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**THE MECHANICAL PROPERTY DATA BASE FROM AN  
AIR FORCE/INDUSTRY COOPERATIVE TEST PROGRAM ON ADVANCED  
ALUMINUM ALLOYS (WELDALITE™ 049 RX815 PLATE (2095-T8))**

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May 1993

Interim Report for Period February 1991 - December 1992

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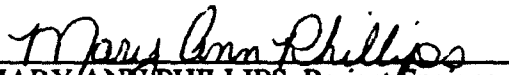
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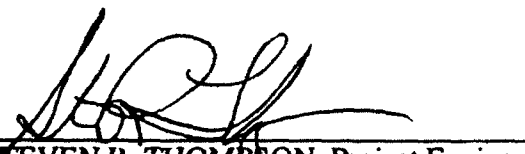

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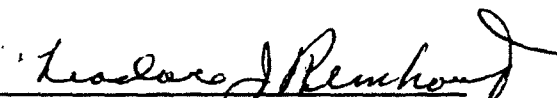
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## PREFACE

This report was prepared by the Materials Engineering Branch (WL/MLSE), Systems Support Division, Materials Directorate, Wright Laboratory, 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 these 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 Wright Laboratory Materials Directorate, 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 the aluminum-lithium alloy Weldalite<sup>tm</sup> 049 RX815 0.5-inch-thick plate produced by Reynolds Metals Company. The Weldalite<sup>tm</sup> 049 RX815 alloy has been registered as 2095 with the Aluminum Association. Comparisons to other materials, and ranking of materials are 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	REYNOLDS	KAISER	ALCOA												
	2091-13 Sheet (0.063")	2091-1351 Plate (0.420")	2091-16 Forging	8090-1651 T Extrusion	8090-1651 Extrusion	8090-18771 Plate (1.75")	PM IN905XL Forging	PM AL905XL Forging	2091-13 Sheet (0.063")	2091-13 Sheet (0.144")	2091-18 Plate (0.50")	8090 Extrusion	Weketalite 049 RX615 Plate (0.5")	7064-174511 Extrusion	7064-174 Forging	CW67 Sheet (0.063")	CW67 Plate (0.40")	CW67 Extrusion	CW67 Forging
Air Force WPAFB, OH	x				x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Army, MA										x									
AVCO, TN								x											
Boeing, WA	x	x	x	x															
Douglas Aircraft, CA								x	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
Jet Propulsion, CA								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	
Martin Marietta, LA	x	x	x	x	x	x	x	x	x	x	x	x		x	x	x	x	x	x
McDonnell Douglas Astro, CA																			
McDonnell Douglas Helicopter, AR								x											
McDonnell Douglas Missile Sys, MO																			
McDonnell Aircraft, MO	x						x	x	x							x	x		x
NASA, VA					x		x	x					x						
Naval Air Development Center	x		x					x											x
Northrop, CA	x	x		x	x	x	x	x	x	x	x	x							
Sikorsky, CT							x								x		x		x
Sundstrand, IL																			
Wyman-Gordon								x											

## SECTION II

### MATERIALS AND TESTS

The Weldalite™ Q10 RX815 (2095) 0.5-inch-thick plate was received the first quarter of 1991. The 2095 was received in the T8 condition. This alloy is considered to be a damage tolerant, medium strength aluminum-lithium alloy. A chemical analysis was performed on the 2095 and the alloy chemistry is shown below.

<u>Element</u>	<u>Weight %</u>	<u>Element</u>	<u>Weight %</u>
Copper	4.17	Iron	0.057
Lithium	1.30	Nickel	0.0030
Magnesium	0.339	Titanium	0.028
Silicon	0.038	Zirconium	0.126
Silver	0.334	Aluminum	Balance

Basic mechanical properties (tension, compression, bearing, etc) were tested according to ASTM standards, unless otherwise specified. General Dynamics generated hardness and conductivity data. Constant amplitude fatigue crack growth tests were conducted according to ASTM E647 standard. Northrop Corporation performed constant amplitude fatigue crack growth test using K controlled methods. A T-38 LIF (lead-in-fighter) spectrum test was performed by Northrop Corporation. The spectrum specimen was not precracked but contained a countersunk hole to simulate a crack initiating from a fastener hole. The Army evaluated the ballistic performance of the material. The Army and Northrop Corporation have corrosion tests in process.

## SECTION III

### PRESENTATION

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, spectrum fatigue crack growth, hardness, and conductivity data were placed in tabular and graphical form. Ballistic performance data were put in text and graphical form.

## SECTION IV

### RESULTS AND DISCUSSION

The data generated by the participants on the 2095-T8 0.5 inch thick plate are shown in Tables I1 thru I36 and Figures I1 thru I15.

TABLE 11

TENSILE RESULTS AT t/2 LOCATION FOR REYNOLDS  
2095-T8 PLATE (0.5" X 24" X 48")

COMPANY	TEST TEMP (DEGREES F)	ORIENT- ATION	ULTIMATE STRENGTH (KSI)	YIELD STRENGTH (KSI)	ELONG (%)	RA (%)	E (MSI)
MCDONNELL DOUGLAS, MO	RT	LONG	89.7	85.7	12.0	23.7	10.9
			88.4	84.3	12.0	19.7	10.8
			86.8	81.1	12.0	26.4	11.4
SUNDSTRAND	RT	LONG	89.4	83.4	13.1	19.2	
			89.4	81.2	12.8	20.1	
			89.9	83.7	13.0	19.3	
ARMY-MTL	RT	LONG	88.6	81.9	12.9		10.8
			88.2	81.3	11.7		10.9
			87.7	80.4	12.9		10.4
GENERAL DYNAMICS	RT	LONG	88.1	82.5	10.7	17.1	11.0
			89.2	84.9	11.0	21.3	11.0
			89.1	84.6	10.0	17.6	11.2
NASA-LANGLEY	RT	LONG	88.0	81.2	12.3		11.2
			84.9	75.6	9.6		11.3
			85.0	77.2	9.6		11.3
NORTHROP	RT	LONG	89.7	83.6	13.9		11.5
			88.1	80.6	13.0		11.1
			89.0	81.8	13.6		11.0
AIR FORCE(*)	RT	LONG	89.4	83.1	7.4	27.0	
MCDONNELL DOUGLAS, CA	RT	LONG	84.0	77.9	12.0		
			82.5	76.0	13.0		
			82.7	77.1	10.0		
AVERAGE			87.6	81.3	11.7	21.1	11.1
STANDARD DEVIATION			2.2	2.9	1.6	3.5	0.3

(\*): TEST SECTION DIAMETER = 0.16"

TABLE 12

TENSILE RESULTS AT t/2 LOCATION FOR REYNOLDS  
2095-T8 PLATE (0.5" X 24" X 48")

COMPANY	TEST TEMP (DEGREES F)	ORIENT- ATION	ULTIMATE STRENGTH (KSI)	YIELD STRENGTH (KSI)	ELONG (%)	RA (%)	E (MSI)
MCDONNELL DOUGLAS, MO	RT	L TRANS	87.0	80.8	11.0	23.8	11.1
			87.0	81.1	11.0	26.8	10.8
			86.8	80.8	11.0	28.4	10.9
SUNDSTRAND	RT	L TRANS	86.3	79.0	12.0	25.1	
			85.8	78.3	12.7	25.7	
			86.2	79.2	13.4	27.3	
ARMY-MTL	RT	L TRANS	84.7	75.4	14.1		10.8
			85.6	76.8	13.6		10.2
			84.9	75.7	15.0		10.7
GENERAL DYNAMICS	RT	L TRANS	84.0	75.6	11.4	21.9	11.0
			86.1	79.1	11.0	22.1	10.7
			83.8	75.4	11.0	29.7	10.8
NASA-LANGLEY	RT	L TRANS	84.8	76.4		13.1	11.3
			87.2	80.1		9.1	11.1
			87.3	80.3		14.5	11.2
NORTHROP	RT	L TRANS	85.7	75.9	14.7		11.6
			87.0	78.5	14.6		11.6
			85.2	75.3	15.5		11.1
AIR FORCE(*)	RT	L TRANS	88.9	82.4	8.8	31.0	
MCDONNELL DOUGLAS, CA	RT	L TRANS	81.2	71.7	14.5		
			80.5	71.0	14.5		
			81.8	73.0	14.0		
AVERAGE			85.4	77.4	12.8	23.0	11.0
STANDARD DEVIATION			2.1	3.1	1.9	6.8	0.4

(\*): TEST SECTION DIAMETER = 0.16"

TABLE I3

TENSILE RESULTS AT t/2 LOCATION FOR REYNOLDS  
2095-T8 PLATE (0.5" X 24" X 48")

COMPANY	TEST TEMP (DEGREES F)	ORIENT- ATION	ULTIMATE STRENGTH (KSI)	YIELD STRENGTH (KSI)	ELONG (%)	RA (%)	E (MSI)
MCDONNELL	RT	45	77.0	70.6	14.0	36.6	11.4
DOUGLAS			77.2	70.1	16.0	39.1	10.9
			76.3	69.2	17.0	39.3	10.8
AIR FORCE(*)	RT	45	75.5	69.0	8.9	41.7	9.9
		AVERAGE	76.5	69.7	14.0	39.2	10.8
		STANDARD DEVIATION	0.8	0.8	3.6	2.1	0.6

(\*): TEST SECTION DIAMETER = 0.16"

TABLE I4

TENSILE RESULTS AT t/2 LOCATION FOR REYNOLDS  
2095-T8 PLATE (0.5" X 24" X 48")

COMPANY	TEST TEMP (DEGREES F)	ORIENT- ATION	ULTIMATE STRENGTH (KSI)	YIELD STRENGTH (KSI)	ELONG (%)	RA (%)	E (MSI)
AIR FORCE	-321(*)	LONG	108.0	97.5		22.0	12.0
		L TRANS	104.0	93.8	9.6	26.0	11.7
	-150	45	95.4	89.9	12.6	25.0	11.0
	-100(*)	LONG	92.3	86.2	8.8	27.0	11.0
		45	78.7	71.5	11.4	21.6	11.5
		L TRANS	91.9	85.0	8.0	26.0	
	-40	45	90.2	83.1	12.3	25.3	10.1
	0	45	89.2	82.2	11.1	22.6	10.0
	150	45	87.5	82.9	11.4	29.2	11.4
			88.7	84.8	11.9	27.7	11.4
	200	45	78.9	78.1	16.4	47.3	10.7
			79.7	78.6	17.2	47.8	11.5

(\*): TEST SECTION DIAMETER = 0.16"

TABLE 15

TENSILE RESULTS AT t/2 LOCATION FOR REYNOLDS  
 2095-T8 PLATE (0.5" X 24" X 48")  
 (1000 HR EXPOSURE @ 350F)

COMPANY	TEST TEMP (DEGREES F)	ORIENT- ATION	ULTIMATE STRENGTH (KSI)	YIELD STRENGTH (KSI)	ELONG (%)	RA (%)	E (MSI)
AIR FORCE	RT	45	70.4	58.3	8.1	22.9	11.2
			70.1	58.0	8.2	23.8	11.3
		AVERAGE	70.3	58.1	8.2	23.3	11.2
		STANDARD DEVIATION	0.2	0.2	0.1	0.6	0.1

TABLE I6

COMPRESSION RESULTS AT t/2 LOCATION FOR REYNOLDS  
2095-T8 PLATE (0.5" X 24" X 48")

COMPANY	TEST TEMPERATURE (DEGREES F)	ORIENTATION	COMPRESSIVE YIELD STRENGTH (KSI)	COMPRESSIVE MODULUS (MSI)
MCDONNELL DOUGLAS, MO	RT	LONG	73.8 75.3 76.1	11.1 10.9 11.1
SUNDSTRAND	RT	LONG	73.1 73.3 73.8	12.0 11.8 11.7
GENERAL DYNAMICS	RT	LONG	77.0 79.0 80.0	11.3 11.6 11.4
NASA-LANGLEY	RT	LONG	62.3	11.4
NORTHROP	RT	LONG	70.9 72.2 76.7	12.2 12.1 11.9
MCDONNELL DOUGLAS, CA	RT	LONG	68.1 69.1 69.6	11.0 11.5 11.7
		AVERAGE	73.1	11.6
		STANDARD DEVIATION	4.5	0.4

TABLE I7

COMPRESSION RESULTS AT t/2 LOCATION FOR REYNOLDS  
2095-T8 PLATE (0.5" X 24" X 48")

COMPANY	TEST TEMPERATURE (DEGREES F)	ORIENTATION	COMPRESSIVE YIELD STRENGTH (KSI)	COMPRESSIVE MODULUS (MSI)
MCDONNELL DOUGLAS, MO	RT	L TRANS	79.5	11.8
			78.5	11.8
			79.1	11.6
SUNDSTRAND	RT	L TRANS	79.4	11.6
			79.0	11.5
			77.6	12.7
GENERAL DYNAMICS	RT	L TRANS	79.2	11.4
			80.6	11.6
			80.4	12.0
NASA-LANGLEY	RT	L TRANS	75.1	11.4
			77.0	11.5
			76.0	11.4
NORTHROP	RT	L TRANS	79.4	11.9
			75.9	12.1
			73.5	12.2
MCDONNELL DOUGLAS, CA	RT	L TRANS	72.9	14.0
			72.3	13.5
			73.2	13.8
AVERAGE			77.1	12.1
STANDARD DEVIATION			2.8	0.8

TABLE 18

COMPRESSION RESULTS AT  $t/2$  LOCATION FOR REYNOLDS  
2095-T8 PLATE (0.5" X 24" X 48")

