATE STRENGTH (KSI)	YIELD STRENGTH (KSI)	ELONG (%)	RA (%)	MODULUS (MSI)
NORTHROP	RT	L TRANS	65.9	47.5	14.3		11.0
			66.0	47.6	13.6		11.4
			66.6	48.0	14.0		11.2
GRUMMAN	RT	L TRANS	64.4	46.3	12.0		11.0
			64.6	46.6	15.0		11.4
			64.8	46.7	14.0		11.5
GENERAL DYNAMICS, TEXAS	RT	L TRANS	67.2	50.2	11.0		
			67.5	50.7	10.4		
		AVERAGE	65.9	48.0	13.0		11.3
		STANDARD DEVIATION	1.2	1.7	1.7		0.2

TABLE B30
 COMPRESSION RESULTS FOR PECHINEY
 2091-T8X SHEET (0.063" X 79" X 39")

COMPANY	TEST TEMPERATURE (DEGREES F)	ORIENTATION	COMPRESSIVE YIELD STRENGTH (KSI)	COMPRESSIVE MODULUS (MSI)
NORTHROP	RT	LONG	46.8	11.6
			46.7	11.5
			46.9	11.5
GRUMMAN	RT	LONG	45.3	11.6
			47.9	11.5
			46.3	11.5
GENERAL DYNAMICS, TEXAS	RT	LONG	48.8	
			49.7	
		AVERAGE	47.3	11.5
		STANDARD DEVIATION	1.4	0.1

TABLE B31
 COMPRESSION RESULTS FOR PECHINEY
 2091-T8X SHEET (0.063" X 79" X 39")

COMPANY	TEST TEMPERATURE (DEGREES F)	ORIENTATION	COMPRESSIVE YIELD STRENGTH (KSI)	COMPRESSIVE MODULUS (MSI)
NORTHROP	RT	L TRANS	53.0	11.5
			52.7	11.5
			53.0	11.3
GRUMMAN	RT	L TRANS	51.3	11.2
			51.3	11.4
			52.3	11.7
GENERAL DYNAMICS, TEXAS	RT	L TRANS	53.1	
			53.7	
		AVERAGE	52.5	11.4
		STANDARD DEVIATION	0.9	0.2

TABLE B32
 COMPRESSION RESULTS FOR PECHINEY
 2091-T8X SHEET (0.063" X 79" X 39")

COMPANY	TEST TEMPERATURE (DEGREES F)	ORIENTATION	COMPRESSIVE YIELD STRENGTH (KSI)	COMPRESSIVE MODULUS (MSI)
GRUMMAN	RT	45	44.6	11.4
			45.5	11.3
			45.2	11.4
		AVERAGE	45.1	11.4
		STANDARD DEVIATION	0.5	0.1

TABLE B33
SLOTTED SHEAR RESULTS FOR PECHINEY
2091-T8X SHEET (0.063" X 79" X 39")

COMPANY	ORIENTATION	SHEAR STRENGTH (KSI)
NORTHROP	LONG	39.4
		35.5
		39.6
GRUMMAN	LONG	38.2
		40.0
		39.1
GENERAL DYNAMICS, TEXAS	LONG	40.9
		42.0
	AVERAGE	39.3
	STANDARD DEVIATION	1.9

TABLE B34
SLOTTED SHEAR RESULTS FOR PECHINEY
2091-T8X SHEET (0.063" X 79" X 39")

COMPANY	ORIENTATION	SHEAR STRENGTH (KSI)
NORTHROP	L TRANS	41.8
		41.9
		41.9
GRUMMAN	L TRANS	41.1
		41.7
		40.7
GENERAL DYNAMICS. TEXAS	L TRANS	38.4
	AVERAGE	41.1
	STANDARD DEVIATION	1.3

TABLE B35
BEARING RESULTS FOR PECHINEY
2091-T8X SHEET (0.063" X 79" X 39")

COMPANY	ORIENTATION	e/D	BEARING	
			ULT. STR. (KSI)	YIELD STR. (KSI)
NORTHROP	LONG	1.5	94.9	67.6
			94.9	68.3
			94.9	67.2
GRUMMAN	LONG	1.5	91.7	65.5
			91.7	65.4
			91.7	66.2
GENERAL DYNAMICS, TEXAS	LONG	1.5	88.6	75.6
			93.8	78.2
AVERAGE			92.8	69.3
STANDARD DEVIATION			2.3	4.9

TABLE B36
BEARING RESULTS FOR PECHINEY
2091-T8X SHEET (0.063" X 79" X 39")

COMPANY	ORIENTATION	e/D	BEARING	
			ULT. STR. (KSI)	YIELD STR. (KSI)
NORTHROP	L TRANS	1.5	96.3	67.6
			96.3	67.1
			96.2	68.0
GRUMMAN	L TRANS	1.5	91.9	65.0
			92.4	66.7
			93.1	66.5
GENERAL DYNAMICS, TEXAS	L TRANS	1.5	92.9	78.8
			92.3	78.5
AVERAGE			93.9	69.8
STANDARD DEVIATION			2.0	5.5

TABLE B37
BEARING RESULTS FOR PECHINEY
2091-T8X SHEET (0.063" X 79" X 39")

COMPANY	ORIENTATION	e/D	BEARING	
			ULT. STR. (KSI)	YIELD STR. (KSI)
NORTHROP	LONG	2.0	117.2	80.0
			118.6	79.8
			117.1	81.5
GRUMMAN	LONG	2.0	116.4	79.2
			116.4	78.7
			116.4	78.6
GENERAL DYNAMICS, TEXAS	LONG	2.0	106.0	88.1
			117.0	92.2
AVERAGE			115.6	82.3
STANDARD DEVIATION			4.0	5.1

TABLE B38
BEARING RESULTS FOR PECHINEY
2091-T8X SHEET (0.063" X 79" X 39")

COMPANY	ORIENTATION	e/D	BEARING	
			ULT. STR. (KSI)	YIELD STR. (KSI)
NORTHROP	L TRANS	2.0	120.4	81.6
			120.1	84.0
			118.6	82.0
GRUMMAN	L TRANS	2.0	121.8	83.2
			120.0	81.8
			117.6	80.8
GENERAL DYNAMICS, TEXAS	L TRANS	2.0	114.0	95.8
			105.0	93.6
AVERAGE			117.2	85.4
STANDARD DEVIATION			5.5	5.9

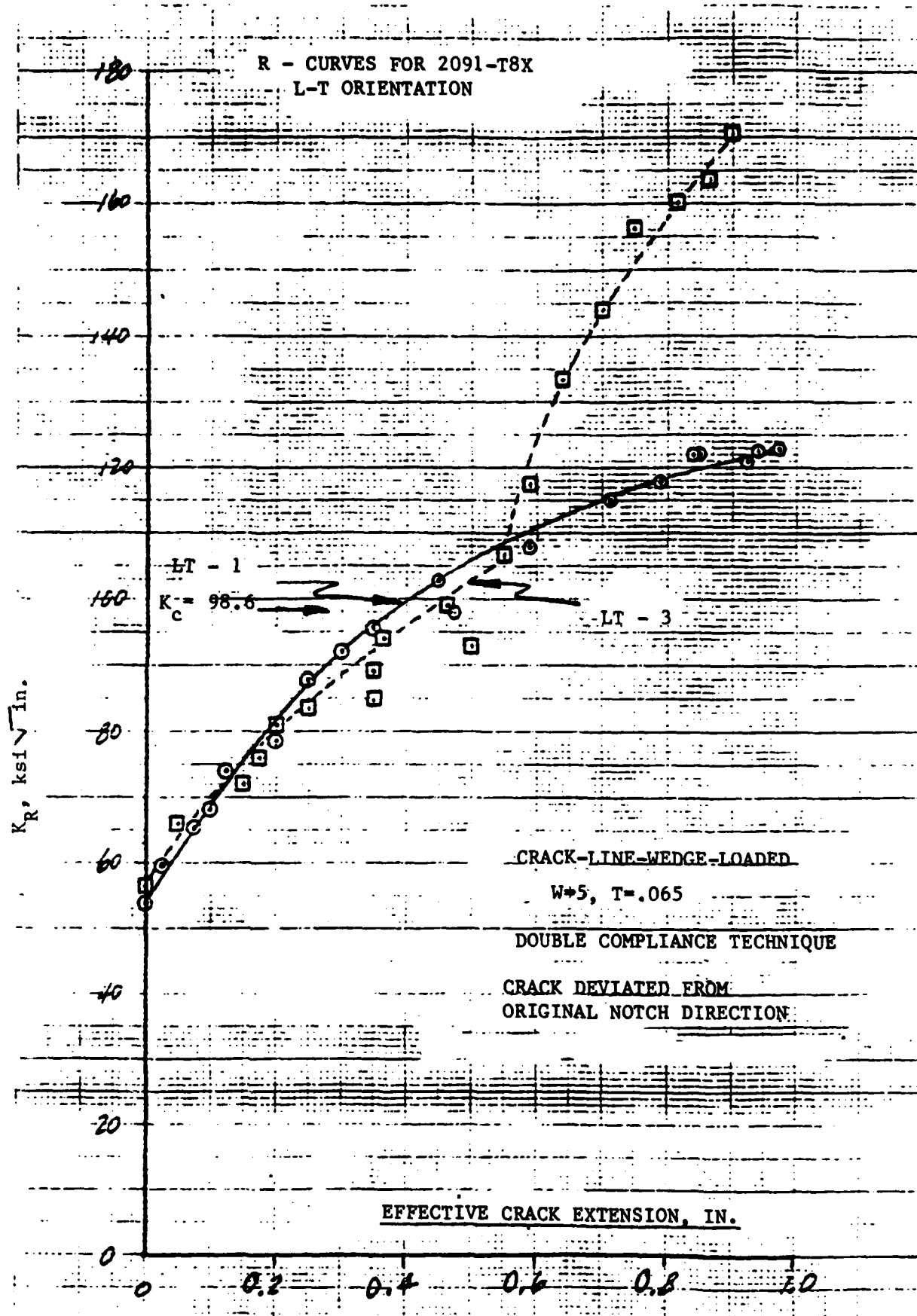


Figure B16 R-Curve Results for 2091-T8X 0.063" Sheet (L-T). Grumman.

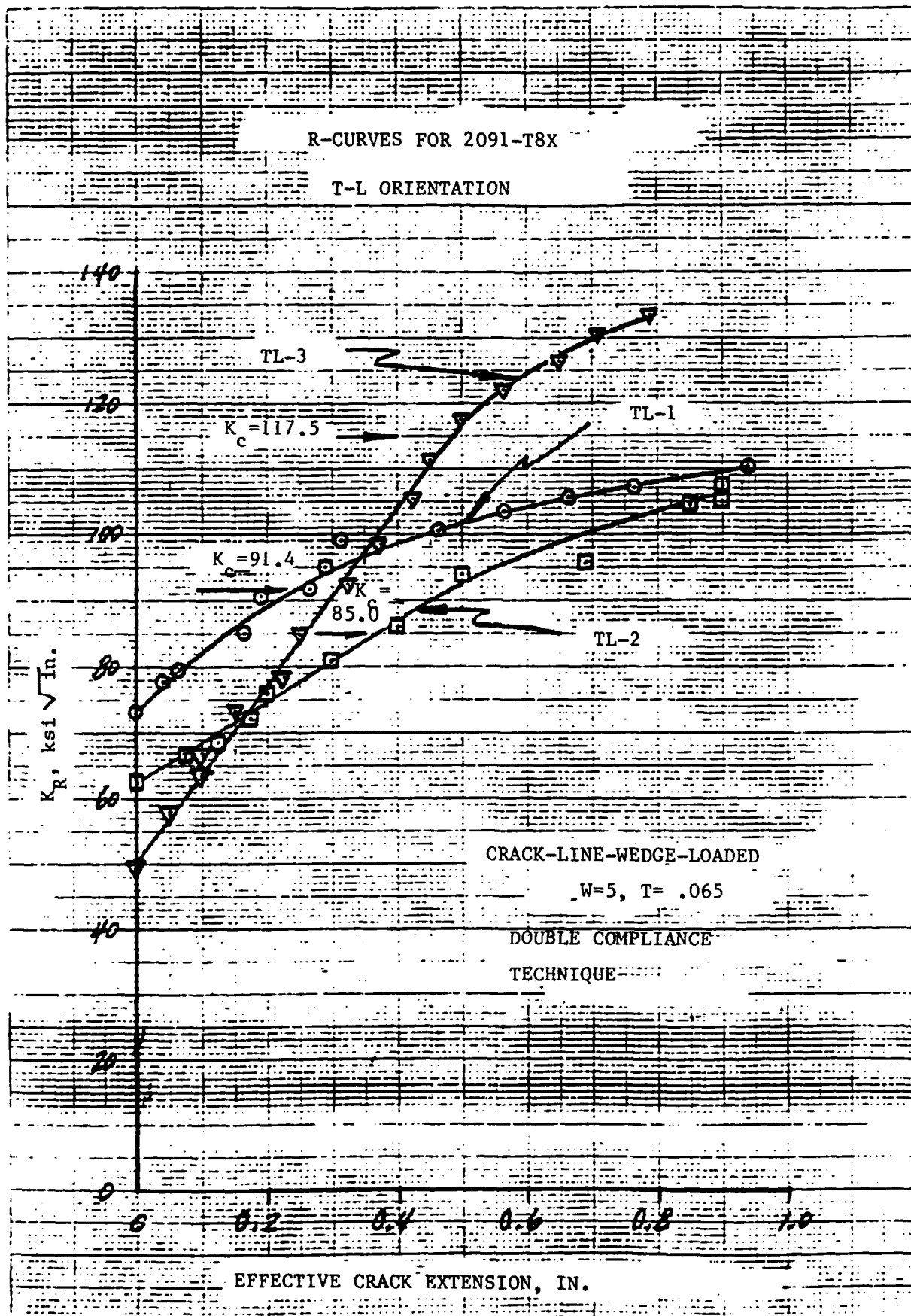


Figure B17 R-Curve Results for 2091-T8X 0.063" Sheet (T-L). Grumman.

TABLE B39

General Dynamics, Texas

Duchiney 2091-T81 Sheet

(0.063" X 79" X 39")

Average Results of R-Curve Tests

$K_{R25}, \text{ksi-in}^{\frac{1}{2}}$

L-T 91.2

T-L 81.4

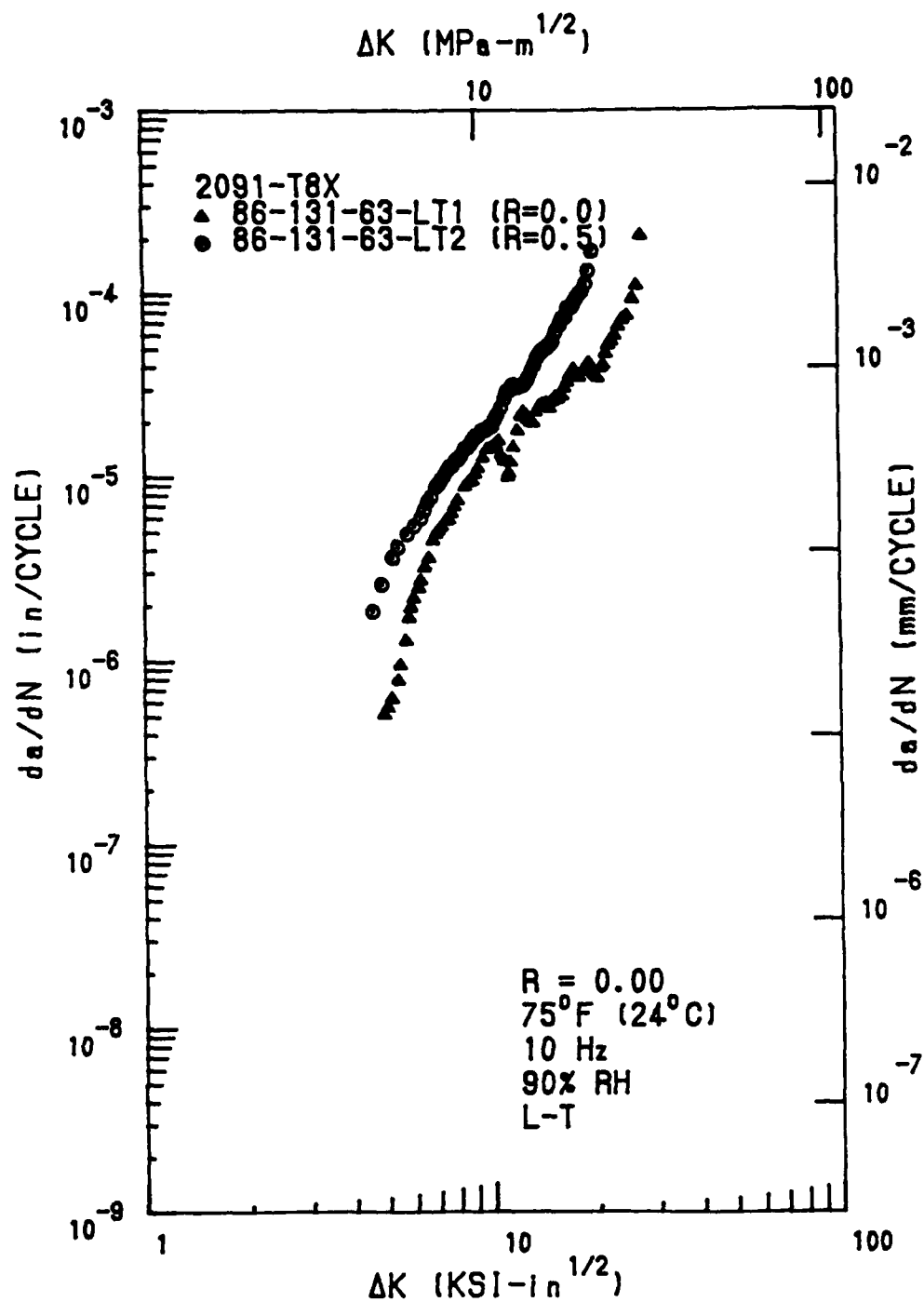


Figure 818 Fatigue Crack Growth Rate Data for Pechiney 2091-T8X
 0.063" Sheet (L-T Orientation). Grumman.

TABLE B40

Fatigue Crack Growth Rate Data Associated with Figure B18

Seven Point Incremental Polynomial Method per ASTM E647

04-18-1989

Specimen Number: B6-131-63-L7-1 Specimen Type: CCT

B= 0.0640 in W= 3.7460 in An= 0.0000

Peak= 1.440 kips Pmin= 0.000 kips

R= 0.00 Frequency= 10.00 Hz.

Test Temperature= 75 F Environment= 90% RH

MCC Delta K da/dN

PT	CYCLES	Area#2	Avg	MCC	Delta K	da/dN
1	0.00	0.3250				
2	75.00	0.3350				
3	150.00	0.3800				
4	195.00	0.4150	0.4103	0.995078	4.86	.5084E-06
5	240.00	0.4350	0.4340	0.993165	5.00	.5535E-06
6	280.00	0.4580	0.4575	0.989971	5.14	.6249E-06
7	340.00	0.4880	0.4941	0.995748	5.35	.7864E-06
8	360.00	0.5100	0.5089	0.993468	5.43	.9568E-06
9	390.00	0.5380	0.5397	0.993278	5.60	.1295E-05
10	410.00	0.5600	0.5662	0.993839	5.75	.1716E-05
11	420.00	0.5830	0.5826	0.998280	5.83	.1955E-05
12	430.00	0.6050	0.6029	0.998490	5.94	.2191E-05
13	445.00	0.6400	0.6408	0.999616	6.14	.2493E-05
14	453.00	0.6600	0.6594	0.997553	6.23	.2754E-05
15	465.00	0.6950	0.6930	0.997169	6.40	.3199E-05
16	475.00	0.7200	0.7254	0.997646	6.56	.3599E-05
17	485.00	0.7450	0.7435	0.995823	6.75	.4464E-05
18	492.00	0.7980	0.7958	0.995673	6.91	.4857E-05
19	496.00	0.8100	0.8175	0.996550	7.01	.5077E-05
20	501.00	0.8500	0.8433	0.996363	7.14	.5312E-05
21	510.00	0.8930	0.8934	0.996626	7.38	.5754E-05
22	515.00	0.9200	0.9237	0.996911	7.52	.5802E-05
23	520.00	0.9530	0.9496	0.997717	7.64	.6291E-05
24	525.00	0.9850	0.9816	0.998313	7.74	.6822E-05
25	530.00	1.0100	1.0175	0.998544	7.96	.7397E-05
26	540.40	1.1050	1.1008	0.998766	8.35	.8735E-05
27	545.00	1.1450	1.1436	0.998807	8.55	.9289E-05
28	550.00	1.1900	1.1931	0.999622	8.78	.9500E-05
29	554.00	1.2350	1.2288	0.995716	8.95	.1034E-04
30	558.00	1.2720	1.2708	0.996205	9.14	.1111E-04
31	563.50	1.3230	1.3339	0.996403	9.44	.1247E-04
32	567.50	1.3950	1.3856	0.997062	9.69	.1408E-04
33	570.50	1.4280	1.4305	0.994176	9.91	.1416E-04
34	573.50	1.4780	1.4780	0.996599	10.14	.1464E-04
35	575.50	1.5100	1.5045	0.996360	10.28	.1489E-04
36	578.50	1.5430	1.5513	0.996052	10.51	.1548E-04
37	580.00	1.5750	1.5773	0.994290	10.64	.1374E-04
38	581.50	1.6000	1.5968	0.987003	10.74	.1275E-04
39	583.00	1.6250	1.6125	0.974455	10.82	.1212E-04
40	588.00	1.6530	1.6606	0.985495	11.08	.9906E-05
41	590.00	1.6780	1.6765	0.994370	11.16	.1040E-04
42	592.00	1.7130	1.7080	0.998735	11.33	.1194E-04
43	596.00	1.7430	1.7468	0.998080	11.54	.1456E-04
44	600.00	1.8080	1.8087	0.999203	11.88	.1784E-04
45	602.50	1.8550	1.8554	0.999563	12.15	.2137E-04
46	604.00	1.8900	1.8890	0.999322	12.35	.2259E-04
47	605.00	1.9100	1.9131	0.995345	12.49	.2121E-04
48	606.00	1.9400	1.9364	0.997794	12.63	.2157E-04
49	607.00	1.9600	1.9555	0.996013	12.75	.2066E-04
50	609.00	1.9930	1.9942	0.996578	12.98	.1989E-04

* - DATA VIOLATES SIZE REQUIREMENTS

TABLE B41

Fatigue Crack Growth Rate Data Associated with Figure B18

Seven Point Incremental Polynomial Method per ASTM E647

04-18-1989

Specimen Number: 86-131-63-LI-2 Specimen Type: CCT

B = 0.0650 in W = 3.7500 in An = 0.0000

Pmax = 2.717 kips Pmin = 1.359 kips

R = 0.50 Frequency = 10.00 Hz.

Test Temperature = 75 F Environment = 90% RH

PT	CYCLES	Area ²	Areq	MCC	Delta K	da/dN
1	0.00	0.2600				
2	50.00	0.3000				
3	100.00	0.3530				
4	150.00	0.3830	0.3887	0.990617	4.52	.1843E-05
5	150.00	0.4230	0.4349	0.989845	4.79	.2577E-05
6	175.00	0.5000	0.5007	0.998443	5.15	.3595E-05
7	185.00	0.5330	0.5367	0.999305	5.35	.4148E-05
8	200.00	0.6100	0.6050	0.999153	5.70	.4867E-05
9	210.00	0.6530	0.6563	0.998918	5.95	.5385E-05
10	220.00	0.7150	0.7135	0.998785	6.22	.5932E-05
11	225.00	0.7400	0.7418	0.999142	6.36	.6542E-05
12	230.00	0.7750	0.7758	0.998461	6.52	.7239E-05
13	235.00	0.8100	0.8114	0.998684	6.68	.7745E-05
14	240.00	0.8530	0.8528	0.998576	6.87	.8718E-05
15	245.00	0.8830	0.8794	0.998185	7.00	.9026E-05
16	246.00	0.9030	0.9077	0.998086	7.12	.9546E-05
17	249.00	0.9400	0.9262	0.998115	7.25	.1002E-04
18	252.00	0.9650	0.9665	0.998529	7.39	.1064E-04
19	255.00	1.0000	1.0011	0.998740	7.54	.1121E-04
20	258.00	1.0350	1.0349	0.998806	7.69	.1135E-04
21	261.00	1.0750	1.0698	0.998556	7.85	.1213E-04
22	264.00	1.1050	1.1065	0.998423	8.01	.1236E-04
23	267.00	1.1400	1.1435	0.998380	8.18	.1292E-04
24	270.00	1.1880	1.1823	0.998395	8.35	.1402E-04
25	272.00	1.2080	1.2119	0.997518	8.48	.1422E-04
26	274.00	1.2400	1.2415	0.997549	8.62	.1453E-04
27	276.00	1.2750	1.2688	0.996671	8.74	.1530E-04
28	278.00	1.2980	1.3019	0.996855	8.89	.1602E-04
29	280.00	1.3200	1.3334	0.997256	9.03	.1652E-04
30	282.00	1.3750	1.2674	0.996721	9.19	.1677E-04
31	284.00	1.4000	1.4027	0.997969	9.35	.1771E-04
32	286.00	1.4400	1.4385	0.997957	9.52	.1777E-04
33	288.00	1.4700	1.4724	0.998630	9.68	.1800E-04
34	290.00	1.5100	1.5104	0.998888	9.86	.1857E-04
35	292.00	1.5450	1.5473	0.998994	10.04	.1875E-04
36	294.00	1.5880	1.5839	0.998335	10.21	.2041E-04
37	296.00	1.6250	1.6239	0.997751	10.41	.2176E-04
38	298.00	1.6650	1.6693	0.997423	10.64	.2358E-04
39	300.00	1.7250	1.7175	0.997538	10.89	.2637E-04
40	301.00	1.7450	1.7455	0.997260	11.03	.2855E-04
41	302.00	1.7700	1.7756	0.994566	11.19	.2921E-04
42	303.00	1.8050	1.8036	0.997005	11.34	.2982E-04
43	304.00	1.8400	1.8262	0.998479	11.52	.3125E-04
44	305.00	1.8650	1.8686	0.999097	11.70	.3143E-04
45	306.00	1.9000	1.8990	0.999234	11.87	.3071E-04
46	307.00	1.9300	1.9288	0.999243	12.04	.3089E-04
47	308.00	1.9600	1.9607	0.999484	12.22	.3143E-04
48	309.00	1.9900	1.9912	0.999787	12.40	.3161E-04
49	310.00	2.0250	2.0231	0.999799	12.59	.3250E-04
50	311.00	2.0550	2.0552	0.999180	12.79	.3446E-04
51	312.00	2.0900	2.0897	0.999112	13.01	.3714E-04
52	313.00	2.1250	2.1271	0.999767	13.25	.4028E-04
53	314.00	2.1700	2.1695	0.999729	13.53	.4407E-04
54	314.70	2.2030	2.2016	0.999659	13.75	.4622E-04
55	315.40	2.2350	2.2358	0.999969	13.99	.4806E-04
56	316.10	2.2700	2.2697	0.999954	14.24	.4959E-04
57	316.80	2.3050	2.3049	0.999901	14.50	.5031E-04
58	317.50	2.3400	2.3400	0.999582	14.77	.5245E-04
59	318.20	2.3780	2.3766	0.999600	15.06	.5495E-04
60	318.90	2.4130	2.4133	0.998024	15.37	.6144E-04
61	319.60	2.4580	2.4585	0.998082	15.74	.6758E-04
62	320.10	2.4900	2.4929	0.998029	16.04	.7318E-04
63	320.60	2.5380	2.5316	0.996890	16.40	.7474E-04
64	320.90	2.5530	2.5546	0.992632	16.62	.8272E-04
65	321.20	2.5800	2.5804	0.990337	16.87	.8318E-04
66	321.50	2.5980	2.6040	0.990266	17.11	.8592E-04
67	321.80	2.6400	2.6315	0.993337	17.39	.8892E-04
68	322.10	2.6550	2.6572	0.992270	17.67	.9452E-04
69	322.40	2.6850	2.6870	0.992819	17.99	.9881E-04
70	322.70	2.7130	2.7145	0.997084	18.31	.1021E-03
71	323.00	2.7530	2.7485	0.998727	18.71	.1126E-03
72	323.30	2.7800	2.7810	0.991772	19.12	.1322E-03
73	323.60	2.8200	2.8216	0.988786	19.63	.1689E-03
74	323.80	2.8450				
75	324.00	2.8980				
76	324.10	2.9300				