COMPANY	TEST TEMPERATURE (DEGREES F)	ORIENTATION	COMPRESSIVE YIELD STRENGTH (KST)	COMPRESSIVE MODULUS (MSI)
MCDONNELL	RT	45	70.5	11.1
DOUGLAS			70.3	11.0
			72.2	10.9
		AVERAGE	71.0	11.0
		STANDARD DEVIATION	1.0	0.1

TABLE 19

COMPRESSION RESULTS AT  $t/2$  LOCATION FOR REYNOLDS  
2095-T8 PLATE (0.5" X 24" X 48")

COMPANY	TEST TEMPERATURE (DEGREES F)	ORIENTATION	COMPRESSIVE ULT STRENGTH (KSI)	COMPRESSIVE MODULUS (MSI)
ARMY-MTL	RT	LONG	111.2	
			107.2	
			110.7	
		AVERAGE	109.7	
		STANDARD DEVIATION	2.2	
ARMY-MTL	RT	L TRANS	115.4	
			119.0	
			114.7	
		AVERAGE	116.4	
		STANDARD DEVIATION	2.3	

TABLE I10

PIN SHEAR RESULTS FOR REYNOLDS  
2095-T8 PLATE (0.5" X 24" X 48")

COMPANY	ORIENTATION	SHEAR STRENGTH (KSI)
ARMY-MTL	LONG	49.5
		48.8
		49.7
NORTHROP	LONG	45.7
		46.6
		46.0
	AVERAGE	47.7
	STANDARD DEVIATION	1.8

TABLE I11

RIVET SHEAR RESULTS FOR REYNOLDS  
2095-T8 PLATE (0.5" X 24" X 48")

COMPANY	ORIENTATION	SHEAR STRENGTH (KSI)
ARMY-MTL	L TRANS	49.0
		48.5
		47.7
	AVERAGE	48.4
	STANDARD DEVIATION	0.7

TABLE 112

TORSIONAL SHEAR RESULTS FOR REYNOLDS  
2095-T8 PLATE (0.5" X 24" X 48")

COMPANY	ORIENTATION	SHEAR STRENGTH (KSI)
SUNDSTRAND	LONG	47.1
		46.4
		45.1
	AVERAGE	46.2
	STANDARD DEVIATION	1.0
SUNDSTRAND	L TRANS	45.4
		45.1
		46.8
	AVERAGE	45.8
	STANDARD DEVIATION	0.9

TABLE I13

AMSLER DOUBLE SHEAR RESULTS FOR REYNOLDS  
2095-T8 PLATE (0.5" X 24" X 48")

COMPANY	ORIENTATION	SHEAR STRENGTH (KSI)
NASA-LANGLEY	L-S	44.4
		46.3
		47.7
	AVERAGE	46.1
	STANDARD DEVIATION	1.7
NASA-LANGLEY	T-S	47.5
		45.6
		45.0
	AVERAGE	46.0
	STANDARD DEVIATION	1.3

TABLE I14

BEARING RESULTS FOR REYNOLDS  
2095-T8 PLATE (0.5" X 24" X 48")

COMPANY	ORIENTATION	e/D	BEARING	
			ULT. STR. (KSI)	BEARING YIELD STR. (KSI)
MCDONNELL DOUGLAS, MO	LONG	1.5	128.0	106.0
			119.0	100.0
			122.0	103.0
NASA-LANGLEY	LONG	1.5	123.1	99.2
			119.4	98.4
			120.6	100.3
NORTHROP	LONG	1.5	156.4	116.5
			154.3	114.3
			153.6	113.7
MCDONNELL DOUGLAS, CA	LONG	1.5	120.2	102.1
			121.1	101.9
			121.1	101.5
AVERAGE			129.9	104.7
STANDARD DEVIATION			15.2	6.4

TABLE I15

BEARING RESULTS FOR REYNOLDS  
2095-T8 PLATE (0.5" X 24" X 48")

COMPANY	ORIENTATION	e/D	BEARING	
			ULT. STR. (KSI)	BEARING YIELD STR. (KSI)
MCDONNELL DOUGLAS, MO	45	1.5	128.0	106.0
			131.0	110.0
			135.0	111.0
AVERAGE			131.3	109.0
STANDARD DEVIATION			3.5	2.6

TABLE I16

BEARING RESULTS FOR REYNOLDS  
2095-T8 PLATE (0.5" X 24" X 48")

COMPANY	ORIENTATION	e/D	BEARING	
			ULT. STR. (KSI)	BEARING YIELD STR. (KSI)
MCDONNELL DOUGLAS, MO	L TRANS	1.5	125.0	106.0
			129.0	105.0
			131.0	107.0
NASA-LANGLEY	L TRANS	1.5	122.2	98.4
			124.2	101.6
			124.7	99.4
NORTHROP	L TRANS	1.5	158.7	121.1
			160.4	120.6
			160.2	128.5
MCDONNELL DOUGLAS, CA	L TRANS	1.5	121.7	100.4
			121.7	98.3
			120.5	97.3
AVERAGE			133.3	107.0
STANDARD DEVIATION			16.3	10.6

TABLE I17  
 BEARING RESULTS FOR REYNOLDS  
 2095-T8 PLATE (0.5" X 24" X 48")

COMPANY	ORIENTATION	e/D	BEARING	
			ULT. STR. (KSI)	BEARING YIELD STR. (KSI)
MCDONNELL DOUGLAS, MO	LONG	2.0	164.0	128.0
			159.0	131.0
			158.0	130.0
NASA-LANGLEY	LONG	2.0		114.5
			148.0	111.0
			146.7	112.3
NORTHROP	LONG	2.0	183.1	120.6
			183.6	123.1
			182.5	122.7
MCDONNELL DOUGLAS, CA	LONG	2.0	157.5	119.6
			156.5	124.1
			157.4	120.2
AVERAGE			163.3	121.4
STANDARD DEVIATION			13.6	6.5

TABLE I18  
 BEARING RESULTS FOR REYNOLDS  
 2095-T8 PLATE (0.5" X 24" X 48")

COMPANY	ORIENTATION	e/D	BEARING	
			ULT. STR. (KSI)	BEARING YIELD STR. (KSI)
MCDONNELL DOUGLAS, MO	45	2.0	172.0	141.0
			166.0	136.0
			169.0	138.0
AVERAGE			169.0	138.3
STANDARD DEVIATION			3.0	2.5

TABLE I19

BEARING RESULTS FOR REYNOLDS  
2095-T8 PLATE (0.5" X 24" X 48")

COMPANY	ORIENTATION	e/D	BEARING	
			ULT. STR. (KSI)	BEARING YIELD STR. (KSI)
MCDONNELL	L TRANS	2.0	163.0	132.0
DOUGLAS, MO			160.0	137.0
			166.0	137.0
NASA-LANGLEY	L TRANS	2.0		116.4
			154.5	116.6
			154.5	116.1
NORTHROP	L TRANS	2.0	186.9	126.7
			188.5	131.2
			189.8	127.5
MCDONNELL	L TRANS	2.0	155.4	122.1
DOUGLAS, CA			158.9	124.6
			156.8	122.9
		AVERAGE	166.8	125.8
		STANDARD DEVIATION	14.4	7.5

TABLE I20

FRACTURE TOUGHNESS RESULTS FOR REYNOLDS  
2095-T8 PLATE (0.5" X 24" X 48")

COMPANY	ORIENTATION	KIC (KSI in <sup>0.5</sup> )	Kq (KSI in <sup>0.5</sup> )	COMMENT
MCDONNELL	L-T		26.3	(1)
DOUGLAS			22.8	(2)
SUNDSTRAND	L-T	30.2 30.0		
ARMY-MTL	L-T	26.8	37.3 33.3 36.4 33.7	(2), (3) (2) (2), (3) (2)
GENERAL DYNAMICS	L-T		33.5 30.7 30.1	(2) (2) (2)
NASA-LANGLEY	L-T	27.0	25.3	(2)
NORTHROP	L-T		37.7 40.4 43.3	(3) (3) (3)
	AVERAGE	28.5	33.1	
	STANDARD DEVIATION	1.8	6.0	

(1): INVALID DUE TO SURFACE CRACK LENGTH MEASUREMENTS  
EXCEEDED 10% OF AVERAGE CRACK LENGTH

(2): INVALID DUE TO  $P_{max}/P_q > 1.10$

(3): INVALID DUE TO  $a \ \& \ B > 2.5(Kq/Y_S)**2$

TABLE I21

FRACTURE TOUGHNESS RESULTS FOR REYNOLDS  
2095-T8 PLATE (0.5" X 24" X 48")

COMPANY	ORIENTATION	KIC (KSI in <sup>0.5</sup> )	Kq (KSI in <sup>0.5</sup> )	COMMENT
MCDONNELL DOUGLAS	T-L	29.6	25.8	(1)
SUNDSTRAND	T-L	29.1 29.0		
ARMY-MTL	T-L		40.2 35.6 35.0 35.9 36.9 35.5	(2), (3) (3) (2), (3) (2), (3) (2), (3) (3)
GENERAL DYNAMICS	T-L	31.4	29.4 29.2	(2) (2)
NASA-LANGLEY	T-L	24.4		
NORTHROP	T-L		38.7 38.3 37.9	(3) (3) (3)
	AVERAGE	28.7	34.9	
	STANDARD DEVIATION	2.6	4.4	

(1): INVALID DUE TO SURFACE CRACK LENGTH MEASUREMENTS  
EXCEEDED 10% OF AVERAGE CRACK LENGTH

(2): INVALID DUE TO  $P_{max}/P_q > 1.10$

(3): INVALID DUE TO  $a \ \& \ B > 2.5(Kq/YS)**2$

TABLE I22

FRACTURE TOUGHNESS RESULTS FOR REYNOLDS  
2095-T8 PLATE (0.5" X 24" X 48")

COMPANY	ORIENTATION	K <sub>IC</sub> (KSI in <sup>-0.5</sup> )	K <sub>q</sub> (KSI in <sup>-0.5</sup> )	COMMENT
MCDONNELL	45		25.4	(1)
DOUGLAS		23.6		

(1): INVALID DUE TO SURFACE CRACK LENGTH MEASUREMENTS  
EXCEEDED 10% OF AVERAGE CRACK LENGTH

TABLE I23

Hardness & Conductivity Results for 2095-T8  
0.5 Inch Plate. General Dynamics, CA

Alloy/Product Form	Hardness (R <sub>B</sub> Scale)	Conductivity (% IACS)
Weldalite 2095-T8 0.50 Inch Plate	See Figure	22 (a) 17 (b)
(a) as received mill surface		
(b) machined surface		

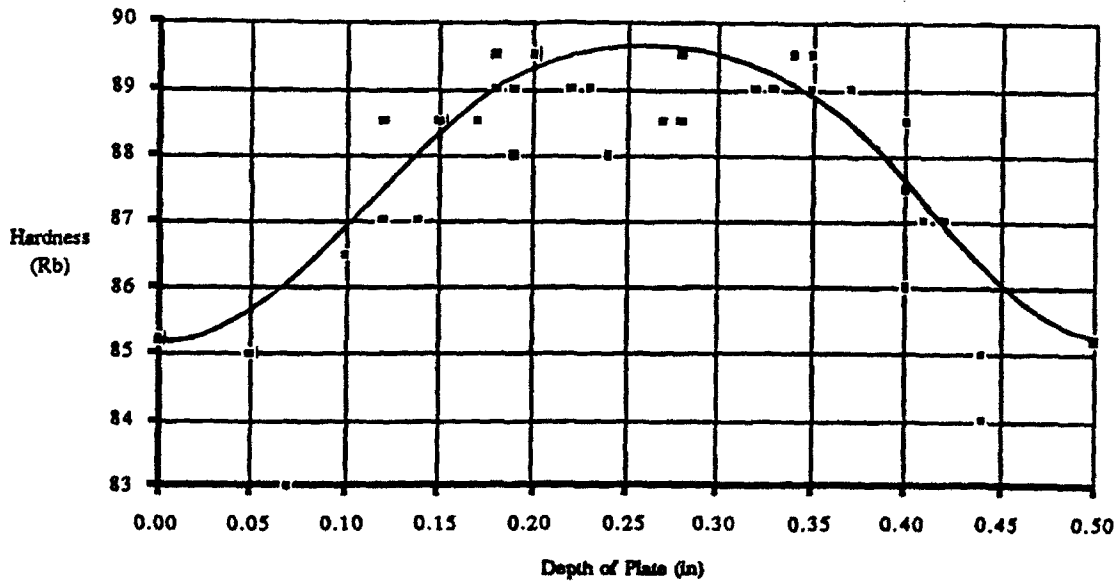
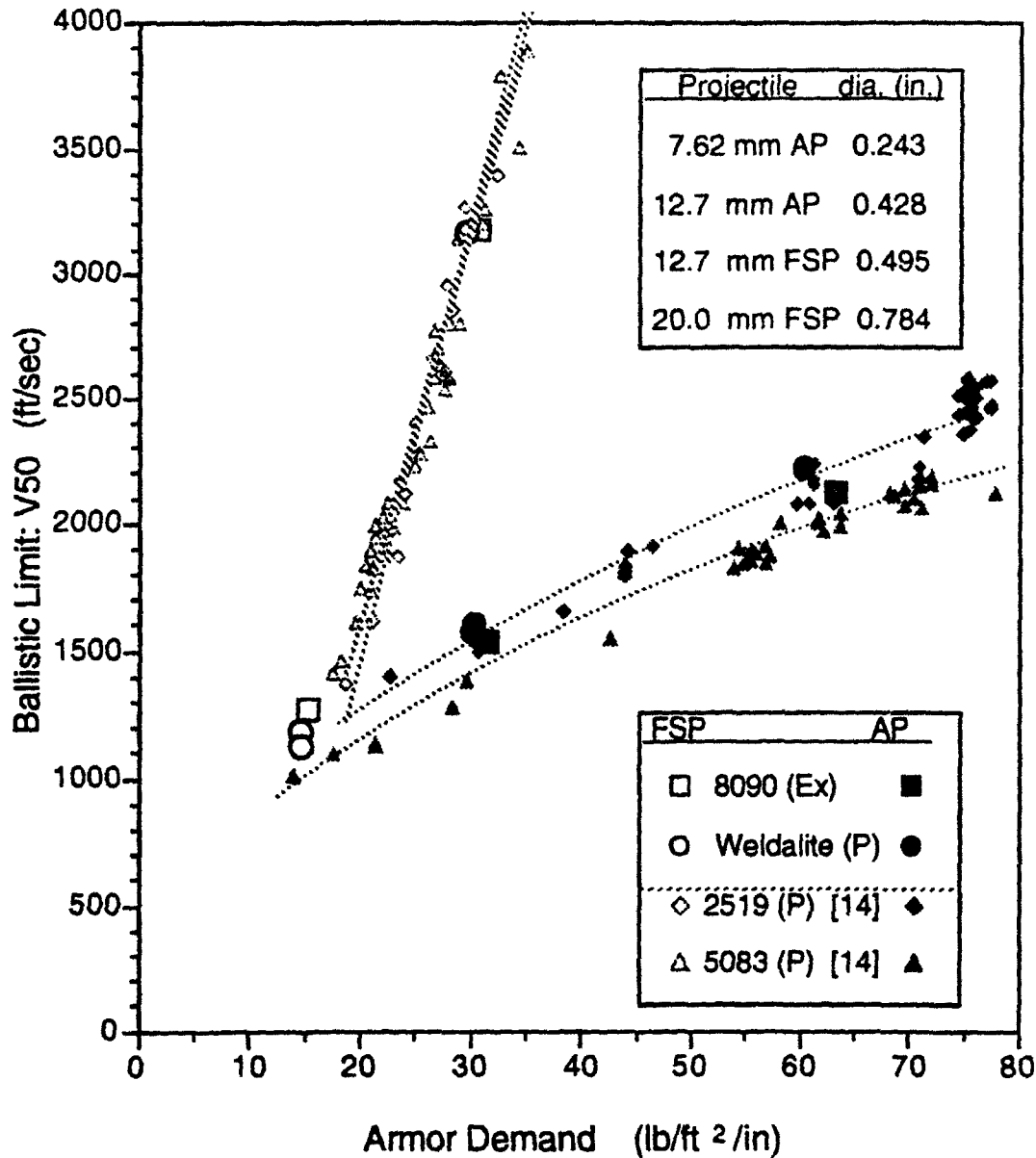