* - DATA VIOLATES SIZE REQUIREMENTS

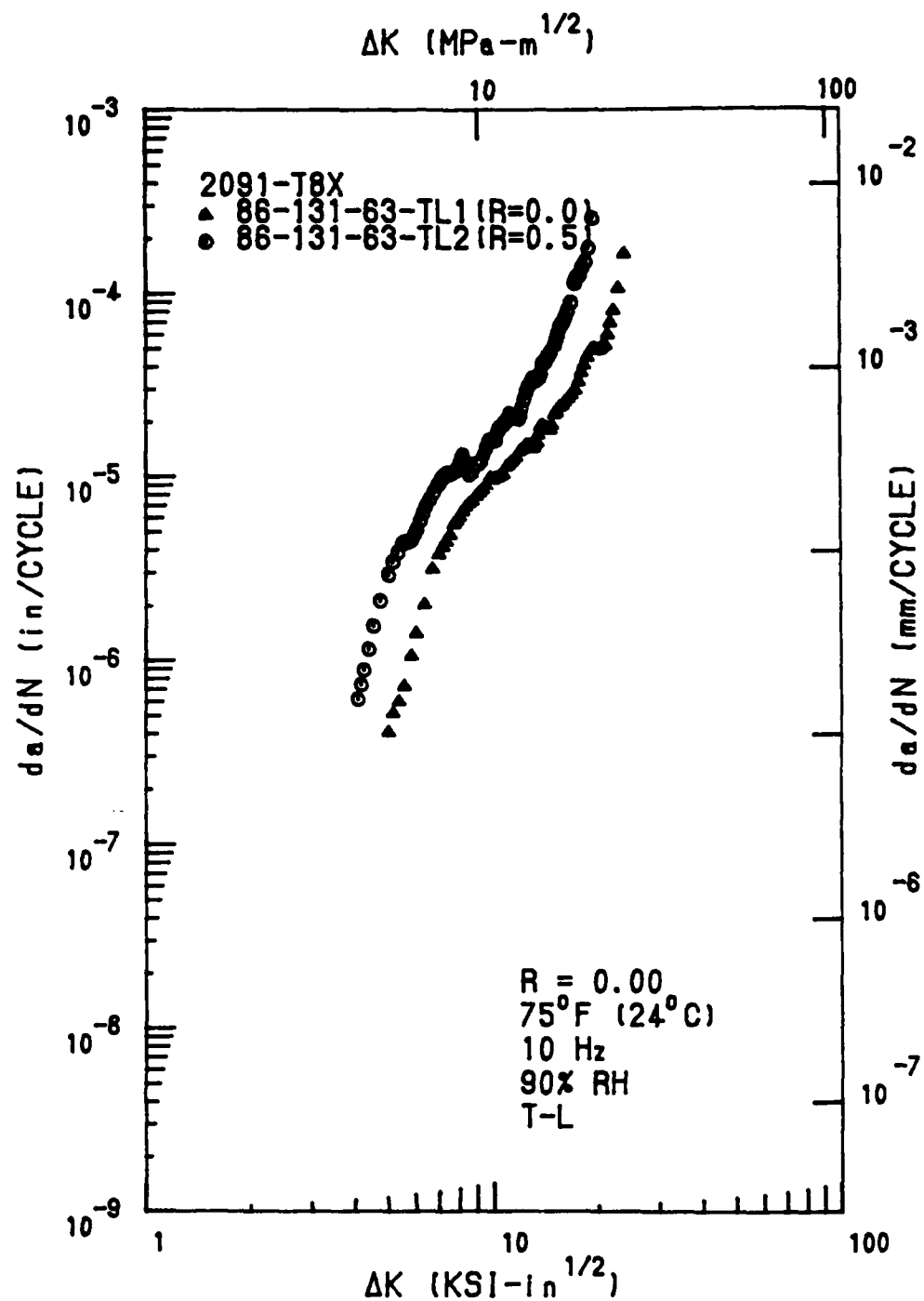


Figure B19 Fatigue Crack Growth Rate Data for Pechiney 2091-T8X
0.063" Sheet (T-L Orientation). Grumman.

TABLE B42

Fatigue Crack Growth Rate Data Associated with Figure B19

Seven Point Incremental Polynomial Method per ASTM E647

04-18-1989

Specimen Number: 86-131-63-TL-1 Specimen Type: CCT

R = 0.0620 in W = 3.7500 in An = 0.0000

Fmax = 1.543 kips Pmin = 0.000 kips

R = 0.00 Frequency = 10.00 Hz.

Test Temperature = 75 F Environment = 90% RH

PT	CYCLES	Area ²	Area	MCC	Delta K	da/dN
1	0.00	0.3100				
2	25.00	0.3200				
3	150.00	0.3280				
4	150.00	0.3350	0.3575	0.997306	5.00	.4042E-06
5	200.00	0.3830	0.3776	0.995947	5.14	.5158E-06
6	250.00	0.4030	0.4040	0.992170	5.34	.5963E-06
7	300.00	0.4230	0.4373	0.992845	5.55	.7226E-06
8	350.00	0.4850	0.4731	0.978160	5.78	.1063E-05
9	380.00	0.4950	0.5038	0.978526	5.97	.1405E-05
10	420.00	0.5450	0.5626	0.984582	6.33	.2023E-05
11	450.00	0.6280	0.6256	0.998830	6.69	.3133E-05
12	465.00	0.6750	0.6744	0.999009	6.98	.3785E-05
13	472.50	0.7000	0.7058	0.998718	7.14	.4130E-05
14	480.00	0.7400	0.7364	0.998561	7.31	.4429E-05
15	487.50	0.7750	0.7723	0.998781	7.51	.4808E-05
16	495.00	0.8100	0.8096	0.996023	7.71	.5481E-05
17	500.00	0.8250	0.8261	0.997306	7.85	.5732E-05
18	505.00	0.8470	0.8462	0.994744	8.01	.6037E-05
19	510.00	0.9050	0.8979	0.997061	8.17	.6471E-05
20	515.00	0.9200	0.9319	0.997842	8.35	.6850E-05
21	520.00	0.9650	0.9658	0.997879	8.53	.7164E-05
22	525.00	1.0050	1.0013	0.998820	8.71	.7243E-05
23	530.00	1.0400	1.0409	0.999660	8.91	.7807E-05
24	535.00	1.0820	1.0804	0.999620	9.12	.8150E-05
25	540.00	1.1200	1.1211	0.999637	9.33	.8492E-05
26	545.00	1.1650	1.1642	0.999639	9.55	.8987E-05
27	550.00	1.2100	1.2094	0.999782	9.78	.9903E-05
28	555.00	1.2400	1.2409	0.996330	9.95	.9629E-05
29	560.00	1.2700	1.2708	0.996084	10.10	.9817E-05
30	565.00	1.3080	1.3009	0.995498	10.26	.9845E-05
31	562.00	1.3250	1.3292	0.994930	10.41	.1004E-04
32	565.00	1.3600	1.3588	0.995363	10.56	.1017E-04
33	568.00	1.3880	1.3890	0.996330	10.72	.1025E-04
34	571.00	1.4250	1.4221	0.998072	10.90	.1125E-04
35	574.00	1.4550	1.4560	0.998515	11.09	.1152E-04
36	577.00	1.4880	1.4920	0.998615	11.28	.1194E-04
37	580.00	1.5330	1.5278	0.998745	11.48	.1230E-04
38	585.00	1.5650	1.5662	0.999087	11.69	.1279E-04
39	586.00	1.6030	1.6035	0.997579	11.90	.1368E-04
40	589.00	1.6450	1.6441	0.997764	12.14	.1409E-04
41	592.00	1.6850	1.6889	0.997438	12.40	.1484E-04
42	595.00	1.7430	1.7349	0.994711	12.67	.1483E-04
43	596.50	1.7550	1.7580	0.996093	12.81	.1468E-04
44	598.00	1.7800				
45	599.50	1.8000				
46	601.00	1.8230				
47	602.50	1.8430				
48	604.00	1.8700				
49	605.50	1.8900				
50	607.00	1.9200				
51	608.50	1.9550				
52	610.00	1.9950				
53	611.50	2.0050				
54	613.00	2.0200				
55	614.50	2.0600				
56	616.00	2.0900				
57	617.50	2.1250				
58	619.00	2.1600				
59	620.50	2.2030				
60	622.00	2.2350				
61	623.50	2.2800				
62	625.00	2.3080				
63	626.50	2.3580				
64	628.00	2.4030				
65	629.00	2.4350				
66	630.00	2.4620				
67	631.00	2.5150				
68	632.00	2.5630				
69	632.50	2.5880				
70	633.00	2.6080				
71	633.50	2.6380				
72	634.00	2.6620				
73	634.50	2.6830				
74	635.00	2.7100				
75	635.50	2.7350				
76	636.00	2.7650				
77	637.00	2.8480				
78	637.00	2.8480				
79	637.50	2.8930				
80	637.80	2.9200				
81	638.10	3.0000				
82	638.20	3.0700				

* - DATA VIOLATES SIZE REQUIREMENTS

TABLE B43

Fatigue Crack Growth Rate Data Associated with Figure B19

Seven Point Incremental Polynomial Method per ASTM E647

04-18-1989

Specimen Number: 86-131-65-7L-2 Specimen Type: CCT

P = 0.0640 in W = 3.7510 in An = 0.0000

Pma = 2.485 kips Pmin = 1.243 kips

R = 0.50 Frequency = 10.00 Hz.

Test Temperature = 75 F Environment = 90% RH

FT	CYCLES	Area2	Areg	MCC	Delta K	da/dN
1	0.00	0.3500				
2	25.00	0.3600				
3	50.00	0.3730				
4	75.00	0.3880	0.2875	0.995926	4.06	.6157E-06
5	100.00	0.4050	0.4029	0.996268	4.15	.7386E-06
6	125.00	0.4200	0.4215	0.997651	4.24	.8900E-06
7	150.00	0.4420	0.4429	0.995924	4.35	.1159E-05
8	175.00	0.4750	0.4729	0.996848	4.50	.1546E-05
9	200.00	0.5100	0.5151	0.997023	4.71	.2104E-05
10	225.00	0.5700	0.5737	0.998097	4.98	.2944E-05
11	250.00	0.6020	0.6026	0.999928	5.12	.3479E-05
12	275.00	0.6580	0.6388	0.999824	5.28	.3846E-05
13	300.00	0.6800	0.6797	0.999722	5.46	.4306E-05
14	325.00	0.7030	0.7018	0.999210	5.55	.4402E-05
15	350.00	0.7230	0.7250	0.999012	5.65	.4406E-05
16	375.00	0.7500	0.7475	0.998882	5.75	.4471E-05
17	400.00	0.7700	0.7691	0.998182	5.84	.4600E-05
18	425.00	0.7900	0.7916	0.997650	5.93	.4907E-05
19	450.00	0.8150	0.8156	0.996651	6.03	.5200E-05
20	475.00	0.8430	0.8429	0.99703	6.15	.5779E-05
21	500.00	0.8750	0.8737	0.999818	6.27	.6342E-05
22	525.00	0.9050	0.9043	0.999701	6.40	.6942E-05
23	550.00	0.9430	0.9422	0.999742	6.55	.7513E-05
24	575.00	0.9800	0.9809	0.999792	6.71	.8188E-05
25	600.00	1.0250	1.0239	0.999809	6.88	.8914E-05
26	625.00	1.0500	1.0510	0.999856	6.99	.9294E-05
27	650.00	1.0800	1.0798	0.999724	7.10	.9743E-05
28	675.00	1.1100	1.1097	0.999724	7.22	.1000E-04
29	700.00	1.1400	1.1405	0.999865	7.35	.1039E-04
30	725.00	1.1750	1.1730	0.998642	7.48	.1032E-04
31	750.00	1.2030	1.2032	0.997968	7.60	.1042E-04
32	775.00	1.2280	1.2342	0.997500	7.73	.1065E-04
33	800.00	1.2600	1.2657	0.997400	7.85	.1089E-04
34	825.00	1.3000	1.2984	0.996948	7.99	.1127E-04
35	850.00	1.3180	1.3137	0.996863	8.06	.1217E-04
36	875.00	1.3350	1.3354	0.997235	8.14	.1244E-04
37	900.00	1.3550	1.3566	0.999015	8.23	.1266E-04
38	925.00	1.3750	1.3754	0.993033	8.30	.1200E-04
39	950.00	1.4000	1.3919	0.992407	8.37	.1193E-04
40	975.00	1.4200	1.4215	0.992417	8.50	.1037E-04
41	1000.00	1.4480	1.4490	0.992918	8.61	.1052E-04
42	1025.00	1.4750	1.4725	0.993882	8.72	.1060E-04
43	1050.00	1.5030	1.5040	0.997080	8.85	.1163E-04
44	1075.00	1.5400	1.5356	0.995819	8.98	.1176E-04
45	1100.00	1.5600	1.5657	0.996190	9.11	.1201E-04
46	1125.00	1.6000	1.5935	0.994257	9.24	.1201E-04
47	1150.00	1.6200	1.6204	0.992010	9.35	.1316E-04
48	1175.00	1.6500	1.6554	0.991897	9.51	.1424E-04
49	1200.00	1.6900	1.6909	0.993019	9.67	.1534E-04

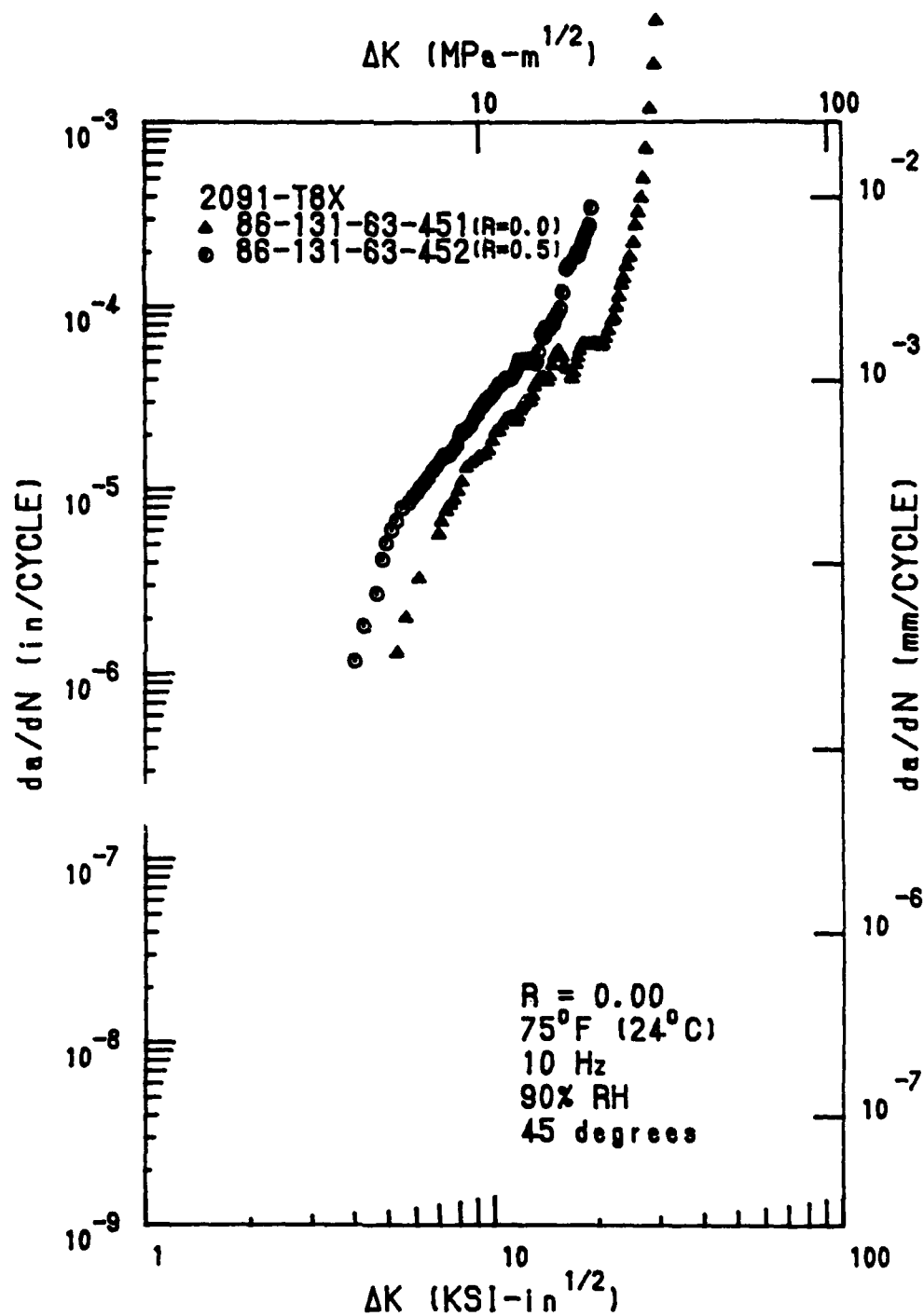


Figure B20 Fatigue Crack Growth Rate Data for Pechiney 2091-T8X 0.063" Sheet (45° Orientation). Grumman.

TABLE B44

Fatigue Crack Growth Rate Data Associated with Figure B20

Seven Point Incremental Polynomial Method per ASTM E647

05-22-1989

Specimen Number: B6-131-63-45-1 Specimen Type: CCT

B = 0.0660 in W = 3.7510 in An = 0.0000

Fmax = 12028.000 lbs Pmin = 0.000 lbs

R = 0.00 Frequency = 10.00 Hz.

Test Temperature = 75 F Environment = 90% RH

PT	CYCLES	2-Point	Ave	MCC	Delta K	da/dN
1	0.00	0.2180				
2	25.00	0.2300				
3	50.00	0.2500				
4	75.00	0.2700				
5	100.00	0.2900				
6	125.00	0.3200				
7	150.00	0.4400				
8	155.00	0.4630				
9	158.00	0.4980				
10	161.00	0.5250				
11	164.00	0.5430				
12	167.00	0.5730				
13	170.00	0.6050				
14	173.00	0.6350				
15	176.00	0.6780				
16	178.50	0.7150				
17	180.00	0.7500				
18	182.50	0.7900				
19	185.00	0.8280				
20	188.50	0.8680				
21	190.50	0.9080				
22	192.00	0.9400				
23	193.50	0.9750				
24	195.00	1.0130				
25	196.50	1.0530				
26	198.00	1.0850				
27	198.80	1.1080				
28	199.60	1.1200				
29	200.40	1.1400				
30	201.20	1.1600				
31	202.00	1.1780				
32	202.80	1.2000				
33	203.60	1.2280				
34	204.40	1.2500				
35	205.20	1.2730				
36	206.00	1.2950				
37	206.80	1.3230				
38	207.60	1.3480				
39	208.40	1.3700				
40	209.20	1.3950				
41	210.00	1.4230				
42	210.80	1.4780				
43	211.50	1.5000				
44	212.20	1.5250				
45	213.00	1.5500				
46	213.60	1.5830				
47	214.30	1.6050				
48	215.00	1.6400				
49	215.50	1.6630				
50	216.00	1.7050				
51	216.50	1.7300				
52	217.00	1.7500				
53	217.50	1.7880				
54	218.30	1.8150				
55	219.30	1.8600				
56	220.00	1.8880				
57	220.50	1.9200				
58	221.50	1.9400				
59	222.00	1.9680				
60	222.50	2.0050				
61	223.00	2.0330				
62	223.50	2.0650				
63	224.00	2.0980				
64	224.50	2.1250				
65	225.00	2.1580				
66	225.50	2.1880				
67	226.00	2.2200				
68	226.50	2.2500				
69	227.00	2.2880				
70	227.50	2.3100				
71	228.00	2.3430				
72	228.50	2.3700				
73	229.10	2.4180				
74	229.40	2.4570				
75	229.70	2.4780				
76	230.00	2.5000				
77	230.30	2.5280				
78	230.50	2.5642				
79	230.70	2.6000				
80	230.90	2.6280				
81	231.10	2.6600				
82	231.20	2.6950				
83	231.30	2.7150				
84	231.40	2.7450				
85	231.45	2.7780				
86	231.50	2.7930				
87	231.55	2.8200				
88	231.58	2.8550				
89	231.59	2.8980				
90	231.60	2.9230				
91	231.61	2.9550				
92	231.62	3.0550				
93	231.63	3.1550				
94	231.64	3.2550				
95	231.65	3.3550				
96	231.66	3.4550				
97	231.67	3.5550				
98	231.68	3.6550				
99	231.69	3.7550				
100	231.70	3.8550				

- DATA WITH AREA AND PERCENTAGE

TABLE B45

Fatigue Crack Growth Rate Data Associated with Figure B20

Seven Point Incremental Polynomial Method per ASTM E647

05-22-1989

Specimen Number: B6-131-45-63-2 Specimen Type: CCT

B = 0.0640 in W = 3.7480 in An = 0.0000

Fmax = 12948.000 lbs Pmin = 11474.000 lbs

R = 0.50 Frequency = 10.00 Hz

Test Temperature = 75 F Environment = 90% RH

PT	CYCLES	2mm/Sec	Area	MCC	Delta K	da/dN
1	0.00	0.2150				
2	25.00	0.2250				
3	50.00	0.2300				
4	100.00	0.2400				
5	125.00	0.2500				
6	150.00	0.2600				
7	160.00	0.2700				
8	165.00	0.2800				
9	170.00	0.2900				
10	175.00	0.3000				
11	180.00	0.3100				
12	185.00	0.3200				
13	188.00	0.3300				
14	191.00	0.3400				
15	194.00	0.3500				
16	197.00	0.3600				
17	200.00	0.3700				
18	203.00	0.3800				
19	206.00	0.3900				
20	209.00	0.4000				
21	211.00	0.4100				
22	213.00	0.4200				
23	215.00	0.4300				
24	217.00	0.4400				
25	219.00	0.4500				
26	221.00	0.4600				
27	222.00	0.4700				
28	225.00	0.4800				
29	228.00	0.4900				
30	230.00	0.5000				
31	232.00	0.5100				
32	234.00	0.5200				
33	236.00	0.5300				
34	238.00	0.5400				
35	240.00	0.5500				
36	241.00	0.5600				
37	242.00	0.5700				
38	243.00	0.5800				
39	244.00	0.5900				
40	245.00	0.6000				
41	246.00	0.6100				
42	247.00	0.6200				
43	248.00	0.6300				
44	249.00	0.6400				
45	250.00	0.6500				
46	251.00	0.6600				
47	252.00	0.6700				
48	253.00	0.6800				
49	254.00	0.6900				
50	243.70	1.4550	1.4491	0.994267	11.27	.4039E-04
51	244.70	1.4900	1.4929	0.994863	11.50	.4248E-04
52	245.20	1.7100	1.7118	0.99501	11.61	.4444E-04
53	245.70	1.7500	1.7534	0.99526	11.72	.4724E-04
54	246.20	1.7580	1.7588	0.995755	11.87	.5043E-04
55	246.70	1.7850	1.7865	0.996952	12.03	.5006E-04
56	247.20	1.8130	1.8114	0.997165	12.17	.4950E-04
57	247.70	1.8400	1.8353	0.995188	12.31	.5064E-04
58	248.20	1.8590	1.8603	0.995348	12.44	.4979E-04
59	248.70	1.8830	1.8843	0.996256	12.60	.5043E-04
60	249.20	1.9150	1.9103	0.995752	12.74	.5114E-04
61	249.70	1.9350	1.9387	0.995549	12.93	.5134E-04
62	250.20	1.9650	1.9629	0.997296	13.08	.5029E-04
63	250.70	1.9880	1.9868	0.997930	13.23	.4886E-04
64	251.20	2.0080	2.0115	0.997424	13.39	.5079E-04
65	251.70	2.0380	2.0344	0.997212	13.54	.5079E-04
66	252.20	2.0600	2.0639	0.992785	13.74	.7059E-04
67	252.50	2.0800	2.0844	0.987649	13.89	.6725E-04
68	252.70	2.1050	2.1014	0.989475	13.99	.6834E-04
69	253.00	2.1230	2.1164	0.993492	14.10	.7637E-04
70	253.60	2.1630	2.1649	0.987020	14.44	.7500E-04
71	254.20	2.2030	2.2097	0.992710	14.77	.8175E-04
72	254.40	2.2350	2.2360	0.992113	14.89	.8015E-04
73	254.50	2.2450	2.2350	0.992492	14.96	.8477E-04
74	255.00	2.2780	2.2787	0.993052	15.30	.9060E-04
75	255.40	2.3100	2.3130	0.995353	15.57	.9759E-04
76	255.70	2.3450	2.3424	0.989777	15.81	.1197E-03
77	256.10	2.3850	2.3951	0.990783	16.26	.1618E-03
78	256.20	2.4050	2.4105	0.989745	16.40	.1644E-03
79	256.30	2.4300	2.4279	0.989074	16.55	.1705E-03
80	256.50	2.4700	2.4705	0.996145	16.95	.1941E-03
81	256.70	2.5030	2.5060	0.994956	17.29	.1864E-03
82	256.90	2.5410	2.5411	0.999121	17.64	.1909E-03
83	257.00	2.5580	2.5604	0.998385	17.85	.2047E-03
84	257.10	2.5820	2.5811	0.998042	18.05	.2122E-03
85	257.20	2.6000	2.6018	0.998252	18.27	.2253E-03
86	257.30	2.6280	2.6289	0.996977	18.54	.2566E-03
87	257.40	2.6530	2.6534	0.997210	18.86	.2789E-03
88	257.50	2.6880	2.6801	0.987409	19.17	.3464E-03
89	257.60	2.7100				
90	257.70	2.7500				
91	257.80	2.8250				

* - DATA VIOLATES SIZE REQUIREMENTS

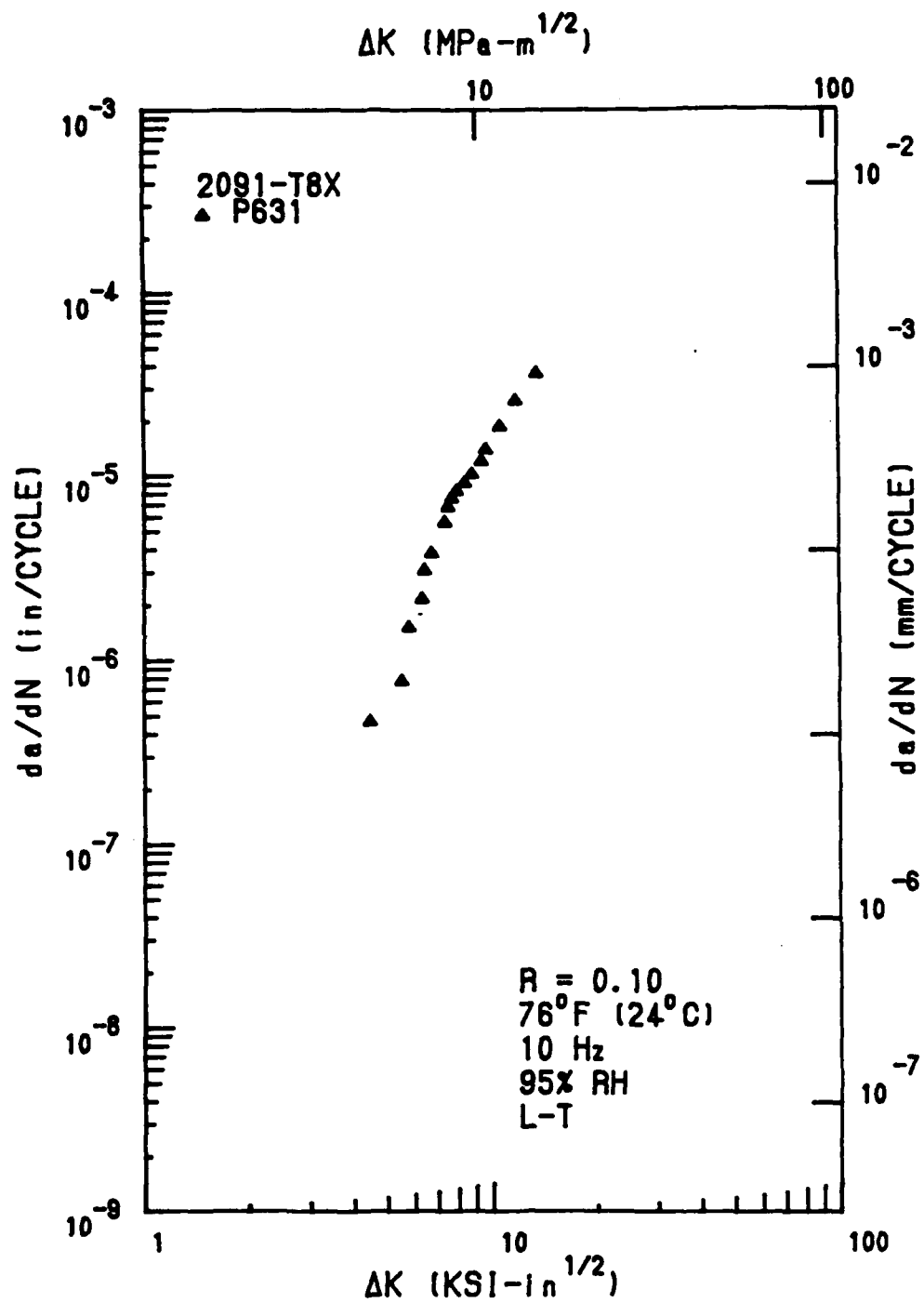


Figure B21 Fatigue Crack Growth Rate Data for Pechiney 2091-T8X
 0.063" Sheet (L-T Orientation). Northrop.