Figure 11. Hardness profile through 2095-T8  
0.5 Inch Plate. General Dynamics, CA.



Both 8090 extrusions (Ex) and Weldalite plates (P) provided enhanced ballistic performance over 2519 and 5083 Al alloys. The  $V_{50}$  ballistic limits against AP and FSP projectiles at  $0^\circ$  obliquity are plotted versus Armor demand. The Armor demand is defined as the (density  $\times$  thickness) / projectile diameter. The ballistic data for different caliber projectiles superimpose on single curves for either AP or FSP projectiles when plotted against armor demand. This technique allows designers to evaluate ballistic performance as a function of projectile type rather than for individual munitions. The AP and FSP projectile diameters are included as inserts in the plot. Ballistic data for 2519 and 5083 are included as the high and low ends of aluminum alloys currently being considered for structural armor applications. The lower set of 8090 and Weldalite data points for both AP and FSP projectiles represent 0.5 inch ballistic targets. The second series of data points for each projectile type represent stacked plates to provide 1.0 inch thickness. The ballistic limits of both AL-Li alloys are attributed to the witness plate being perforated by spalling rather than by the projectile exiting the target.

Figure I2. Ballistic limit ( $V_{50}$ ) versus Armor Demand at  $0^\circ$  obliquity against Armor Piercing (AP) and Fragment Simulating Projectiles (FSP). Army.

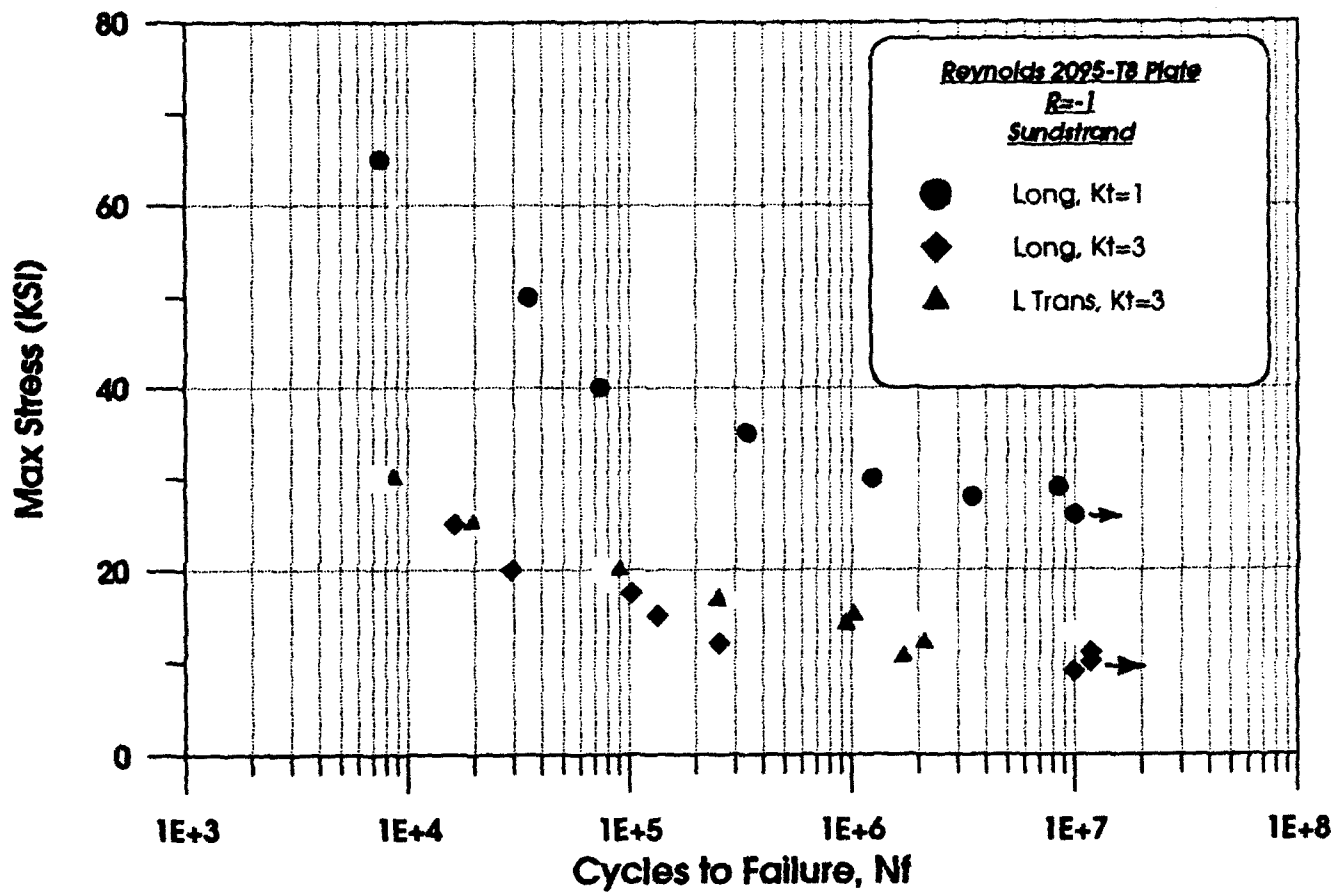


Figure I3. Fatigue Results for 2095-T8 0.5 Inch Plate ( $R = -1$ ,  $K_t = 1.0$  and  $K_t = 3.0$ ) and 2095-T6 ( $R = -1$  and  $K_t = 3$ )

TABLE I24

FATIGUE RESULTS WITH R=-1.0 AND Kt=1.0 FOR  
REYNOLDS 2095-T8 PLATE (0.5" X 24" X 48")

COMPANY	ORIENTATION	STRESS (KSI)	CYCLES
SUNDSTRAND	LONG	65.0	7,500
		50.0	34,950
		40.0	73,820
		35.0	338,910
		30.0	1,240,950
		29.0	8,461,080
		28.0	3,489,830
		26.0	10,000,000 *

(\*): RUN OUT

TABLE I25

FATIGUE RESULTS WITH R=-1.0 AND Kt=3.0 FOR  
REYNOLDS 2095-T8 PLATE (0.5" X 24" X 48")

COMPANY	ORIENTATION	STRESS (KSI)	CYCLES
SUNDSTRAND	LONG	25.0	16,300
		20.0	29,460
		17.5	102,580
		15.0	133,920
		12.0	253,810
		11.0	11,796,000 *
		10.0	11,913,000 *
		9.0	10,000,000 *

(\*): RUN OUT

TABLE I26

FATIGUE RESULTS WITH R=-1.0 AND Kt=3.0 FOR  
REYNOLDS 2095-T8 PLATE (0.5" X 24" X 48")

COMPANY	ORIENTATION	STRESS (KSI)	CYCLES
SUNDSTRAND	L TRANS	30.0	8,620
		25.0	19,690
		20.0	90,000
		17.0	254,530
		15.0	1,024,210
		14.0	943,790
		12.0	2,110,280
		10.5	1,715,500

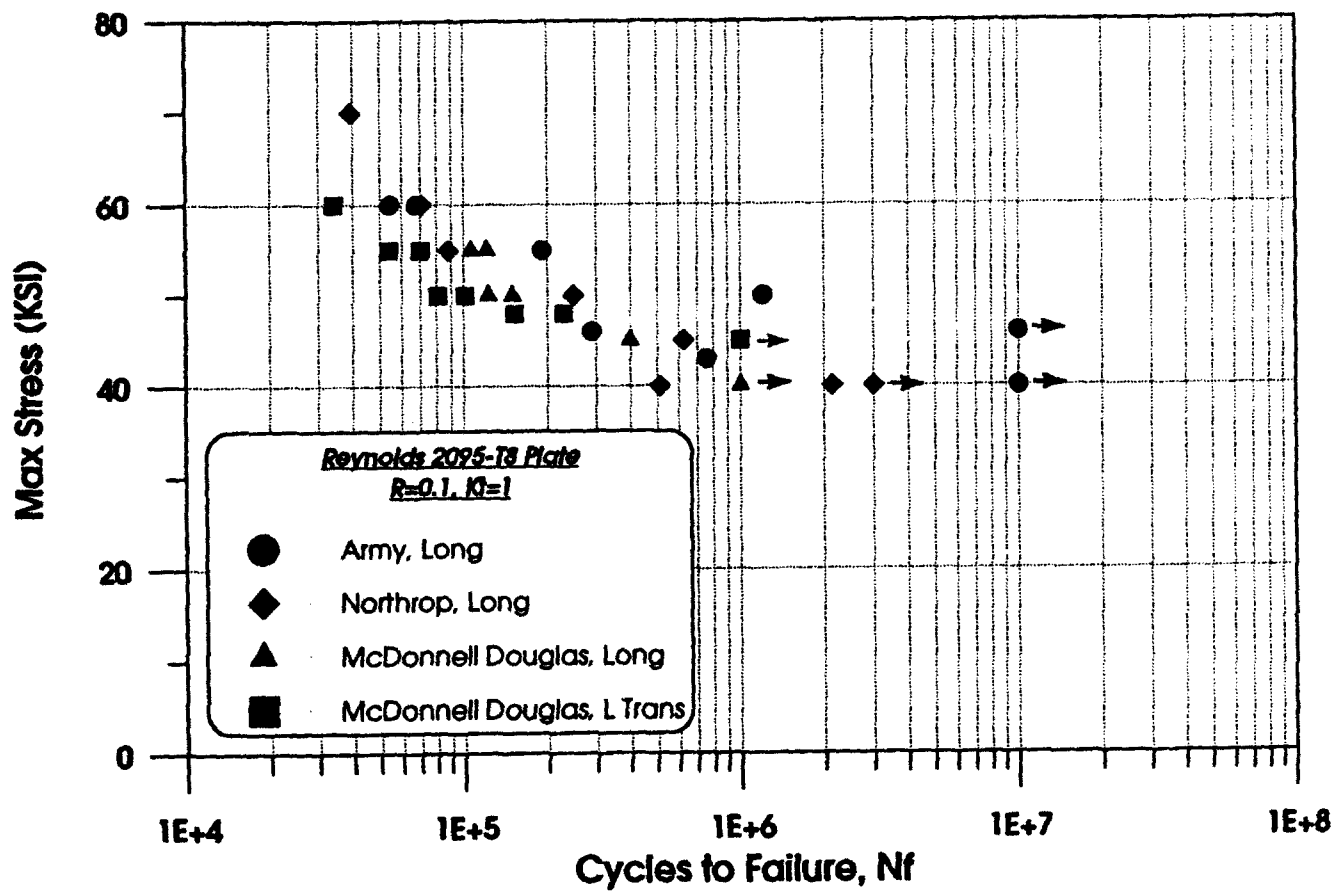


Figure I4. Fatigue Results for 2095-T8 0.5 Inch Plate (R = 0.1 and Kt = 1.0)

TABLE I27

FATIGUE RESULTS WITH R=0.1 AND Kt=1.0 FOR  
REYNOLDS 2095-T8 PLATE (0.5" X 24" X 48")