TABLE B46

Fatigue Crack Growth Rate Data
Associated with Figure B21

Seven Point Incremental Polynomial Method per ASTM E647

06-12-1989

Specimen Number: P6-31 Specimen Type: CCT

B= 0.0630 in W= 3.0030 in An= 0.0000

Pmax= 1.000 kips Pmin= 0.100 kips

R= 0.10 Frequency= 10.00 hz.

Test Temperature= 76 F Environment= 95% RH

PT	CYCLES	Amax#2	Aavg	MCC	Delta K	da/dN
1	0.00	0.2963				
2	250.00	0.3470				
3	902.00	0.5110				
4	982.00	0.5390	0.5372	0.979692	4.46	.4670E-06
5	1392.00	0.7253	0.7817	0.969526	5.50	.7741E-06
6	1492.00	0.8080	0.8460	0.985488	5.77	.1509E-05
7	1564.00	0.9493	0.9801	0.977966	6.32	.2152E-05
8	1582.00	0.9960	1.0023	0.997699	6.42	.3065E-05
9	1607.00	1.0723	1.0806	0.996984	6.74	.3800E-05
10	1640.00	1.2058	1.2184	0.996398	7.34	.5584E-05
11	1647.00	1.2507	1.2571	0.996997	7.51	.6752E-05
12	1654.00	1.3020	1.3027	0.999357	7.72	.7498E-05
13	1660.00	1.3535	1.3522	0.999690	7.95	.8217E-05
14	1670.00	1.4423	1.4389	0.999743	8.37	.9102E-05
15	1679.00	1.5193	1.5208	0.999155	8.79	.1019E-04
16	1689.00	1.6260	1.6260	0.998973	9.36	.1201E-04
17	1694.00	1.6820	1.6767	0.994428	9.65	.1394E-04
18	1704.00	1.8215	1.8279	0.994767	10.61	.1865E-04
19	1712.00	1.9610	1.9842	0.996627	11.78	.2567E-04
20	1718.00	2.1475	2.1678	0.988696	13.50	.3607E-04
21	1719.00	2.1865				
22	1720.00	2.2345				
23	1720.60	2.3095				

* - DATA VIOLATES SIZE REQUIREMENTS

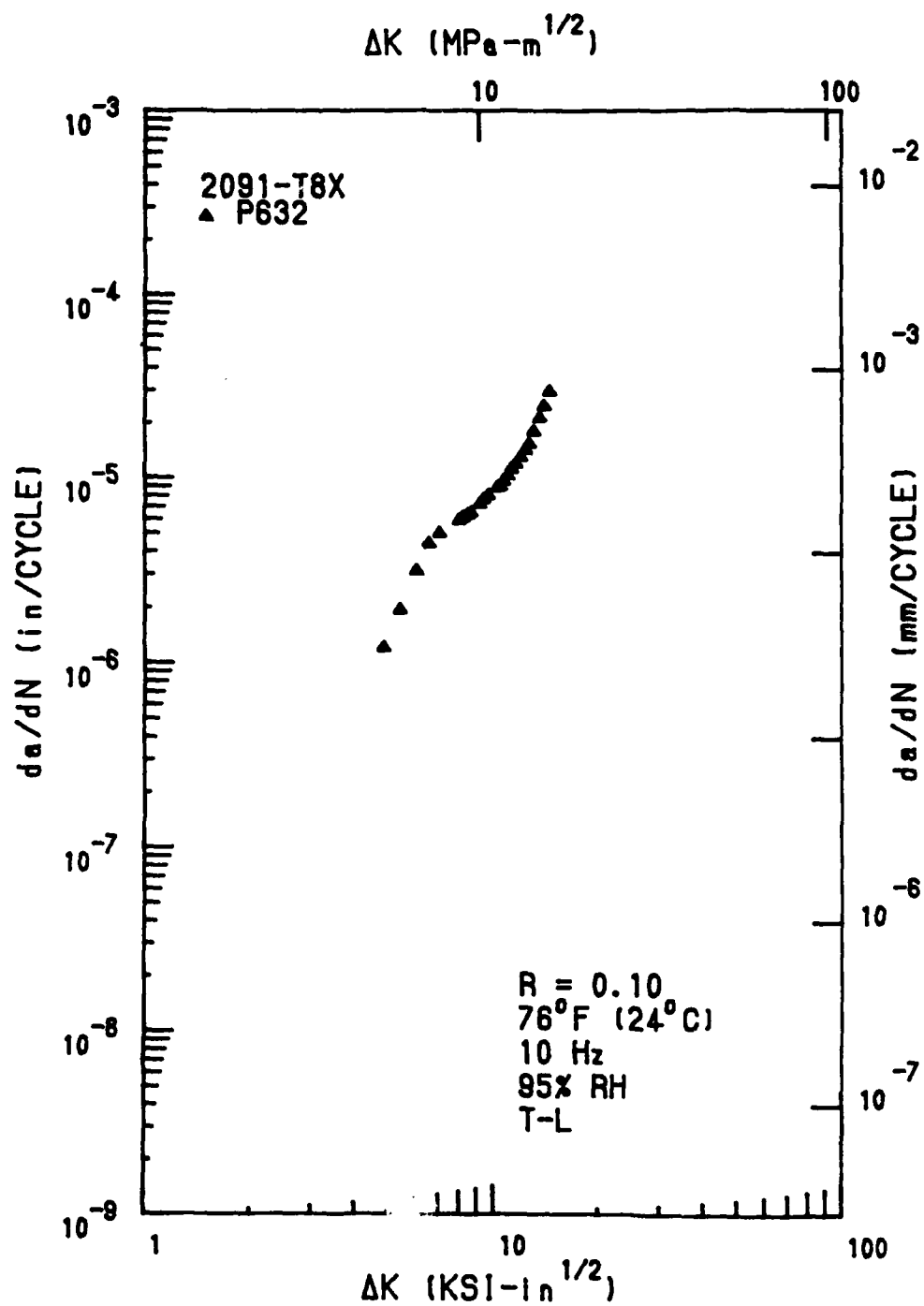


Figure B22 Fatigue Crack Growth Rate Data for Pechiney 2091-T8X
0.063" Sheet (T-L Orientation). Northrop.

TABLE B47

Fatigue Crack Growth Rate Data
Associated with Figure B22

Seven Point Incremental Polynomial Method per ASTM E647

06-12-1989

Specimen Number: P6-32 Specimen Type: CCT

B= 0.0630 in W= 3.0000 in An= 0.0000

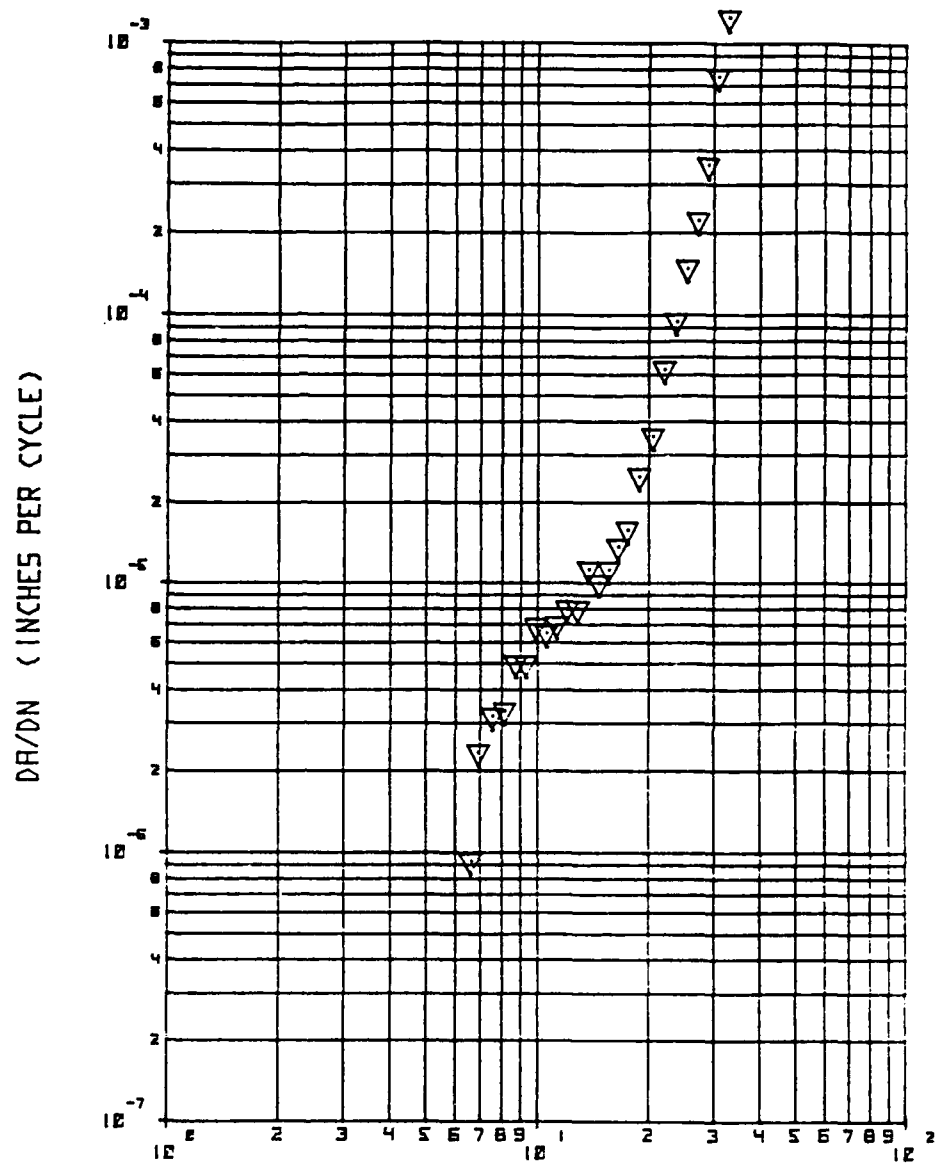
Pmax= 1.200 kips Pmin= 0.120 kips

R= 0.10 Frequency= 10.00 Hz.

Test Temperature= 76 F Environment= 95% RH

PT	CYCLES	Amax*2	Aavg	MCC	Delta K	da/dN
1	0.00	0.2160				
2	100.00	0.2345				
3	250.00	0.2775				
4	540.00	0.4165	0.4456	0.939963	4.85	.1207E-05
5	616.00	0.4820	0.5465	0.947477	5.41	.1925E-05
6	671.00	0.6080	0.6655	0.973384	6.03	.3112E-05
7	710.00	0.7745	0.7685	0.999616	6.55	.4418E-05
8	730.40	0.8625	0.8627	0.999633	7.01	.5001E-05
9	766.40	1.0625	1.0626	0.999830	8.01	.5846E-05
10	773.40	1.1040	1.1029	0.999850	8.22	.6080E-05
11	780.40	1.1470	1.1471	0.999943	8.45	.6276E-05
12	787.40	1.1910	1.1902	0.999876	8.67	.6469E-05
13	800.40	1.2755	1.2764	0.999827	9.13	.7192E-05
14	806.40	1.3200	1.3199	0.999956	9.37	.7586E-05
15	812.40	1.3660	1.3665	0.999932	9.64	.7978E-05
16	824.40	1.4690	1.4682	0.999945	10.24	.8820E-05
17	828.40	1.5050	1.5043	0.999889	10.46	.8944E-05
18	832.40	1.5395	1.5404	0.998644	10.69	.9581E-05
19	837.40	1.5885	1.5868	0.998912	10.99	.1028E-04
20	841.40	1.6235	1.6286	0.999322	11.27	.1114E-04
21	845.40	1.6780	1.6755	0.998970	11.59	.1190E-04
22	849.40	1.7260	1.7249	0.998867	11.95	.1293E-04
23	853.40	1.7805	1.7791	0.998746	12.37	.1416E-04
24	856.40	1.8165	1.8204	0.999263	12.70	.1536E-04
25	859.40	1.8675	1.8663	0.997438	13.08	.1796E-04
26	862.40	1.9195	1.9211	0.998984	13.57	.2124E-04
27	864.40	1.9605	1.9649	0.998780	13.98	.2460E-04
28	866.40	2.0200	2.0133	0.997572	14.46	.2974E-04
29	868.40	2.0715				
30	870.40	2.1445				
31	872.40	2.2475				

* - DATA VIOLATES SIZE REQUIREMENTS



Material: 2091-T81
 Age: 335°F - 32 hrs
 Environment: Lab air, Room temperature
 Orientation: L-T
 Stress Ratio: 0.1
 Frequency: 5 Hz

Figure B23 K-increasing Constant Amplitude Fatigue Crack Growth Rate Data for Pechiney 2091-T8X 0.063" Sheet (L-T Orientation). General Dynamics, TX.