COMPANY	ORIENTATION	STRESS (KSI)	CYCLES
ARMY-MTL	LONG	60.0	54,220
		60.0	67,580
		55.0	191,520
		50.0	1,205,760
		46.0	290,042
		46.0	10,026,880 *
		43.0	754,000
		40.0	10,010,000 *
NORTHROP	LONG	70.0	39,420
		60.0	70,550
		55.0	87,944
		50.0	247,950
		45.0	623,760
		40.0	511,870
		40.0	3,000,000 *
		40.0	2,135,840
MCDONNELL DOUGLAS, CA	LONG	55.0	106,010
		55.0	120,950
		50.0	149,620
		50.0	122,970
		45.0	398,910
		45.0	398,300
		40.0	1,000,000 *
		40.0	1,000,000 *
MCDONNELL DOUGLAS, CA	L TRANS	60.0	34,170
		55.0	53,870
		55.0	69,800
		50.0	101,060
		50.0	80,470
		48.0	153,080
		48.0	229,570
		45.0	1,000,000 *
		45.0	1,000,000 *

(\*): RUN-OUT

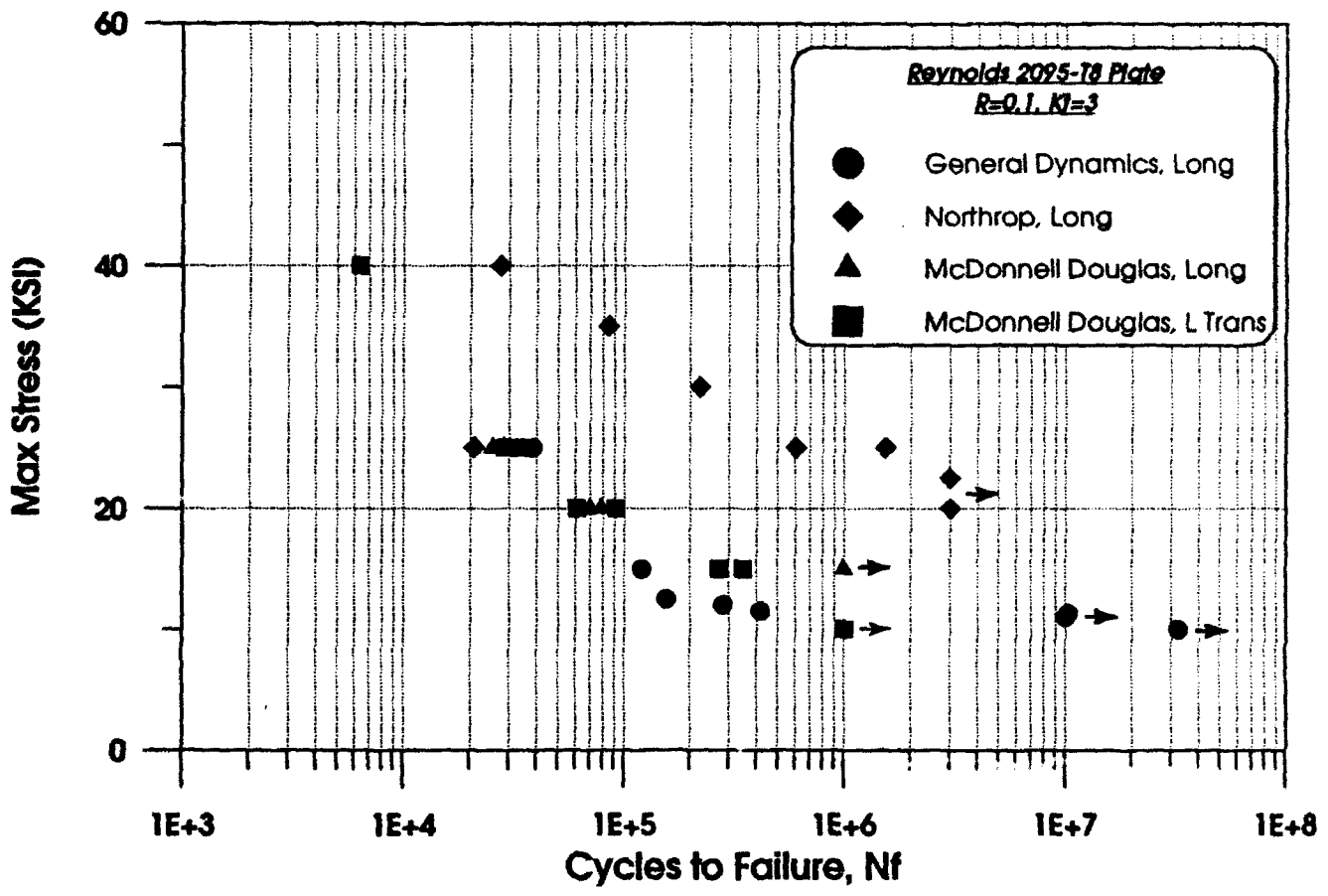


Figure I5. Fatigue Results for 2095-T8 0.5 Inch Plate (R = 0.1 and Kt = 3)

TABLE I28

FATIGUE RESULTS WITH R=0.1 AND Kt=3.0 FOR  
REYNOLDS 2095-T8 PLATE (0.5" X 24" X 48")

COMPANY	ORIENTATION	STRESS (KSI)	CYCLES
GENERAL DYNAMICS	LONG	25.0	38,200
		15.0	120,600
		12.5	155,500
		12.0	281,900
		11.5	417,100
		11.3	10,240,300 *
		11.0	10,000,000 *
		10.0	32,313,000 *
NORTHROP	LONG	40.0	27,530
		35.0	84,820
		30.0	220,840
		25.0	20,830
		25.0	605,470
		25.0	1,535,480
		22.5	3,000,000 *
		20.0	3,000,000 *
MCDONNELL DOUGLAS, CA	LONG	25.0	28,540
		25.0	25,320
		20.0	78,410
		20.0	69,950
		15.0	1,000,000 *
		15.0	1,000,000 *
		10.0	1,000,000 *
		10.0	1,000,000 *
MCDONNELL DOUGLAS, CA	L TRANS	40.0	6,331
		25.0	28,860
		25.0	32,940
		20.0	60,520
		20.0	91,030
		15.0	348,180
		15.0	271,490
		10.0	1,000,000 *
		10.0	1,000,000 *

(\*): RUN-OUT

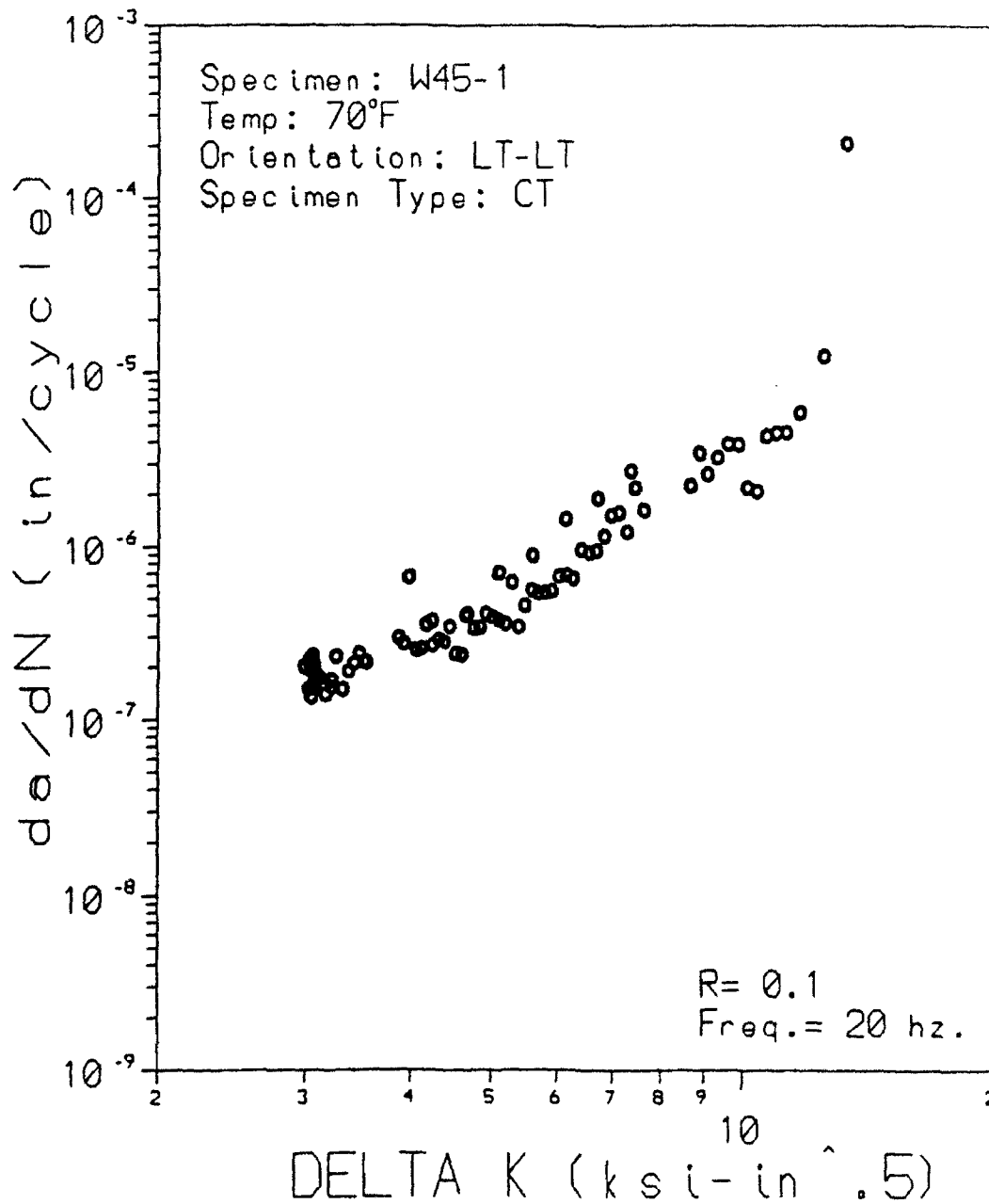


Figure I6. Fatigue Crack Growth Rate Data for 2095-T8 0.5 Inch Plate (LT-LT orientation, Specimen W45-1). Air Force.



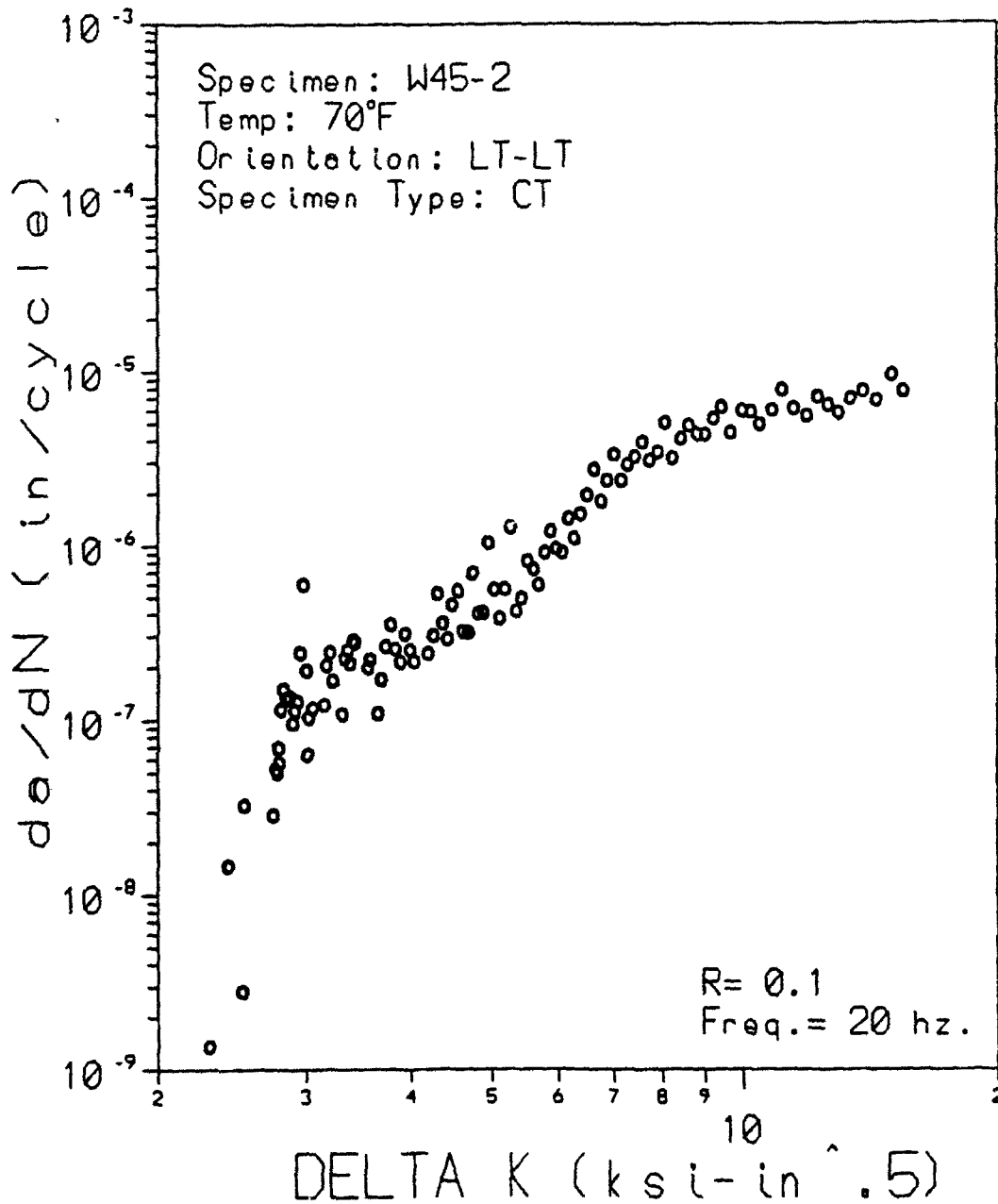


Figure 17. Fatigue Crack Growth Rate Data for 2095-T8 0.5 Inch Plate (LT-LT orientation, Specimen W45-2). Air Force.



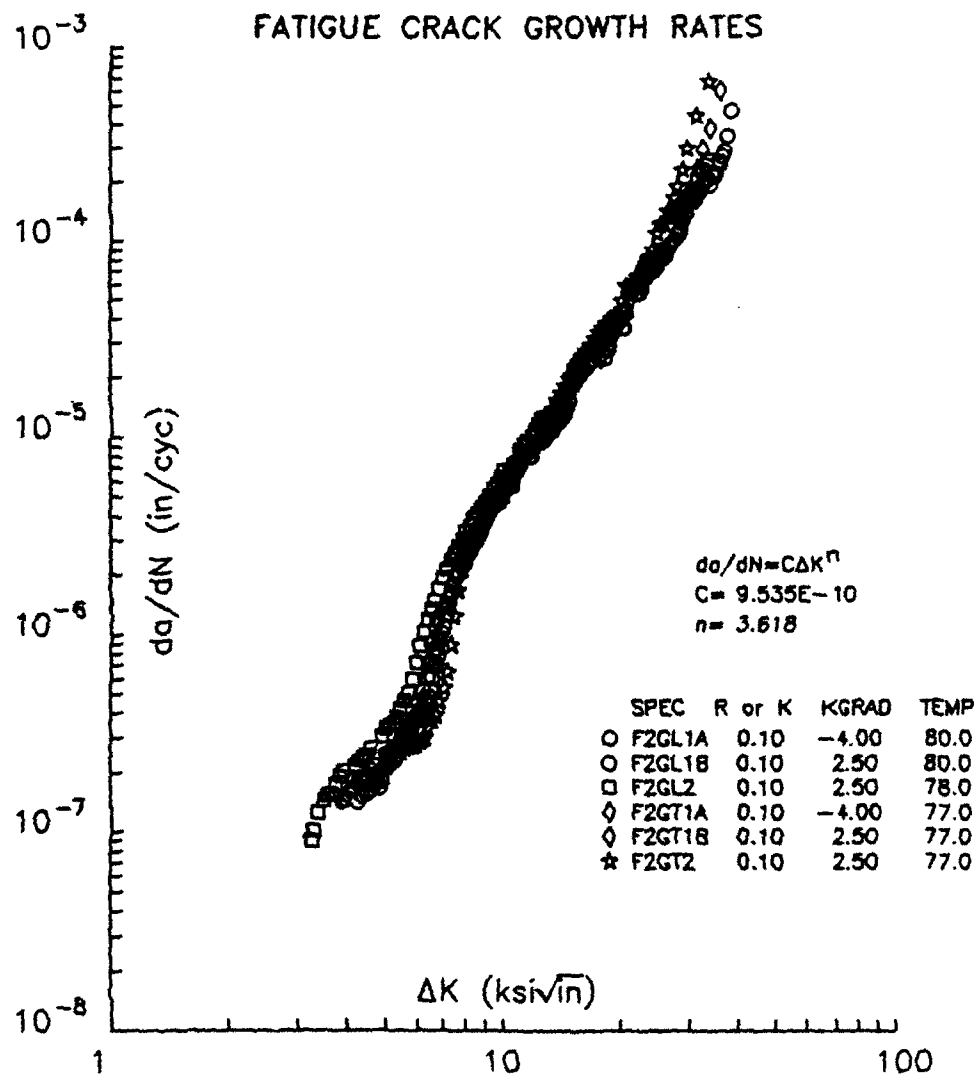


Figure 18. Fatigue Crack Growth Rate Data for 2095-T8 0.5 Inch Thick Plate (L-T and T-L orientations). Northrop.

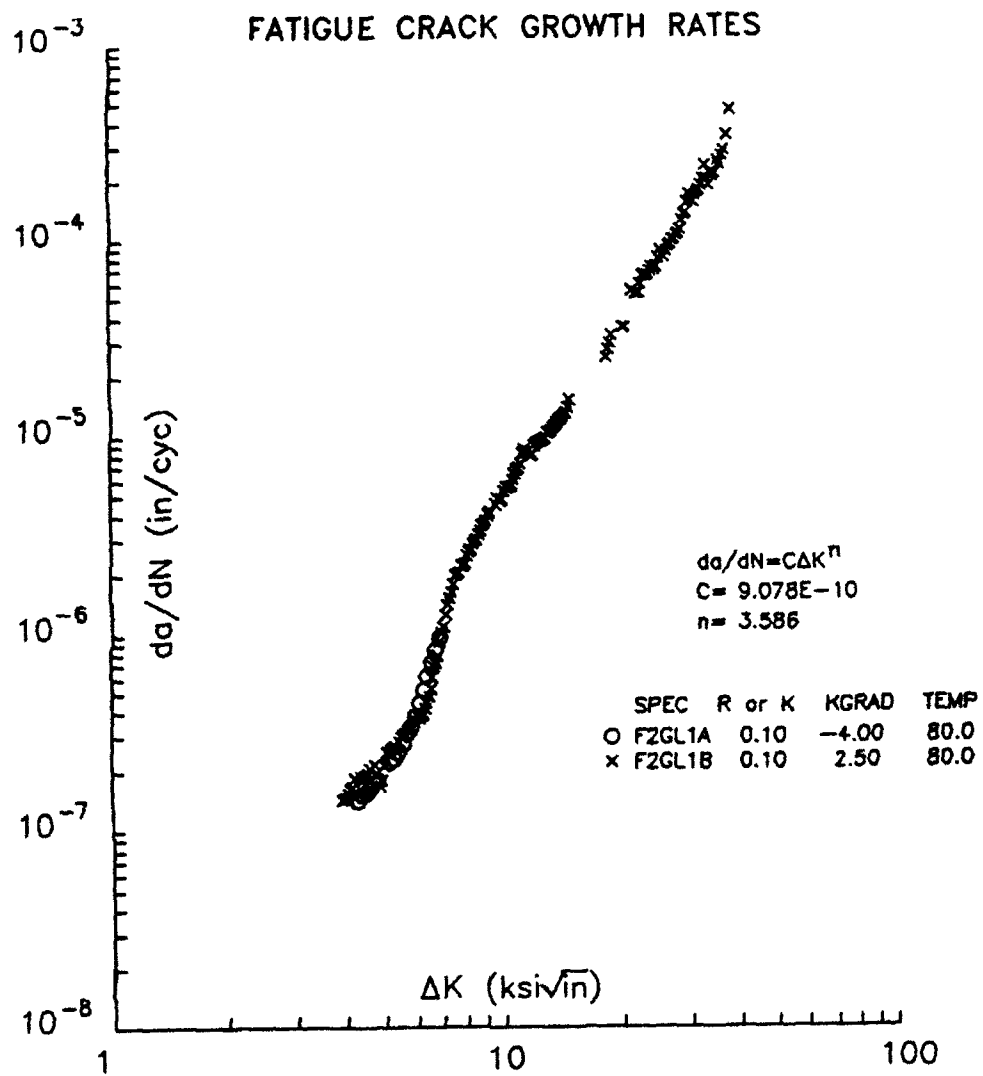


Figure 19. Fatigue Crack Growth Rate Data for 2095-T8 0.5 Inch Thick Plate (L-T orientation, KGRAD - 4.00 and 2.50). Northrop.

TABLE I31

Fatigue Crack Growth Data Associated with Figure I9 (Specimen F2GL1A)

AUTOMATED FATIGUE CRACK GROWTH RATE ANALYSIS

Specimen Id.	F2GL1A	Geometry	C(T)
Contract #	WB02115N	Orientation	L-T
Material	Weldalite	Yield (ksi)	82.0
Temperature (F)	80	Modulus	11.1
Environment	Lab. air		

Specimen Dimensions (in)

Thickness	0.495	Notch depth	0.609
Width	2.997	Gage length	1.000
Height	3.600	Alpha ratio	1.250

Precrack Parameters

Pmax (lbs)	1471.0	Stress ratio (R)	0.10
Final a (in)	0.689	Kmax	8.00

Test Parameters

Initial a (in)	0.689	Initial K	8.00
K-gradient	-4.00	Stress ratio (R)	0.10

K Coeff	EvB/P Coeff	Analysis Codes
0.886000	1.000980	KRP 2 0
4.640000	-4.669510	
-13.320000	18.460100	
14.720000	-236.824997	
-5.600000	1214.880000	
0.000000	-2143.570100	

Visual Observations

EvB/P	Crack (EvB/P)	Crack (visual)	Error	CAF
19.54	0.689	0.656	-.033	1.000
20.82	0.745	0.715	-.031	1.000
21.33	0.766	0.728	-.038	1.000
21.58	0.776	0.754	-.023	1.000
21.67	0.780	0.757	-.023	1.000
23.00	0.831	0.800	-.031	1.000
23.65	0.855	0.818	-.036	1.000
24.14	0.872	0.836	-.036	1.000
25.06	0.904	0.870	-.034	1.000
27.11	0.969	0.928	-.041	1.000
29.75	1.045	1.017	-.028	1.000
92.36	1.818	1.818	-.000	1.000

Peak (lbs)	EvB/P	a (in)	N (X1)	Δa (in)	ΔN (X1)	Δa/ΔN (in/cyc)	ΔK (ksi/in)
	19.64	0.6938	4398				
1393	19.80	0.7011	11308	0.0130	13262	9.783E-07	6.89
1347	19.93	0.7067	17660	0.0118	14041	8.406E-07	6.70
1308	20.07	0.7129	25349	0.0125	17258	7.251E-07	6.55
1269	20.22	0.7193	34918	0.0126	20541	6.157E-07	6.38
1232	20.36	0.7255	45890	0.0120	22772	5.256E-07	6.23
1195	20.49	0.7312	57689	0.0117	26035	4.505E-07	6.08
1162	20.63	0.7373	71925	0.0118	30699	3.849E-07	5.94
1128	20.77	0.7430	88388	0.0118	34418	3.416E-07	5.80
1095	20.91	0.7490	106343	0.0124	39201	3.158E-07	5.66
1063	21.07	0.7554	127588	0.0123	44693	2.761E-07	5.53
1031	21.21	0.7614	151035	0.0120	48064	2.496E-07	5.39
1001	21.36	0.7674	175652	0.0121	51794	2.336E-07	5.27
974	21.51	0.7735	202829	0.0111	49535	2.245E-07	5.15
	21.64	0.7785	225187				
	21.82	0.7859	249807				
888	21.97	0.7918	282411	0.0119	66418	1.796E-07	4.77
863	22.13	0.7978	316225	0.0121	69261	1.745E-07	4.66
838	22.28	0.8038	351672	0.0118	71831	1.638E-07	4.55
814	22.43	0.8096	388056	0.0116	73904	1.574E-07	4.45
791	22.59	0.8155	425576	0.0120	78849	1.523E-07	4.34
768	22.75	0.8216	466905	0.0122	85698	1.428E-07	4.24
	22.91	0.8277	511274				
	23.08	0.8341	537843				
	23.23	0.8395	565306				

TABLE I32

Fatigue Crack Growth Data Associated with Figure I9 (Specimen F2GL1B)

**AUTOMATED FATIGUE CRACK  
GROWTH RATE ANALYSIS**

Specimen Id.	F2GL1B	Geometry	C(T)
Contract #	WB02115N	Orientation	L-T
Material	Weldalite	Yield (ksi)	82.0
Temperature (F)	80	Modulus	11.1
Environment	Lab. air		

Specimen Dimensions (in)

Thickness	0.495	Notch depth	0.609
Width	2.997	Gage length	1.000
Height	3.600	Alpha ratio	1.250

Pre-crack Parameters

Pmax (lbs)	1471.0	Stress ratio (R)	0.10
Final a (in)	0.689	Kmax	8.00

Test Parameters

Initial a (in)	0.855	Initial K	4.10
K-gradient	2.50	Stress ratio (R)	0.10

K Coeff	EvB/P Coeff	Analysis Codes
0.886000	1.000980	KRP 2 0
4.640000	-4.669510	
-13.320000	18.460100	
14.720000	-236.824997	
-5.600000	1214.880000	
0.000000	-2143.570100	

Visual Observations

EvB/P	Crack (EvB/P)	Crack (visual)	Error	CAF
19.54	0.689	0.656	-.033	1.000
20.82	0.745	0.715	-.031	1.000
21.33	0.766	0.728	-.038	1.000
21.58	0.776	0.754	-.023	1.000
21.67	0.780	0.757	-.023	1.000
23.00	0.831	0.800	-.031	1.000
23.65	0.855	0.818	-.036	1.000
24.14	0.872	0.836	-.036	1.000
25.06	0.904	0.870	-.034	1.000
27.11	0.969	0.928	-.041	1.000
29.75	1.045	1.017	-.028	1.000
92.36	1.818	1.818	-.000	1.000

Comments

Date of test: 08-12-1992

TABLE I32 (Continued)