TABLE B48

Fatigue Crack Growth Rate Data Associated with Figure B23

CENTER-CRACKED PANEL

S46

2091

RT

LT ORIENTATION

GENERAL DYNAMICS

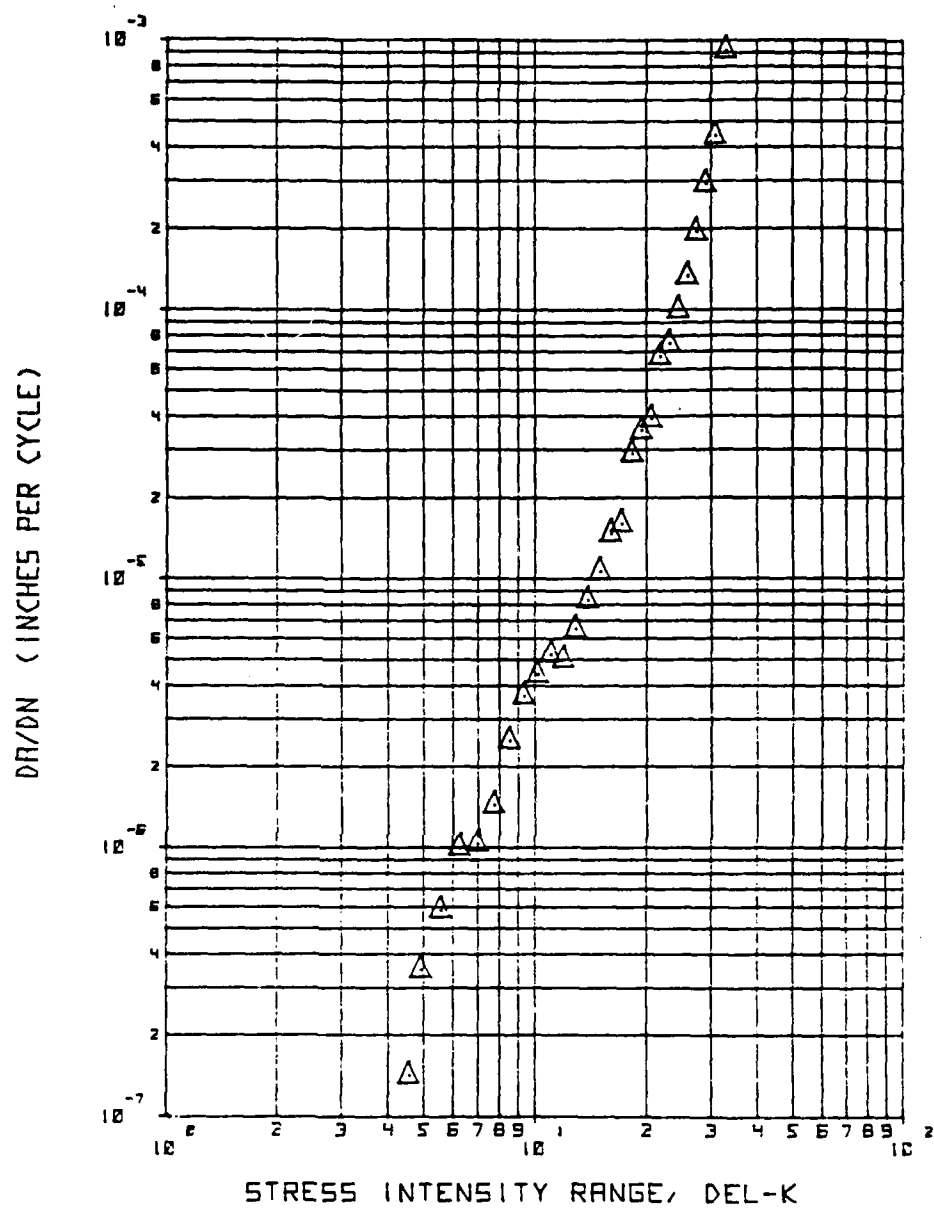
FORT WORTH DIVISION

2/87

300 CPM

R= 0.1 B= 0.0645 W= 5.996

NO. OF PTS.	TOTAL CYCLES	TOTAL AVG. CRACK LENGTH (IN)	TOTAL DELTA CRACK LENGTH (IN)	LSQ FIT DA/DN (IN/CYC)	CORR. COEFF.	AVG. MAX. LOAD (LBS)	AVG. DEL-K (KSI-SQRT)
2	24195	1.7925	0.0450	9.30E-07	1.000	1600	6.61
2	15000	1.8500	0.0700	2.33E-06	1.000	1650	6.96
2	11000	1.9200	0.0700	3.18E-06	1.000	1750	7.56
2	7500	1.9800	0.0500	3.33E-06	1.000	1850	8.16
2	5000	2.0300	0.0500	5.00E-06	1.000	1950	8.75
2	4000	2.0750	0.0400	5.00E-06	1.000	2050	9.33
2	4000	2.1225	0.0550	6.88E-06	1.000	2150	9.95
2	5000	2.1825	0.0650	6.50E-06	1.000	2250	10.61
2	5000	2.2500	0.0700	7.00E-06	1.000	2350	11.33
2	5000	2.3250	0.0800	8.00E-06	1.000	2450	12.10
2	5000	2.4050	0.0800	8.00E-06	1.000	2550	12.91
2	4000	2.4900	0.0900	1.13E-05	1.000	2650	13.78
2	4000	2.5750	0.0800	1.00E-05	1.000	2750	14.68
2	3566	2.6550	0.0800	1.12E-05	1.000	2850	15.58
2	2920	2.7350	0.0800	1.37E-05	1.000	2950	16.52
2	3000	2.8225	0.0950	1.58E-05	1.000	3050	17.53
2	2000	2.9200	0.1000	2.50E-05	1.000	3200	18.94
2	710	2.9950	0.0500	3.52E-05	1.000	3400	20.56
2	478	3.0500	0.0600	6.28E-05	1.000	3600	22.12
2	290	3.1075	0.0550	9.48E-05	1.000	3800	23.75
2	236	3.1700	0.0700	1.48E-04	1.000	4000	25.45
2	124	3.2325	0.0550	2.22E-04	1.000	4200	27.21
2	99	3.2950	0.0700	3.54E-04	1.000	4400	29.02
2	53	3.3700	0.0800	7.55E-04	1.000	4600	30.99
2	20	3.4350	0.0500	1.25E-03	1.000	4800	32.94
2	20	3.5125	0.1050	2.63E-03	1.000	5000	35.07



Material: 2091-T81 Sheet
 Age: 335°F - 32 hrs
 Environment: Lab air, Room temperature
 Orientation: T-L
 Stress Ratio: 0.1
 Frequency: 5 Hz

Figure B24 K-increasing Constant Amplitude Fatigue Crack Growth Rate Data for Pechiney 2091-T8X 0.063" Sheet (T-L). General Dynamics, TX.

TABLE B49

Fatigue Crack Growth Rate Data Associated with Figure B24

CENTER-CRACKED PANEL

S45

2091

RT

TL ORIENTATION

GENERAL DYNAMICS

FORT WORTH DIVISION

3/87

300 CPM

R= 0.1 B= 0.0642 W= 5.995

NO. OF PTS.	TOTAL CYCLES	TOTAL AVG. CRACK LENGTH (IN)	TOTAL DELTA CRACK LENGTH (IN)	LSQ FIT DA/DN (IN/CYC)	CORR. COEFF.	AVG. MAX. LOAD (LBS)	AVG. DEL-K (KSI- $\sqrt{\text{IN}}$)
2	150000	1.5563	0.0425	1.42E-07	1.000	1200	4.56
2	50000	1.5950	0.0350	3.50E-07	1.000	1275	4.92
2	30000	1.6300	0.0350	5.83E-07	1.000	1425	5.58
2	30000	1.6775	0.0600	1.00E-06	1.000	1575	6.27
2	20500	1.7288	0.0425	1.04E-06	1.000	1725	7.00
2	20000	1.7788	0.0575	1.44E-06	1.000	1875	7.75
2	11500	1.8363	0.0575	2.50E-06	1.000	2025	8.54
2	7500	1.8925	0.0550	3.67E-06	1.000	2175	9.36
2	6250	1.9475	0.0550	4.40E-06	1.000	2325	10.19
2	6200	2.0075	0.0650	5.24E-06	1.000	2475	11.07
2	5000	2.0650	0.0500	5.00E-06	1.000	2625	11.97
2	5000	2.1225	0.0650	6.50E-06	1.000	2775	12.90
2	4200	2.1900	0.0700	8.33E-06	1.000	2925	13.90
2	4000	2.2675	0.0850	1.06E-05	1.000	3075	14.98
2	1700	2.3350	0.0500	1.47E-05	1.000	3225	16.05
2	2500	2.4000	0.0800	1.60E-05	1.000	3375	17.15
2	1205	2.4750	0.0700	2.90E-05	1.000	3525	18.33
2	813	2.5388	0.0575	3.54E-05	1.000	3675	19.49
2	800	2.5988	0.0625	3.91E-05	1.000	3825	20.66
2	523	2.6650	0.0700	6.69E-05	1.000	3975	21.91
2	400	2.7300	0.0600	7.50E-05	1.000	4125	23.18
2	350	2.7950	0.0700	1.00E-04	1.000	4275	24.49
2	300	2.8700	0.0800	1.33E-04	1.000	4425	25.92
2	200	2.9488	0.0775	1.94E-04	1.000	4575	27.43
2	175	3.0388	0.1025	2.93E-04	1.000	4725	29.09
2	108	3.1375	0.0950	4.40E-04	1.000	4875	30.88
2	79	3.2575	0.1450	9.18E-04	1.000	5025	32.95

APPENDIX C

PECHINEY

2091-T6 PRECISION FORGING

INTRODUCTION

The Pechiney 2091-T6 precision forgings were received the third quarter of 1986. Five participants tested this material; Boeing Commercial Airplane Company, General Dynamics Fort Worth Division, Lockheed Aeronautical Systems Company, Martin Marietta Manned Space Systems and Northrop Corporation. Forging Dimensions are shown in Figure C1.

TESTING

Basic mechanical properties (tension, compression, bearing, etc.) were tested according to ASTM standards, unless otherwise specified.

Constant amplitude fatigue crack growth tests were conducted according to ASTM E647 Standard. The growth rate $a-N$ data that was generated by the participant, Northrop Corporation, was reduced using a seven-point incremental polynomial method. This involves fitting a second-order polynomial (parabola) to sets of seven successive data points. The data are also checked against size requirements per ASTM E647, Section 7.2.

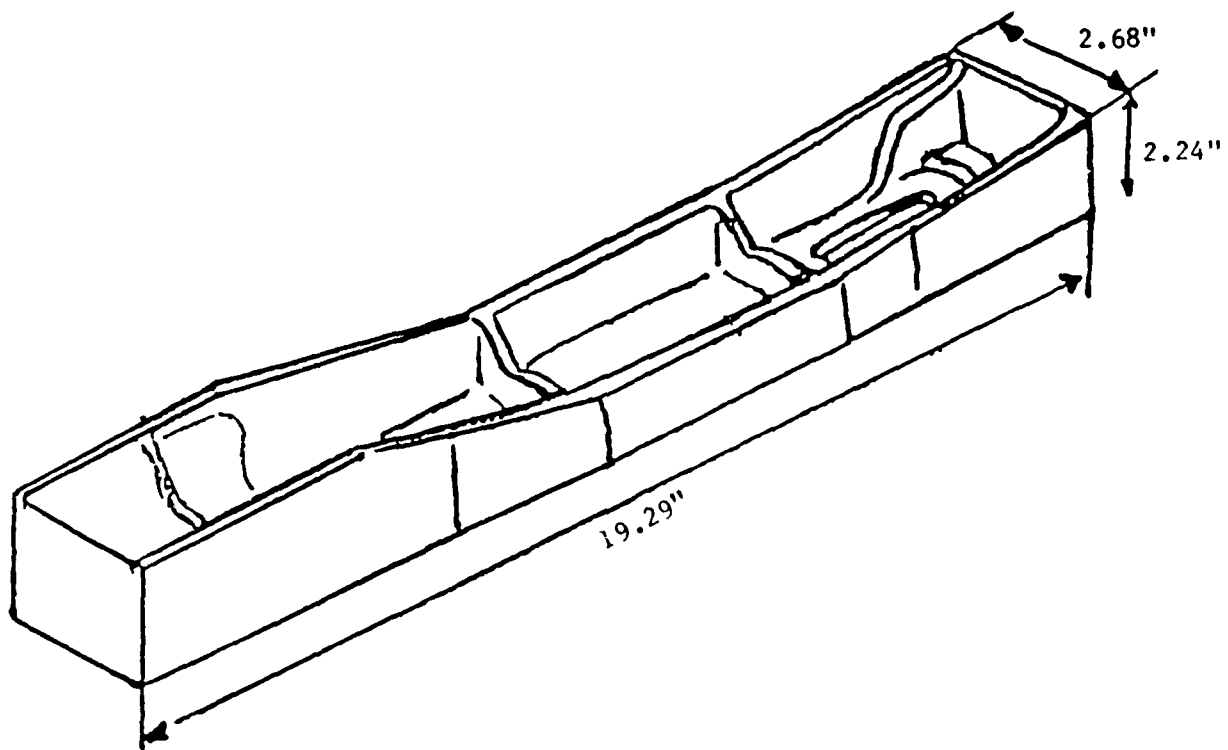


Figure C1 2091-T6 Precision Die Forging Dimensions.