Specimen Id. F2GL18		Page 1										Page 2									
Phax (lbs)	E48/P (in)	M (X1)	Aa (in)	AN (X1)	Am/AN (in/cyc)	AK (ksi/in)	Phax (lbs)	E48/P (in)	M (X1)	Aa (in)	AN (X1)	Am/AN (in/cyc)	AK (ksi/in)	Phax (lbs)	E48/P (in)	M (X1)	Aa (in)	AN (X1)	Am/AN (in/cyc)	AK (ksi/in)	
669	24.01	0.8676	106831	0.0106	73428	1.449E-07	3.86	935	30.98	1.0768	1004990	0.0091	18862	4.840E-07	6.43						
674	24.17	0.8732	146247	0.0093	63733	1.457E-07	3.91	942	31.16	1.0814	1014201	0.0093	17546	5.297E-07	6.50						
680	24.32	0.8782	180259	0.0089	60742	1.472E-07	3.96	949	31.34	1.0861	1022536	0.0095	15479	6.108E-07	6.58						
685	24.48	0.8825	209981	0.0095	61687	1.543E-07	4.00	956	31.53	1.0908	1029679	0.0091	13151	6.907E-07	6.65						
690	24.72	0.8920	241001	0.0095	58702	1.614E-07	4.05	963	31.70	1.0952	1035686	0.0087	11912	7.275E-07	6.73						
695	24.86	0.8966	271668	0.0092	55018	1.665E-07	4.10	970	31.87	1.0995	1041591	0.0089	11248	7.897E-07	6.80						
700	24.99	0.9012	326686	0.0076	41150	1.843E-07	4.14	977	32.06	1.1040	1046934	0.0091	9853	9.256E-07	6.88						
	25.08	0.9042	340853					985	32.24	1.1086	1051444	0.0091	8856	1.029E-06	6.96						
	25.27	0.9106	351337					992	32.43	1.1132	1055790	0.0088	7892	1.109E-06	7.04						
716	25.40	0.9147	378211	0.0086	45977	1.878E-07	4.29	999	32.60	1.1174	1059335	0.0088	6876	1.276E-06	7.12						
722	25.54	0.9192	397314	0.0092	50824	1.802E-07	4.34	1007	32.79	1.1219	1062665	0.0093	6517	1.427E-06	7.20						
727	25.68	0.9239	423034	0.0091	48344	1.887E-07	4.38	1014	32.99	1.1267	1065855	0.0089	5795	1.533E-06	7.28						
732	25.82	0.9283	445658	0.0085	44229	1.913E-07	4.43	1021	33.16	1.1308	1068460	0.0086	5212	1.642E-06	7.36						
738	25.94	0.9323	467264	0.0090	45789	1.962E-07	4.48	1029	33.35	1.1352	1071065	0.0092	5087	1.812E-06	7.44						
743	26.10	0.9373	491447	0.0098	47368	2.060E-07	4.53	1036	33.56	1.1400	1073547	0.0091	4562	1.995E-06	7.52						
	26.25	0.9421	514632					1044	33.74	1.1443	1075626	0.0088	4357	2.028E-06	7.61						
	26.37	0.9460	541121					1052	33.94	1.1489	1077904	0.0095	4588	2.063E-06	7.70						
760	26.54	0.9513	567212	0.0092	42714	2.164E-07	4.69	1060	34.15	1.1538	1080215	0.0095	4233	2.235E-06	7.79						
765	26.67	0.9552	583835	0.0073	36982	1.962E-07	4.74	1068	34.35	1.1583	1082137	0.0087	3878	2.236E-06	7.88						
773	26.78	0.9595	604194	0.0119	1076	1.695E-07	4.81	1076	34.55	1.1625	1084093	0.0089	3859	2.308E-06	7.97						
779	27.06	0.9671	653618	0.0153	84036	1.815E-07	4.87	1083	34.75	1.1673	1085006	0.0089	3558	2.528E-06	8.05						
788	27.28	0.9738	688230	0.0112	52470	2.140E-07	4.95	1091	34.93	1.1713	1087601	0.0085	3236	2.634E-06	8.15						
795	27.43	0.9783	706088	0.0088	35600	2.482E-07	5.02	1099	35.13	1.1758	1089242	0.0087	3215	2.706E-06	8.23						
801	27.57	0.9826	723831	0.0089	35807	2.494E-07	5.08	1107	35.33	1.1800	1090616	0.0087	3011	2.903E-06	8.32						
807	27.73	0.9872	741895	0.0090	35028	2.572E-07	5.14	1114	35.53	1.1845	1092252	0.0087	2899	3.019E-06	8.41						
813	27.88	0.9916	758659	0.0089	33811	2.630E-07	5.20	1123	35.73	1.1888	1093714	0.0091	2993	3.052E-06	8.51						
819	28.03	0.9961	775705	0.0091	33723	2.705E-07	5.25	1131	35.96	1.1937	1095245	0.0094	2899	3.239E-06	8.61						
	28.19	1.0007	792582					1139	36.17	1.1982	1096613	0.0088	2599	3.394E-06	8.70						
	28.34	1.0049	808585					1147	36.37	1.2025	1097844	0.0088	2477	3.562E-06	8.80						
837	28.49	1.0093	824320	0.0089	31332	2.841E-07	5.43	1156	36.59	1.2070	1099091	0.0093	2542	3.777E-06	8.90						
843	28.65	1.0138	839917	0.0094	31185	3.006E-07	5.49	1164	36.82	1.2118	1100367	0.0092	2442	4.079E-06	9.00						
849	28.82	1.0187	855505	0.0094	30476	3.071E-07	5.56	1173	37.03	1.2162	1101533	0.0089	2193	4.234E-06	9.11						
856	28.98	1.0232	870392	0.0089	28439	3.121E-07	5.62	1181	37.25	1.2208	1102880	0.0089	2094	4.434E-06	9.21						
862	29.14	1.0275	883944	0.0088	27058	3.258E-07	5.68		37.47	1.2251	1103627										
868	29.30	1.0320	897450	0.0090	27034	3.258E-07	5.75		37.69	1.2297	1104724										
875	29.46	1.0365	910978	0.0089	27019	3.304E-07	5.81	1208	37.91	1.2341	1105772	0.0094	2046	4.583E-06	9.53						
881	29.62	1.0409	924470	0.0087	23027	3.759E-07	5.88	1216	38.16	1.2390	1106770	0.0093	1898	4.924E-06	9.64						
	29.78	1.0452	934006					1225	38.38	1.2434	1107670	0.0086	1799	4.786E-06	9.75						
	29.99	1.0509	940920					1234	38.60	1.2476	1108559	0.0086	1743	4.905E-06	9.85						
902	30.12	1.0542	950546	0.0079	21063	3.731E-07	6.09	1242	38.82	1.2520	1109414	0.0088	1628	5.395E-06	9.96						
907	30.29	1.0588	961982	0.0090	23286	3.864E-07	6.14	1251	39.05	1.2564	1110187	0.0090	1587	5.644E-06	10.07						
914	30.46	1.0632	973833	0.0091	23266	3.910E-07	6.22	1261	39.29	1.2609	1111001	0.0093	1467	5.660E-06	10.19						
921	30.63	1.0679	985248	0.0090	21506	4.191E-07	6.28	1270	39.53	1.2657	1111855	0.0094	1468	5.639E-06	10.31						
928	30.80	1.0723	995339	0.0089	19742	4.499E-07	6.36	1279	39.78	1.2703	1112669	0.0087	1327	5.731E-06	10.42						
								1288	40.00	1.2744	1113361	0.0086	1104	6.100E-06	10.54						
								1297	40.24	1.2789	1114072	0.0091	1083	6.545E-06	10.65						
								1307	40.49	1.2835	1114764	0.0093	1053	6.884E-06	10.78						
								1316	40.75	1.2882	1115426	0.0092	1008	7.057E-06	10.90						
								1326	40.99	1.2927	1116072	0.0089	1014	7.325E-06	11.03						

TABLE I32 (Continued)

Specimen Id. FZGL18										Specimen Id. FZGL1B									
Page 3					Page 4														
PNUM	E/IB/P	A	M	AS	AN	AB/AN	AK	PNUM	E/IB/P	A	M	AS	AN	AB/AN	AK				
(lbs)	(in)	(in)	(X1)	(in)	(X1)	(in/cyc)	(ksf/in)	(lbs)	(in)	(in)	(X1)	(in)	(X1)	(in/cyc)	(ksf/in)				
1335	41.24	1.2971	1116639	0.0088	1062	8.264E-06	11.15	2126	64.77	1.6080	1141807	0.0087	122	7.129E-05	24.24				
1344	41.48	1.3015	1117134	0.0088	1016	8.630E-06	11.27	2140	65.20	1.6121	1141868	0.0089	122	7.340E-05	24.53				
1354	41.73	1.3059	1117655	0.0096	1146	8.337E-06	11.41	2151	65.69	1.6169	1141928	0.0086	115	7.418E-05	24.77				
1364	42.02	1.3110	1118280	0.0097	1147	8.426E-06	11.54	2166	66.09	1.6206	1141983	0.0090	109	8.211E-05	25.08				
1373	42.28	1.3155	1118802	0.0080	985	8.106E-06	11.66	2179	66.64	1.6259	1142038	0.0099	109	9.042E-05	25.35				
1383	42.48	1.3190	1119265	0.0081	995	8.150E-06	11.79	2193	67.13	1.6305	1142092	0.0092	109	8.442E-05	25.66				
1392	42.75	1.3236	1119797	0.0094	1041	9.059E-06	11.92	2207	67.62	1.6351	1142147	0.0091	109	8.327E-05	25.95				
1402	43.03	1.3284	1120306	0.0091	997	9.147E-06	12.05	2221	68.12	1.6396	1142201	0.0092	103	8.923E-05	26.25				
1412	43.29	1.3328	1120794	0.0088	932	9.416E-06	12.19	2235	68.63	1.6442	1142250	0.0091	97	9.442E-05	26.55				
1422	43.55	1.3372	1121238	0.0085	887	9.553E-06	12.32	2249	69.13	1.6487	1142298	0.0093	90	9.696E-05	26.87				
1432	43.79	1.3412	1121681	0.0091	951	9.580E-06	12.47	2262	69.67	1.6536	1142346	0.0091	90	1.006E-04	27.16				
1442	44.10	1.3463	1122189	0.0095	974	9.768E-06	12.60	2276	70.15	1.6578	1142398	0.0085	84	1.017E-04	27.47				
1453	44.37	1.3507	1122655	0.0092	921	9.992E-06	12.76	2290	70.65	1.6621	1142430	0.0090	84	1.070E-04	27.78				
1463	44.67	1.3555	1123110	0.0093	880	1.052E-05	12.90	2303	71.19	1.6668	1142472	0.0092	84	1.092E-04	28.09				
1473	44.95	1.3601	1123543	0.0085	804	1.051E-05	13.04	2318	71.71	1.6713	1142514	0.0097	84	1.153E-04	28.44				
1484	45.19	1.3640	1123914	0.0086	794	1.085E-05	13.19	2332	72.33	1.6764	1142556	0.0098	77	1.271E-04	28.76				
1494	45.49	1.3687	1124337	0.0095	853	1.116E-05	13.34	2347	72.88	1.6811	1142591	0.0089	65	1.365E-04	29.10				
1504	45.79	1.3735	1124767	0.0088	772	1.141E-05	13.48	2360	73.39	1.6853	1142621	0.0082	59	1.398E-04	29.42				
1514	46.05	1.3775	1125109	0.0082	689	1.186E-05	13.63	2375	73.89	1.6893	1142650	0.0093	58	1.594E-04	29.77				
1525	46.32	1.3817	1125456	0.0095	774	1.233E-05	13.80	2389	74.54	1.6946	1142679	0.0102	59	1.746E-04	30.11				
1536	46.67	1.3871	1125883	0.0100	805	1.243E-05	13.95	2405	75.16	1.6996	1142709	0.0096	59	1.622E-04	30.48				
1547	46.97	1.3917	1126261	0.0090	702	1.276E-05	14.12	2420	75.74	1.7042	1142738	0.0093	59	1.594E-04	30.85				
1558	47.26	1.3960	1126585	0.0085	646	1.320E-05	14.27	2434	76.35	1.7089	1142767	0.0089	52	1.730E-04	31.19				
1568	47.54	1.4002	1126907	0.0084	631	1.331E-05	14.43	2447	76.89	1.7131	1142790	0.0082	46	1.776E-04	31.54				
1579	47.83	1.4044	1127216	0.0088	619	1.421E-05	14.59	2461	77.42	1.7171	1142814	0.0085	47	1.831E-04	31.88				
1590	48.14	1.4090	1127526	0.0094	606	1.558E-05	14.75	2475	78.00	1.7216	1142836	0.0095	49	1.932E-04	32.25				
	48.47	1.4139	1127823					2492	78.68	1.7267	1142863	0.0107	52	2.086E-04	32.66				
	48.77	1.4180	1128102					2508	79.45	1.7323	1142888	0.0110	45	2.453E-04	33.09				
1808	54.57	1.4956	1139298	0.0088	342	2.569E-05	18.28	2522	80.18	1.7377	1142908	0.0096	41	2.088E-04	33.45				
1822	54.86	1.4993	1139445	0.0085	305	2.796E-05	18.51	2537	80.62	1.7409	1142929	0.0073	38	1.942E-04	33.85				
1833	55.26	1.5041	1139603	0.0096	318	3.010E-05	18.71	2551	81.19	1.7450	1142946	0.0096	44	2.204E-04	34.22				
1846	55.65	1.5089	1139762	0.0093	279	3.318E-05	18.93	2568	81.97	1.7505	1142972	0.0118	55	2.146E-04	34.67				
	56.03	1.5134	1139983					2582	82.88	1.7568	1143001	0.0100	45	2.288E-04	35.07				
	56.42	1.5180	1139993					2602	83.42	1.7605	1143017	0.0094	37	2.582E-04	35.60				
1915	56.87	1.5234	1140101	0.0314	862	3.644E-05	20.15	2614	84.25	1.7662	1143037	0.0099	40	2.476E-04	35.96				
1928	59.16	1.5494	1140854	0.0302	834	3.619E-05	20.39	2635	84.88	1.7704	1143057	0.0110	40	2.743E-04	36.52				
1971	59.53	1.5536	1140935	0.0096	173	5.714E-05	21.21	2649	85.90	1.7772	1143077	0.0116	40	2.905E-04	36.94				
1983	60.04	1.5591	1141027	0.0093	166	5.623E-05	21.42	2675	86.64	1.7820	1143097	0.0139	40	3.485E-04	37.68				
2000	60.39	1.5629	1141101	0.0104	192	5.400E-05	21.74	2702	88.06	1.7911	1143117	0.0209	45	4.708E-04	38.48				
2011	61.00	1.5695	1141220	0.0106	193	5.469E-05	21.96												
2024	61.38	1.5735	1141294	0.0067	123	6.058E-05	22.21												
2036	61.64	1.5762	1141343	0.0074	122	6.028E-05	22.45												
2048	62.08	1.5808	1141416	0.0097	147	6.621E-05	22.68												
2060	62.57	1.5859	1141490	0.0091	134	6.817E-05	22.92												
2074	62.97	1.5900	1141550	0.0085	128	6.632E-05	23.20												
2087	63.41	1.5944	1141618	0.0090	134	6.704E-05	23.45												
2100	63.86	1.5990	1141685	0.0090	128	7.016E-05	23.71												
2113	64.31	1.6034	1141746	0.0090	122	7.355E-05	23.98												