TABLE C1
TENSILE RESULTS AT t/2 LOCATION FOR
PECHINEY 2091-T6 FORGINGS

COMPANY	TEST TEMP (DEGREES F)	ORIENT- ATION	ULTIMATE STRENGTH (KSI)	YIELD STRENGTH (KSI)	ELONG (%)	RA (%)	MODULUS (MSI)	COMMENT

BOEING	RT	LONG	73.6	65.3	4.0			
			77.9	66.5	5.0			
			82.2	72.3	8.0			
NORTHROP	RT	LONG	81.3	69.4	10.0	9.0	11.2	(1), (2)
			82.8	72.1	9.0	7.5	11.4	(2)
			83.1	73.0	8.0	6.4	11.4	(2)
			85.9	76.7	8.0	7.5	11.1	(2)
			80.2	69.8	8.0	7.1	11.5	(2)
			85.0	75.5	8.0	7.4	11.3	(2)
			81.7	72.7	5.0	4.5	11.2	(3)
			81.6	71.8	7.0	5.7	11.3	(3)
			67.1	58.4	3.0	2.0	11.2	(4)
68.0	56.6	4.0	3.3	11.2	(4)			
GENERAL DYNAMICS, TEXAS	RT	LONG	84.4	73.5	6.7			
			84.0	73.0	6.8			
LOCKHEED, GEORGIA	RT	LONG	83.9	72.7	9.0		12.8	
			80.1	68.4	8.0		12.5	
			80.9	68.9	9.0		11.5	
			83.9	72.4	8.0		11.1	
			83.7	72.7	9.0		11.8	
MARTIN MARIETTA, LOUISIANA	RT	LONG	74.6	68.4	2.0	6.0	11.4	
			81.3	68.7	5.0	10.0	11.8	
			77.9	63.2	5.0	10.0	11.8	
AVERAGE			80.2	69.7	6.8	6.6	11.5	
STANDARD DEVIATION			5.0	5.0	2.2	2.4	0.5	

- (1): INDICATES THAT THE SPECIMEN FAILED OUTSIDE THE GAGE MARKS
(2): SPECIMEN REMOVED FROM THE FORGING BASE
(3): SPECIMEN REMOVED FROM THE FORGING SIDE WALL
(4): SPECIMEN REMOVED FROM THE FORGING END WALL

TABLE C2
TENSILE RESULTS AT t/2 LOCATION FOR
PECHINEY 2091-T6 FORGINGS

COMPANY	TEST TEMP (DEGREES F)	ORIENT- ATION	ULTIMATE STRENGTH (KSI)	YIELD STRENGTH (KSI)	ELONG (%)	RA (%)	MODULUS (MSI)	COMMENT
NORTHROP	RT	L TRANS	66.4				11.2	(1), (2)
			78.6	70.9	5.0		11.4	(2)
			63.8				11.3	(1), (2)
			75.0	68.3	3.0		11.2	(1), (2)
			60.6		1.0		11.2	(1), (2)
			71.5	66.0	2.0		10.8	(1), (2)
			69.2	63.2	2.0		11.3	(4)
			66.1	58.7	2.0		11.1	(4)
		AVERAGE	68.9	65.4	2.5		11.2	
		STANDARD DEVIATION	5.9	4.7	1.4		0.2	

- (1): INDICATES THAT THE SPECIMEN FAILED OUTSIDE THE GAGE MARKS
 (2): SPECIMEN REMOVED FROM THE FORGING BASE
 (3): SPECIMEN REMOVED FROM THE FORGING SIDE WALL
 (4): SPECIMEN REMOVED FROM THE FORGING END WALL

TABLE C3
TENSILE RESULTS AT t/2 LOCATION FOR
PECHINEY 2091-T6 FORGINGS

COMPANY	TEST TEMP (DEGREES F)	ORIENT- ATION	ULTIMATE STRENGTH (KSI)	YIELD STRENGTH (KSI)	ELONG (%)	RA (%)	MODULUS (MSI)	COMMENT

LOCKHEED.	RT	S TRANS	68.7		6.0			
GEORGIA			72.2		6.0			
			66.6		6.0			
			70.9		6.0			
			72.1		6.0			
		AVERAGE	70.1		6.0			
		STANDARD DEVIATION	2.4		0.0			

TABLE C4
COMPRESSION RESULTS AT t/2 LOCATION FOR
PECHINEY 2091-T6 FORGINGS

COMPANY	TEST TEMPERATURE (DEGREES F)	ORIENTATION	COMPRESSIVE YIELD STRENGTH (KSI)	COMPRESSIVE MODULUS (MSI)

BOEING	RT	LONG	68.6	
			72.4	
			70.4	
NORTHROP	RT	LONG	67.3	11.7
			73.8	11.6
			75.4	11.8
LOCKHEED, GEORGIA	RT	LONG	67.0	
			62.0	
			64.7	
			62.7	
			65.6	
GENERAL DYNAMICS, TEXAS	RT	LONG	57.7	
MARTIN MARIETTA, LOUISIANA	RT	LONG	73.4	12.2
			64.3	12.1
AVERAGE			67.5	11.9
STANDARD DEVIATION			5.1	0.3

NOTE: NORTHROP SPECIMENS TAKEN FROM FORGING SIDE WALL.

TABLE C5

COMPRESSION RESULTS AT t/2 LOCATION FOR
PECHINEY 2091-T6 FORGINGS

COMPANY	TEST TEMPERATURE (DEGREES F)	ORIENTATION	COMPRESSIVE YIELD STRENGTH (KSI)	COMPRESSIVE MODULUS (MSI)
MARTIN	RT	L TRANS	61.7	12.0
MARIETTA.			60.2	12.0
LOUISIANA				
AVERAGE			61.0	12.0
STANDARD DEVIATION			1.1	0.0

TABLE C6

AMSLER DOUBLE SHEAR RESULTS FOR
PECHINEY 2091-T6 FORGINGS

COMPANY	ORIENTATION	SHEAR STRENGTH (KSI)

NORTHROP	L-S	38.6
		39.5
		38.9
LOCKHEED . GEORGIA	L-S	38.7
		40.4
		39.8
AVERAGE		39.3
STANDARD DEVIATION		0.7

NOTE: NORTHROP SPECIMENS TAKEN FROM FORGING SIDE WALL.

TABLE C7
 AMSLER DOUBLE SHEAR RESULTS FOR
 PECHINEY 2091-T6 FORGINGS

COMPANY	ORIENTATION	SHEAR STRENGTH (KSI)
NORTHROP	T-S	38.0
		37.1
		35.8
LOCKHEED, GEORGIA	T-S	39.0
		42.4
		38.3
	AVERAGE	38.4
	STANDARD DEVIATION	2.2

NOTE: NORTHROP SPECIMENS TAKEN FROM FORGING SIDE WALL.

TABLE C8
SLOTTED SHEAR RESULTS FOR PECHINEY
2091-T6 FORGINGS

COMPANY	ORIENTATION	SHEAR STRENGTH (KSI)
BOEING	LONG	43.3
		44.9
		43.1
	AVERAGE	43.8
	STANDARD DEVIATION	1.0

TABLE C9
BEARING RESULTS FOR PECHINEY
2091-T6 FORGINGS

COMPANY	ORIENTATION	e/D	BEARING		BEARING	
			ULT.	STR.	YIELD	STR.

BOEING	LONG	1.5		73.9		65.6
				82.7		65.9
				85.5		72.3
NORTHROP	LONG	1.5		103.8		87.7
				95.0		81.8
				99.8		82.2
LOCKHEED. GEORGIA	LONG	1.5		95.3		84.7
				99.0		85.7
				102.2		86.3
AVERAGE				93.0		79.1
STANDARD DEVIATION				10.1		8.8

NOTE: NORTHROP SPECIMENS REMOVED FROM FORGING SIDE WALL.

TABLE C10
BEARING RESULTS FOR PECHINEY
2091-T6 FORGINGS

COMPANY	ORIENTATION	e/D	BEARING	
			ULT. STR. (KSI)	BEARING YIELD STR. (KSI)
BOEING	LONG	2.0	142.3	105.3
			144.9	112.9
			142.0	105.7
NORTHROP	LONG	2.0	134.8	104.3
			139.6	105.1
			136.4	105.0
GENERAL DYNAMICS, TEXAS	LONG	2.0	129.0	116.0
LOCKHEED, GEORGIA	LONG	2.0	129.2	108.8
			128.1	105.1
			132.8	109.2
AVERAGE			135.9	107.7
STANDARD DEVIATION			6.1	4.0

NOTE: NORTHROP SPECIMENS REMOVED FROM FORGING SIDE WALL.

TABLE C11

BEARING RESULTS FOR PECHINEY

2091-T6 FORGINGS

COMPANY	ORIENTATION	e/D	BEARING		BEARING	
			ULT.	STR. (KSI)	YIELD	STR. (KSI)
GENERAL DYNAMICS, TEXAS	L TRANS	2.0		128.0		87.2
AVERAGE				128.0		87.2
STANDARD DEVIATION						

TABLE C12

FRACTURE TOUGHNESS RESULTS FOR
PECHINEY 2091-T6 FORGINGS

COMPANY	ORIENTATION	KIC	Kq	COMMENT
		(KSI IN ^{-0.5})	(KSI IN ^{-0.5})	
NORTHROP	L-T		29.1	(1), (3), (4)
			22.2	(2), (3), (4)
MARTIN MARIETTA, LOUISIANA	L-T		25.8	(4), (5)
			27.6	(4), (5)
AVERAGE			26.2	
STANDARD DEVIATION			3.0	

(1): W=1.0

(2): W=0.8

(3): SPECIMEN REMOVED FROM FORGING BASE

(4): INVALID

(5): VIOLATES SPECIMEN THICKNESS REQUIREMENTS

TABLE C13
FRACTURE TOUGHNESS RESULTS FOR
PECHINEY 2091-T6 FORGINGS

COMPANY	ORIENTATION	K _{IC} (KSI IN ^{-0.5})	K _q (KSI IN ^{-0.5})	COMMENT

NORTHROP	T-L		24.1	(1), (3), (4)
			27.4	(2), (3), (4)
GENERAL DYNAMICS, TEXAS	T-L		25.9	(5)
			20.4	(5)
MARTIN MARIETTA, LOUISIANA	T-L		22.0	(4), (7)
			25.3	(4), (7)
	AVERAGE		24.2	
	STANDARD DEVIATION		2.6	

- (1): W=1.0
- (2): W=0.8
- (3): SPECIMEN REMOVED FROM FORGING BASE
- (4): INVALID
- (5): INVALID DUE TO - INSUFFICIENT THICKNESS, $P_{max}/P_q > 1.10$,
AND MINIMUM SURFACE CRACK LENGTH $< 90\%$
- (6): INVALID DUE TO - $P_{max}/P_q > 1.10$, MINIMUM SURFACE CRACK LENGTH
 $< 90\%$, AND CRACK CURVATURE $> 5\%$
- (7): VIOLATES SPECIMEN THICKNESS REQUIREMENTS

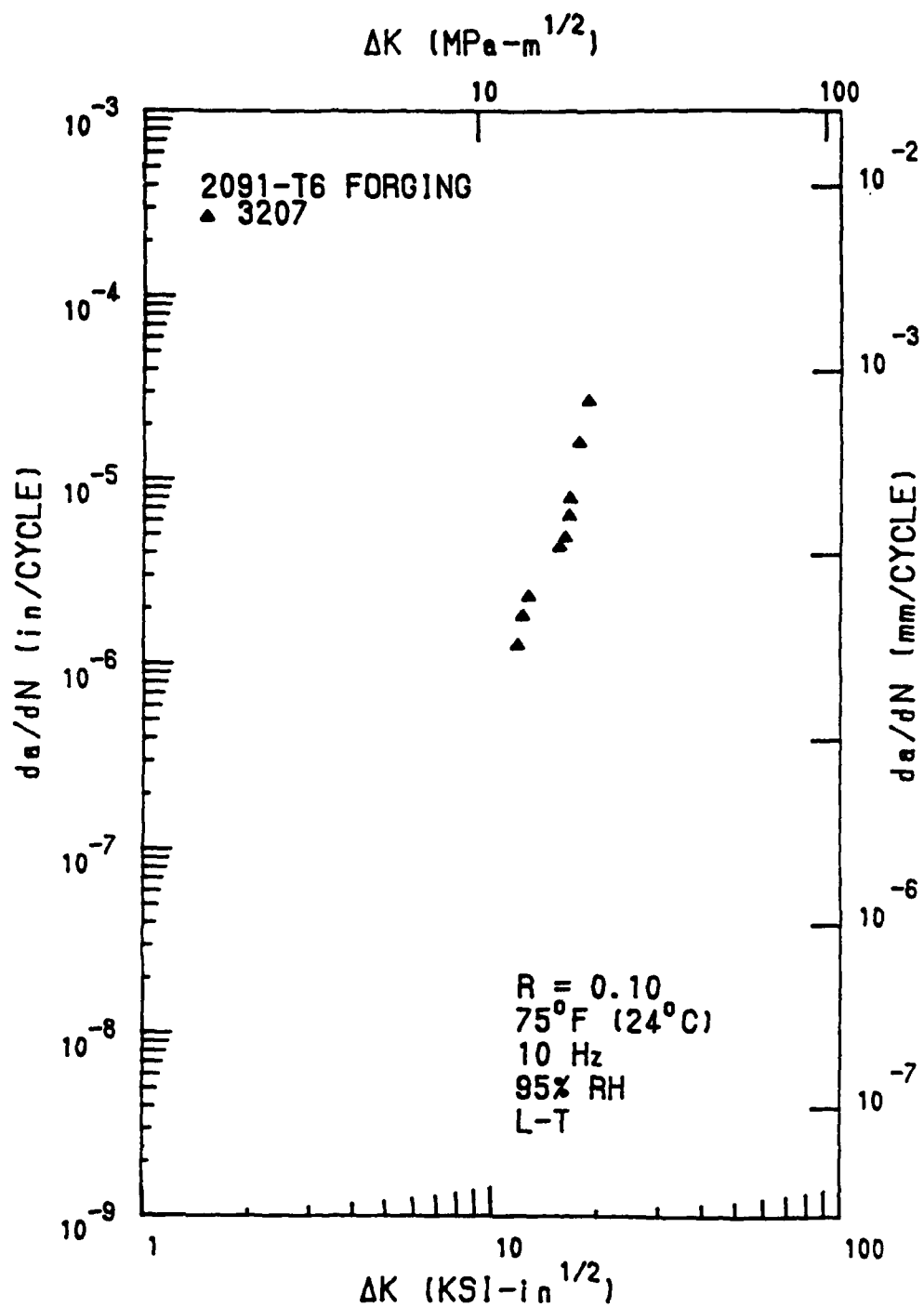


Figure C2 Fatigue Crack Growth Rate Data for Pechiney 2091-T6 Forging (L-T Orientation). Northrop.

TABLE C14

Fatigue Crack Growth Rate Data
Associated with Figure C2

Seven Point Incremental Polynomial Method per ASTM E647

09-27-1989

Specimen Number: 3207 Specimen Type: CT

B= 0.2520 in W= 2.0250 in An= 0.0000

Pmax= 850.0 lbs Pmin= 85.0 lbs

R= 0.10 Frequency= 10.00 hz.