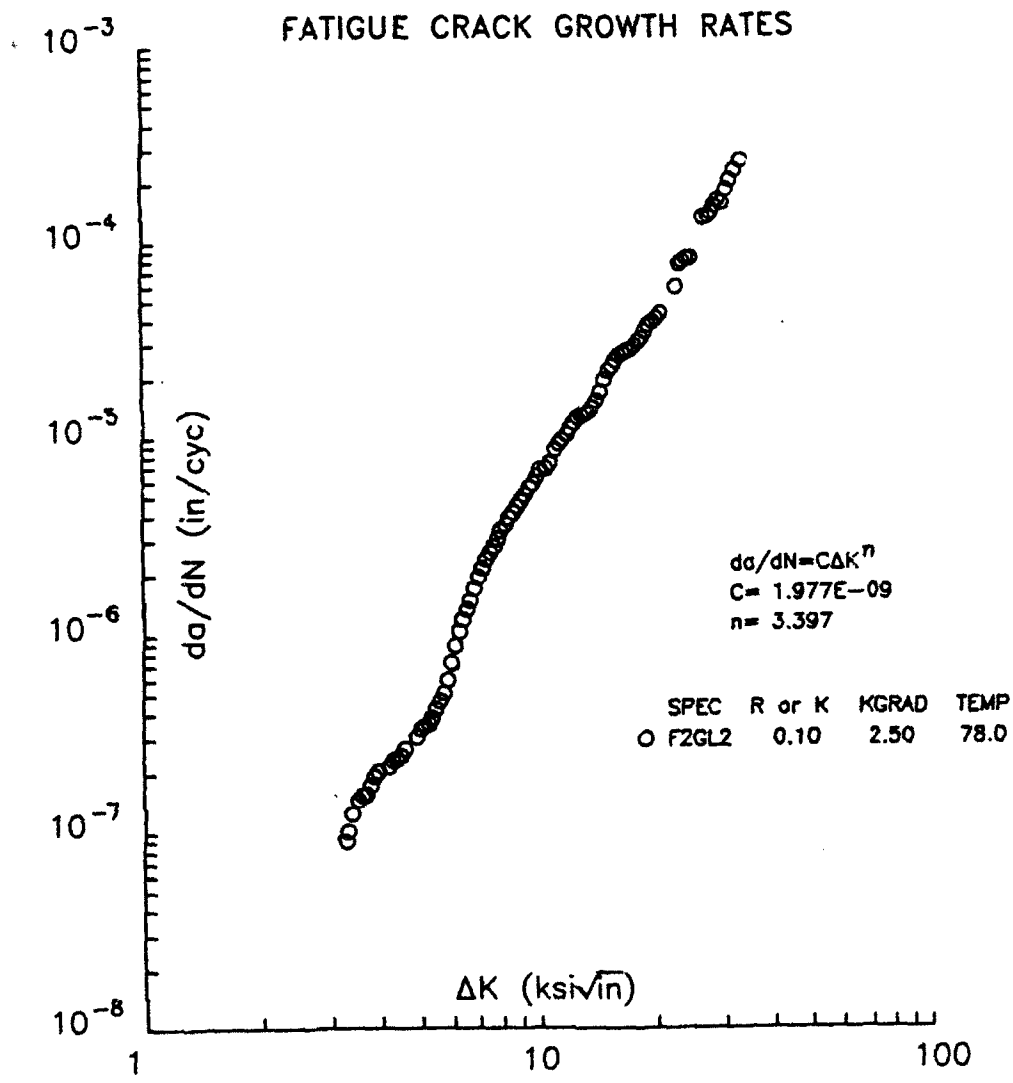


Figure I10. Fatigue Crack Growth Rate Data for 2095-T8 0.5 Inch Thick Plate (L-T orientation, KGRAD 2.50). Northrop.

TABLE I33

Fatigue Crack Growth Data Associated with Figure I10 (Specimen F2GL2)

AUTOMATED FATIGUE CRACK  
GROWTH RATE ANALYSIS

Specimen Id.	F2GL2	Geometry	C(T)
Contract #	WB02115.J	Orientation	L-T
Material	WELDALITE	Yield (ksi)	101.0
Temperature (F)	78	Modulus	10.6
Environment	Lab. air		

Specimen Dimensions (In)

Thickness	0.495	Notch depth	0.605
Width	2.996	Gage length	1.000
Height	3.600	Alpha ratio	1.250

Precrack Parameters

Pmax (lbs)	911.0	Stress ratio (R)	0.10
Final a (In)	0.680	Kmax	4.91

Test Parameters

Initial a (In)	0.771	Initial K	3.40
K-gradient	2.50	Stress ratio (R)	0.10

K Coeff	EvB/P Coeff	Analysis Codes
0.886000	1.000980	KRP     i   0
4.640000	-4.669510	
-13.320000	18.460'00	
14.720000	-236.824997	
-5.600000	1214.880000	
0.000000	-2143.570100	

Visual Observations

EvB/P	Crack (EvB/P)	Crack (visual)	Error	CAF
24.03	0.855	0.849	-.006	0.985
25.57	0.909	0.910	0.002	0.986
27.48	0.970	0.972	0.002	0.988
30.72	1.063	1.069	0.007	0.991
32.46	1.108	1.110	0.002	0.993
34.22	1.150	1.150	-.000	0.994
36.98	1.211	1.206	-.006	0.996

Comments

Date of test: 01-28-1992

TABLE I33 (Continued)

Specimen Id. F2Q2.2		Page 1		Specimen Id. F2Q2.2		Page 2							
Peak (lbs)	E <sub>AB</sub> /P (in)	ΔN (XI)	Δε/ΔN (in/cyc)	AK (kstr/in)	Peak (lbs)	E <sub>AB</sub> /P (in)	ΔN (XI)	Δε (in)	M (XI)	Δε (in)	ΔN (XI)	Δε/ΔN (in/cyc)	AK (kstr/in)
605	21.89	0.7752	0.0181	3.23	1309	40.08	1.2723	0.0271	1498556	0.0271	3696	7.333E-06	10.65
614	22.12	0.7841	0.0185	3.31	1337	40.56	1.2812	0.0172	1499582	0.0172	1386	8.666E-06	11.01
623	22.35	0.7933	0.0186	3.38	1356	41.02	1.2895	0.0177	1500542	0.0177	1906	9.275E-06	11.26
632	22.60	0.8027	0.0181	3.46	1375	41.54	1.2988	0.0181	1501488	0.0181	1846	9.793E-06	11.50
642	23.08	0.8207	0.0178	3.54	1395	42.03	1.3076	0.0186	1502388	0.0186	1761	1.030E-05	11.77
651	23.32	0.8296	0.0184	3.62	1415	42.57	1.3170	0.0178	1503250	0.0178	1682	1.106E-05	12.04
661	23.58	0.8391	0.0185	3.70	1435	43.11	1.3262	0.0169	1504070	0.0169	1499	1.190E-05	12.31
671	23.83	0.8481	0.0182	3.79	1455	43.62	1.3348	0.0174	1504748	0.0174	1336	1.266E-05	12.59
681	24.09	0.8573	0.0183	3.88	1475	44.12	1.3431	0.0169	1505406	0.0169	1348	1.288E-05	12.87
	24.35	0.8665			1496	44.68	1.3522	0.0187	1506096	0.0187	1413	1.332E-05	13.16
	24.60	0.8752			1517	45.29	1.3619	0.0167	1506819	0.0167	1384	1.351E-05	13.46
711	24.88	0.8853	0.0196	4.15	1539	45.85	1.3709	0.0179	1507480	0.0179	1261	1.423E-05	13.78
723	25.16	0.8949	0.0191	4.25	1561	46.43	1.3799	0.0181	1508080	0.0181	1168	1.553E-05	14.09
733	25.44	0.9044	0.0185	4.35	1583	47.03	1.3890	0.0179	1508648	0.0179	1046	1.713E-05	14.41
744	25.71	0.9133	0.0180	4.45	1605	47.62	1.3978	0.0179	1509125	0.0179	901	1.981E-05	14.74
755	25.98	0.9224	0.0185	4.55	1626	48.23	1.4069	0.0177	1509550	0.0177	805	2.204E-05	15.07
	26.27	0.9318			1648	48.83	1.4156	0.0172	1509930	0.0172	740	2.323E-05	15.40
	26.51	0.9395			1671	49.42	1.4240	0.0181	1510289	0.0181	720	2.509E-05	15.76
789	26.87	0.9509	0.0204	4.86	1693	50.10	1.4336	0.0184	1510651	0.0184	698	2.643E-05	16.10
801	27.15	0.9599	0.0179	4.99	1717	50.75	1.4425	0.0180	1510987	0.0180	661	2.721E-05	16.48
813	27.44	0.9688	0.0180	5.10	1741	51.42	1.4516	0.0183	1511312	0.0183	649	2.815E-05	16.86
825	27.74	0.9779	0.0182	5.21	1764	52.11	1.4608	0.0181	1511635	0.0181	636	2.846E-05	17.24
837	28.04	0.9870	0.0184	5.33	1789	52.79	1.4697	0.0181	1511947	0.0181	610	2.962E-05	17.64
850	28.35	0.9963	0.0191	5.46	1812	53.50	1.4788	0.0174	1512246	0.0174	559	3.119E-05	18.02
862	28.69	1.0061	0.0189	5.58	1836	54.16	1.4871	0.0173	1512506	0.0173	534	3.231E-05	18.43
876	29.00	1.0152	0.0182	5.71	1861	54.88	1.4961	0.0190	1512780	0.0190	547	3.484E-05	18.86
889	29.32	1.0243	0.0185	5.84	1886	55.71	1.5062	0.0193	1513053	0.0193	508	3.800E-05	19.29
902	29.66	1.0337	0.0187	5.98	1912	56.47	1.5154	0.0180	1513287	0.0180	457	3.944E-05	19.75
915	29.99	1.0430	0.0186	6.12	1938	57.23	1.5242	0.0180	1513510	0.0180	444	4.056E-05	20.21
929	30.33	1.0523	0.0184	6.26	1964	58.02	1.5334	0.0186	1513732	0.0186	431	4.310E-05	20.68
943	30.67	1.0614	0.0182	6.40									
956	31.01	1.0705	0.0180	6.54									
970	31.35	1.0794	0.0179	6.69	2068	61.43	1.5707	0.0185	1514642	0.0185	312	5.938E-05	22.62
985	31.70	1.0885	0.0185	6.84	2096	62.20	1.5789	0.0169	1514751	0.0169	218	7.773E-05	23.17
999	32.07	1.0979	0.0185	7.00	2121	63.06	1.5876	0.0175	1514860	0.0175	218	8.041E-05	23.66
1014	32.43	1.1070	0.0187	7.16	2147	63.92	1.5963	0.0179	1514969	0.0179	217	8.238E-05	24.20
1029	32.82	1.1166	0.0186	7.32	2175	64.85	1.6055	0.0190	1515077	0.0190	230	8.254E-05	24.77
1044	33.19	1.1256	0.0181	7.49									
1060	33.56	1.1346	0.0187	7.67									
1076	33.97	1.1443	0.0191	7.84									
1091	34.37	1.1537	0.0179	8.02	2265	68.57	1.6405	0.0202	1515325	0.0202	152	1.331E-04	26.66
1108	34.74	1.1622	0.0181	8.21	2302	69.12	1.6455	0.0137	1515438	0.0137	100	1.372E-04	27.47
1124	35.17	1.1719	0.0192	8.39	2325	70.11	1.6543	0.0183	1515536	0.0183	129	1.413E-04	27.97
1140	35.59	1.1814	0.0183	8.59	2352	71.20	1.6638	0.0184	1515606	0.0184	120	1.538E-04	28.60
1157	35.99	1.1902	0.0185	8.79	2381	72.25	1.6727	0.0181	1515658	0.0181	109	1.552E-04	29.27
1174	36.41	1.1993	0.0179	8.98	2409	73.35	1.6818	0.0177	1515716	0.0177	111	1.594E-04	29.92
1191	36.84	1.2085	0.0183	9.19	2437	74.40	1.6904	0.0171	1515769	0.0171	93	1.848E-04	30.58
1208	37.28	1.2176	0.0181	9.40	2471	75.47	1.6990	0.0209	1515809	0.0209	101	2.070E-04	31.39
1226	37.72	1.2266	0.0180	9.61	2511	77.06	1.7113	0.0289	1515870	0.0289	123	2.346E-04	32.40
1244	38.17	1.2356	0.0185	9.84	2550	79.25	1.7278	0.0209	1515932	0.0209	123	2.346E-04	32.40
1262	38.66	1.2452	0.0185	10.05									
1291	39.12	1.2540	0.0272	10.42	82.87	1.7538	1.7538	0.0280	1516023	0.0280	126	2.634E-04	33.38
					85.09	1.7689	1.7689		1516111				