Test Temperature= 75 F Environment= 95% RH

PT	CYCLES	Ameas	Areq	MCC	Delta K	da/dN
1	0.00	0.4615				
2	100.00	0.4795				
3	194.00	0.5125				
4	326.10	0.5810	0.5983	0.916447	11.85	.1260E-05
5	352.00	0.5995	0.6225	0.959535	12.22	.1805E-05
6	373.70	0.6300	0.6504	0.992076	12.66	.2306E-05
7	432.00	0.8128	0.8124	0.999865	15.58	.4251E-05
8	437.00	0.8328	0.8348	0.999543	16.04	.4761E-05
9	441.00	0.8510	0.8569	0.991889	16.52	.6302E-05
10	443.50	0.8660	0.8613	0.978287	16.62	.7829E-05
11	449.00	0.8995	0.9058	0.964758	17.66	.1582E-04
12	452.00	0.9460	0.9490	0.974070	18.76	.2670E-04
13	455.00	1.0120				
14	457.00	1.1170				
15	458.00	1.2000				

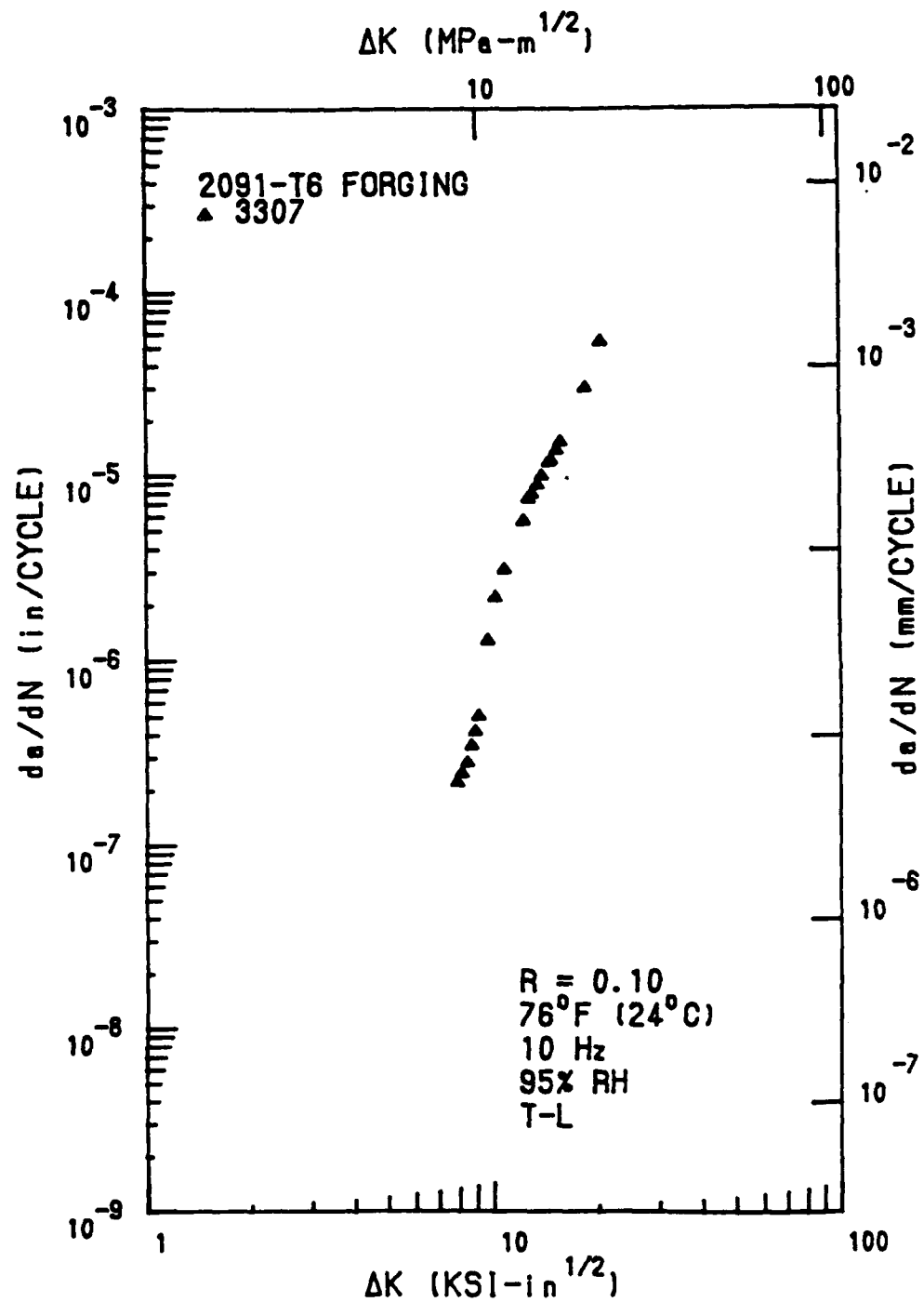


Figure C3 Fatigue Crack Growth Rate Data for Pechiney 2091-T6 Forging (T-L Orientation). Northrop.

TABLE C15

Fatigue Crack Growth Rate Data
Associated with Figure C5

Seven Point Incremental Polynomial Method per ASTM E647

09-27-1989

Specimen Number: 3307 Specimen Type: CT

B= 0.2500 in W= 2.0020 in An= 0.0000

Pmax= 560.0 lbs Pmin= 56.0 lbs

R= 0.10 Frequency= 10.00 Hz.

Test Temperature= 76 F Environment= 95% RH

PT	CYCLES	Amax	Aavg	MCC	Delta K	da/dN
1	0.00	0.4985				
2	168.00	0.5055				
3	368.00	0.5200				
4	814.00	0.5975	0.5950	0.999616	7.95	.2181E-06
5	914.00	0.6175	0.6183	0.999504	8.19	.2455E-06
6	1014.00	0.6430	0.6448	0.998416	8.48	.2798E-06
7	1100.00	0.6670	0.6681	0.999107	8.73	.3465E-06
8	1150.00	0.6845	0.6854	0.995776	8.93	.4145E-06
9	1192.00	0.7025	0.7012	0.988609	9.11	.5023E-06
10	1280.00	0.7435	0.7522	0.907554	9.73	.1273E-05
11	1310.00	0.7715	0.7884	0.942234	10.20	.2186E-05
12	1330.00	0.8000	0.8333	0.966970	10.83	.3099E-05
13	1355.00	0.9150	0.9226	0.993375	12.25	.5622E-05
14	1359.00	0.9445	0.9455	0.999493	12.67	.7386E-05
15	1361.20	0.9610	0.9613	0.999589	12.96	.7894E-05
16	1364.00	0.9840	0.9846	0.994968	13.42	.8860E-05
17	1366.20	1.0060	1.0036	0.993728	13.82	.9919E-05
18	1369.20	1.0280	1.0352	0.994112	14.52	.1174E-04
19	1370.00	1.0475	1.0448	0.996747	14.74	.1194E-04
20	1371.70	1.0680	1.0640	0.988877	15.21	.1364E-04
21	1375.20	1.0875	1.0818	0.984883	15.67	.1515E-04
22	1378.00	1.1590	1.1748	0.983163	18.49	.3012E-04
23	1379.50	1.2160	1.2273	0.973899	20.50	.5377E-04
24	1380.00	1.2425				
25	1380.50	1.2770				
26	1381.00	1.3425				

* - DATA VIOLATES SIZE REQUIREMENTS

APPENDIX D

PECHINEY

8090-T651 T-EXTRUSION

INTRODUCTION

The Pechiney 8090-T651 T-Extrusion was received the fourth quarter of 1986. Dimensions of the T-Extrusion are 0.19" x 2.5" x 3.0" x 79". Four participants tested this material; Boeing Commercial Airplane Company WA, General Dynamics Fort Worth Division, LTV Aircraft Products Group TX, and the Navy (Naval Air Development Center).

TESTING

Basic mechanical properties (tension, compression, bearing, etc.) were tested according to ASTM standards, unless otherwise specified.

TABLE D1
TENSILE RESULTS FOR PECHINEY

8090-T651 T-EXTRUSION (0.19' X 2.5' X 3' X 79')

COMPANY	TEST TEMPERATURE (DEGREES F)	ORIENT- ATION	ULTIMATE STRENGTH (KSI)	YIELD STRENGTH (KSI)	ELONG (%)	RA (%)	E (MSI)

BOEING	RT	LONG	77.4	66.9	8.0		
			77.5	67.0	8.0		
			77.4	67.0	8.0		
GENERAL DYNAMICS. TEXAS	RT	LONG	81.0	71.5	5.9		
			77.1	68.3	2.9		
			80.3	70.5	5.7		
			80.7	70.9	4.9		
NADC	RT	LONG	76.0	66.9	3.0		10.4
			81.2	72.4	3.0		11.5
			80.7	71.3	3.0		10.0
			82.2	72.4	3.0		9.5
LTV	RT	LONG	78.5	68.9	6.1		11.6
			77.4	68.5	7.2		11.6
			78.5	69.2	6.9		10.6
AVERAGE			79.0	69.4	5.4		10.9
STANDARD DEVIATION			2.0	2.1	2.1		0.9

TABLE D2
TENSILE RESULTS FOR PECHINEY

8090-T651 T-EXTRUSION (0.19' X 2.5' X 3' X 79')

COMPANY	TEST TEMPERATURE (DEGREES F)	ORIENT- ATION	ULTIMATE STRENGTH (KSI)	YIELD STRENGTH (KSI)	ELONG (%)	RA (%)	E (MSI)
GENERAL DYNAMICS, TEXAS	RT	L TRANS	78.4	69.5	4.4		
			78.2	69.6	4.5		
		AVERAGE	78.3	69.6	4.5		
		STANDARD DEVIATION	0.1	0.1	0.1		

TABLE D3
COMPRESSION RESULTS FOR PECHINEY

8090-T651 T-EXTRUSION (0.19' X 2.5' X 3' X 79')

COMPANY	TEST TEMPERATURE (DEGREES F)	ORIENTATION	COMPRESSIVE YIELD STRENGTH (KSI)	COMPRESSIVE MODULUS (MSI)

BOEING	RT	LONG	68.0 67.1 67.7	
		AVERAGE	67.6	
		STANDARD DEVIATION	0.5	

TABLE D4
SLOTTED SHEAR RESULTS FOR PECHINEY
8090-T651 T-EXTRUSION (0.19' X 2.5' X 3' X 79')

COMPANY	ORIENTATION	SHEAR STRENGTH (KSI)
BOEING	LONG	42.5
		42.5
		42.5
	AVERAGE	42.5
	STANDARD DEVIATION	0.0

TABLE D5
SLOTTED SHEAR RESULTS FOR PECHINEY
8090-T651 T-EXTRUSION (0.19' X 2.5' X 3' X 79')

COMPANY	ORIENTATION	SHEAR STRENGTH (KSI)
GENERAL DYNAMICS, TEXAS	L TRANS	41.7
		41.2
	AVERAGE	41.5
	STANDARD DEVIATION	0.4

TABLE D6
IOSIPESCU SHEAR RESULTS FOR PECHINEY
8090-T651 T-EXTRUSION (0.19" X 2.5" X 3" X 79")

COMPANY	ORIENTATION	SHEAR STRENGTH (KSI)
LTV	LONG	41.4
		40.6
		42.5
	AVERAGE	41.5
	STANDARD DEVIATION	1.0

TABLE D7
IOSIPESCU SHEAR RESULTS FOR PECHINEY
8090-T651 T-EXTRUSION (0.19" X 2.5" X 3" X 79")

COMPANY	ORIENTATION	SHEAR STRENGTH (KSI)
LTV	L TRANS	39.5
		40.4
		39.3
	AVERAGE	39.7
	STANDARD DEVIATION	0.6

**TABLE D8
BEARING RESULTS FOR PECHINEY**

8090-T651 T-EXTRUSION (0.19" X 2.5" X 3" X 79")

COMPANY	ORIENTATION	e/D	BEARING	
			ULT. STR. (KSI)	YIELD STR. (KSI)

BOEING	LONG	1.5	103.4	90.2
			106.5	94.6 *
			107.6	95.5 *
GENERAL DYNAMICS, TEXAS	LONG	1.5	106.0	94.3
			104.0	91.2
LTV	LONG	1.5	105.5	97.4
			107.0	96.2
			106.2	93.3
AVERAGE			105.8	94.1
STANDARD DEVIATION			1.4	2.4

(*): INDICATES SHEAR TEAR OUT FAILURE

TABLE D9
BEARING RESULTS FOR PECHINEY

8090-T651 T-EXTRUSION (0.19" X 2.5" X 3" X 79")

COMPANY	ORIENTATION	e/D	BEARING		BEARING	
			ULT.	STR. (KSI)	YIELD	STR. (KSI)

BOEING	LONG	2.0		131.8		105.1 *
				138.6		113.1 *
				135.2		111.4 *
GENERAL DYNAMICS. TEXAS	LONG	2.0		116.0		106.0
				135.0		107.0
LTV	LONG	2.0		135.6		116.4
				136.0		
				133.6		111.2
AVERAGE				132.7		110.0
STANDARD DEVIATION				7.0		4.1

(*): INDICATES SHEAR-TENSION FAILURE

TABLE D10
 FATIGUE RESULTS WITH R=0.1 AND Kt=2.8 FOR
 PECHINEY 8090-T651 T-EXTRUSION (0.19' X 2.5' X 3' X 79')

COMPANY	ORIENTATION	STRESS (KSI)	CYCLES
LTV	LONG	22.0	54,800
		22.0	58,700
		21.2	83,700
		19.6	213,900
		19.5	73,800
		19.5	176,700
		17.3	219,100
		16.5	212,300
		16.0	300,200
		15.0	341,600
		14.9	1,000,000 *

(*): INDICATES A RUN-OUT TEST

* LTV, Kt=2.8

Cycles	Stress (KSI)
1.0E+03	~22
1.0E+04	~20
1.0E+05	~18
1.0E+06	~16
1.0E+07	~14
1.0E+08	~12

Figure D1 Fatigue Results for 8090-T651 T-Extrusion (R=0.1, Kt=2.8). LTV.