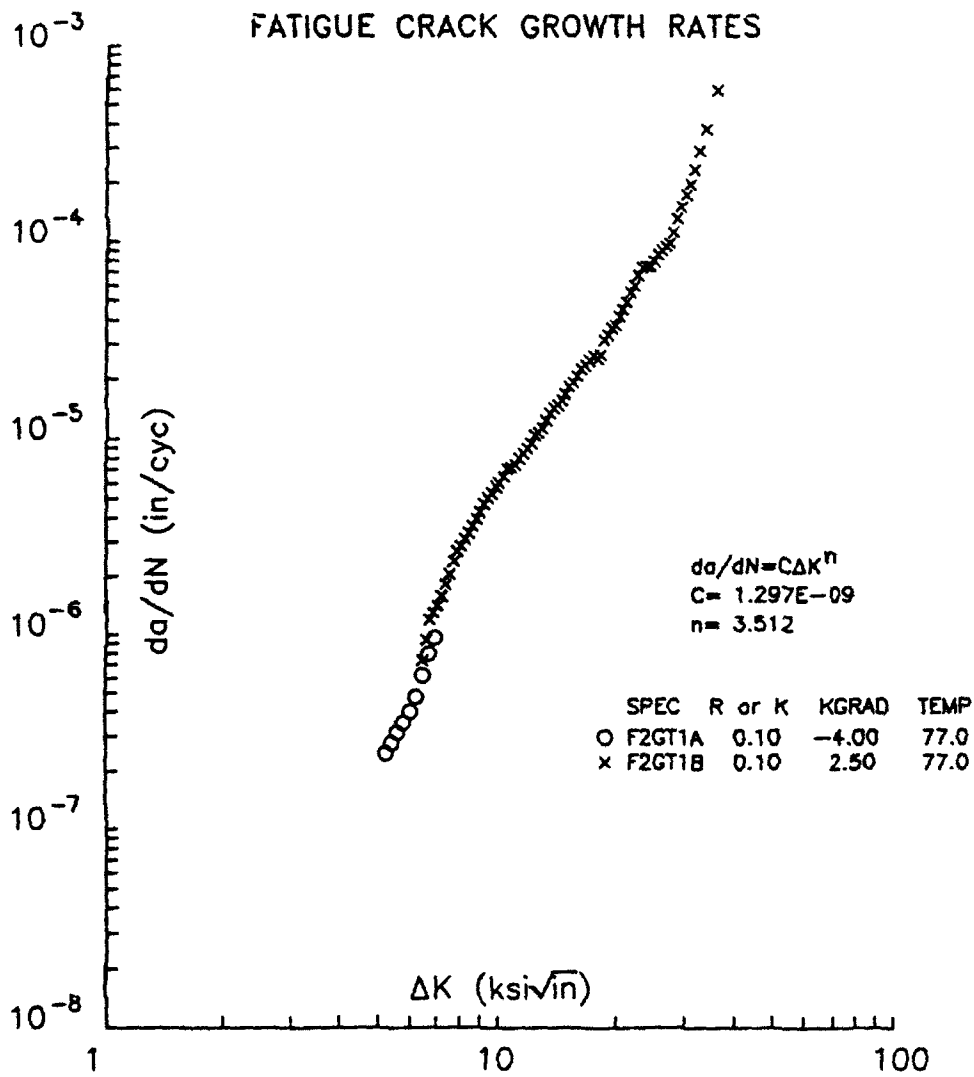


Figure I11. Fatigue Crack Growth Rate Data for 2095-T8 0.5 Inch Thick Plate (T-L orientation, KGRAD - 4.00 and 2.50). Northrop.

TABLE I34

Fatigue Crack Growth Data Associated with Figure I11 (Specimen F2GT1A)

**AUTOMATED FATIGUE CRACK  
GROWTH RATE ANALYSIS**

Specimen Id.	F2GT1A	Geometry	C(T)
Contract #	WB02115N	Orientation	T-L
Material	WELDALITE	Yield (ksi)	51.0
Temperature (F)	77	Modulus	10.9
Environment	Lab. air		

Specimen Dimensions (in)

Thickness	0.486	Notch depth	0.614
Width	2.997	Gage length	1.000
Height	3.600	Alpha ratio	1.250

Precrack Parameters

Pmax (lbs)	1271.0	Stress ratio (R)	0.10
Final a (in)	0.901	Kmax	8.50

Test Parameters

Initial a (in)	0.901	Initial K	8.50
K-gradient	-4.00	Stress ratio (R)	0.10

K Coeff	EvB/P Coeff	Analysis Codes
0.886000	1.000980	KRP 2 0
4.640000	-4.669510	
-13.320000	18.460100	
14.720000	-236.824997	
-5.600000	1214.880000	
0.000000	-2143.570100	

Visual Observations

EvB/P	Crack (EvB/P)	Crack (visual)	Error	CAF
24.97	0.900	0.872	-.028	1.000
26.23	0.941	0.947	0.005	1.000
28.03	0.996	1.010	0.014	1.000
32.61	1.118	1.119	0.001	1.000
37.42	1.224	1.203	-.021	1.000
40.54	1.285	1.261	-.024	1.000
47.82	1.405	1.381	-.024	1.000
50.85	1.447	1.426	-.022	1.000
55.56	1.508	1.481	-.027	1.000
58.77	1.545	1.525	-.020	1.000

Pmax (lbs)	EvB/P	a (in)	N (X1)	Δa (in)	ΔN (X1)	Δa/ΔN (in/cyc)	ΔK (ksi/in)
	25.44	0.9161	12656				
1127	25.73	0.9256	21925	0.0183	18984	9.616E-07	6.93
1078	26.00	0.9343	31640	0.0174	21722	8.018E-07	6.68
1033	26.27	0.9430	43646	0.0174	28109	6.203E-07	6.45
989	26.55	0.9518	59749	0.0179	37173	4.808E-07	6.22
947	26.85	0.9609	80820	0.0183	45759	3.998E-07	6.01
906	27.15	0.9701	105508	0.0185	52122	3.552E-07	5.79
867	27.46	0.9794	132941	0.0183	57804	3.164E-07	5.58
829	27.76	0.9884	163312	0.0178	64272	2.772E-07	5.38
794	28.06	0.9972	197213	0.0178	71996	2.477E-07	5.19
	28.37	1.0062	235308				

TABLE I35

Fatigue Crack Growth Data Associated with Figure I11 (Specimen F2GT1B)

AUTOMATED FATIGUE CRACK GROWTH RATE ANALYSIS

Specimen Id.	F2GT1B	Geometry	C(T)
Contract #	WB02115N	Orientation	T-L
Material	WELDALITE	Yield (ksi)	101.0
Temperature (F)	77	Modulus	10.9
Environment	Lab. air		

Specimen Dimensions (in)

Thickness	0.486	Notch depth	0.614
Width	2.997	Gage length	0.200
Height	3.600	Alpha ratio	1.000

Precrack Parameters

Pmax (lbs)	1271.0	Stress ratio (R)	0.10
Final a (in)	0.901	Kmax	8.50

Test Parameters

Initial a (in)	1.064	Initial K	4.40
K-gradient	2.50	Stress ratio (R)	0.10

K Coeff	EvB/P Coeff	Analysis Codes
0.886000	1.000980	KRP 2 0
4.640000	-4.669510	
-13.320000	18.460100	
14.720000	-236.824997	
-5.600000	1214.880000	
0.000000	-2143.570100	

Visual Observations

EvB/P	Crack (EvB/P)	Crack (visual)	Error	CAF
24.97	0.900	0.872	-.028	1.000
26.23	0.941	0.947	0.005	1.000
28.03	0.996	1.010	0.014	1.000
32.61	1.118	1.119	0.001	1.000
37.42	1.224	1.203	-.021	1.000
40.54	1.285	1.261	-.024	1.000
47.82	1.405	1.381	-.024	1.000
50.85	1.447	1.426	-.022	1.000
55.56	1.508	1.481	-.027	1.000
58.77	1.545	1.525	-.020	1.000

Comments

Date of test: 01-14-1992

TABLE I35 (Continued)

Specimen Id. F2GT1B		Page 1		Specimen Id. F2GT1B		Page 2							
Peak (lbs)	E4B/P (In)	M (X1)	Aa (In)	AN (X1)	ΔE/AN (In/Cyc)	ΔK (KSI/In)	Peak (lbs)	E4B/P (In)	M (X1)	Aa (In)	AN (X1)	ΔE/AN (In/Cyc)	ΔK (KSI/In)
784	38.67	1.2491	493512	24618	7.364E-07	6.43	1483	74.00	1.6905	0.0185	548	3.362E-05	18.93
795	39.13	1.2582	506627	19751	9.345E-07	6.58	1502	75.09	1.6992	0.0178	484	3.675E-05	19.38
806	40.11	1.2673	518130	15063	1.195E-06	6.73	1518	76.24	1.7083	0.0174	459	3.788E-05	19.80
818	40.59	1.2853	533193	13111	1.306E-06	6.88	1536	77.31	1.7166	0.0169	402	4.174E-05	20.24
830	41.04	1.2938	539489	12495	1.413E-06	7.04	1552	78.45	1.7251	0.0166	362	4.587E-05	20.66
842	41.55	1.3029	545688	11807	1.579E-06	7.20	1571	79.53	1.7332	0.0192	386	4.960E-05	21.17
854	42.09	1.3124	551296	10345	1.815E-06	7.36	1589	81.07	1.7443	0.0202	364	5.544E-05	21.63
866	42.63	1.3217	556032	8543	2.059E-06	7.53	1609	82.36	1.7534	0.0183	303	6.044E-05	22.19
879	43.11	1.3300	559839	7405	2.422E-06	7.71	1628	83.70	1.7627	0.0189	277	6.844E-05	22.72
890	43.69	1.3396	563437	6559	2.717E-06	7.87	1645	85.13	1.7723	0.0179	240	7.508E-05	23.22
903	44.18	1.3478	566396	6017	2.876E-06	8.06	1664	86.38	1.7806	0.0172	228	7.508E-05	23.76
916	44.74	1.3569	569454	5983	3.106E-06	8.24	1682	87.77	1.7895	0.0182	240	7.508E-05	24.29
929	45.33	1.3664	572381	5491	3.334E-06	8.42	1700	89.23	1.7987	0.0181	228	7.508E-05	24.84
942	45.90	1.3752	574945	4884	3.626E-06	8.62	1719	90.29	1.8077	0.0186	216	8.507E-05	25.43
955	46.47	1.3841	577265	4461	3.954E-06	8.81	1738	92.29	1.8173	0.0196	216	9.076E-05	26.04
968	47.04	1.3929	579406	4126	4.271E-06	9.01	1757	93.98	1.8272	0.0193	203	9.507E-05	26.66
982	47.63	1.4017	581391	3816	4.681E-06	9.21	1776	95.63	1.8366	0.0176	178	9.507E-05	27.27
995	48.24	1.4107	583221	3564	4.994E-06	9.42	1796	97.09	1.8448	0.0185	166	1.166E-04	27.95
1009	48.85	1.4195	584955	3442	5.323E-06	9.64	1814	99.00	1.8551	0.0201	153	1.166E-04	28.59
1022	49.52	1.4291	586663	2967	5.790E-06	9.84	1835	100.84	1.8649	0.0202	133	1.166E-04	29.34
1036	50.07	1.4367	587922	2739	6.013E-06	10.07	1855	102.87	1.8753	0.0203	116	1.166E-04	30.07
1051	50.70	1.4455	589402	3050	6.479E-06	10.30	1874	104.84	1.8852	0.0179	91	1.166E-04	30.77
1064	51.51	1.4545	590972	2701	7.150E-06	10.53	1895	106.49	1.8932	0.0191	81	2.596E-04	31.59
1080	52.14	1.4648	592103	2339	7.215E-06	10.78	1918	108.82	1.9043	0.0260	88	2.596E-04	32.51
1095	52.79	1.4734	593311	2491	7.466E-06	11.04	1949	112.09	1.9192	0.0345	91	3.0010E-04	33.78
1109	53.58	1.4834	594594	2319	7.986E-06	11.27	2004	116.58	1.9388	0.0579	96	6.130E-04	36.14
1125	54.25	1.4919	595631	2075	8.472E-06	11.55		126.20	1.9771				
1139	54.99	1.5010	596669	2031	8.943E-06	11.80							
1154	55.73	1.5100	597662	1807	9.508E-06	12.06							
1170	56.42	1.5182	598476	1695	1.042E-05	12.34							
1184	57.22	1.5277	599357	1681	1.079E-05	12.60							
1200	57.98	1.5363	600157	1573	1.138E-05	12.90							
1216	58.79	1.5456	600930	1489	1.250E-05	13.20							
1232	59.64	1.5550	601647	1375	1.341E-05	13.50							
1248	60.48	1.5641	602305	1275	1.422E-05	13.82							
1264	61.32	1.5731	602921	1162	1.482E-05	14.12							
1281	62.11	1.5813	603467	1136	1.570E-05	14.45							
1296	63.04	1.5909	604057	1082	1.681E-05	14.76							
1313	63.90	1.5995	604549	980	1.845E-05	15.12							
1329	64.86	1.6090	605036	931	1.943E-05	15.45							
1346	65.75	1.6176	605480	867	2.070E-05	15.81							
1363	66.73	1.6269	605903	828	2.256E-05	16.17							
1380	67.73	1.6363	606308	760	2.367E-05	16.54							
1397	68.68	1.6449	606663	712	2.496E-05	16.93							
1414	69.71	1.6541	607021	669	2.651E-05	17.29							
1432	70.69	1.6627	607332	709	2.556E-05	17.70							
1448	71.80	1.6722	607730	670	2.692E-05	18.08							
1467	72.81	1.6807	608001	573	3.185E-05	18.53							

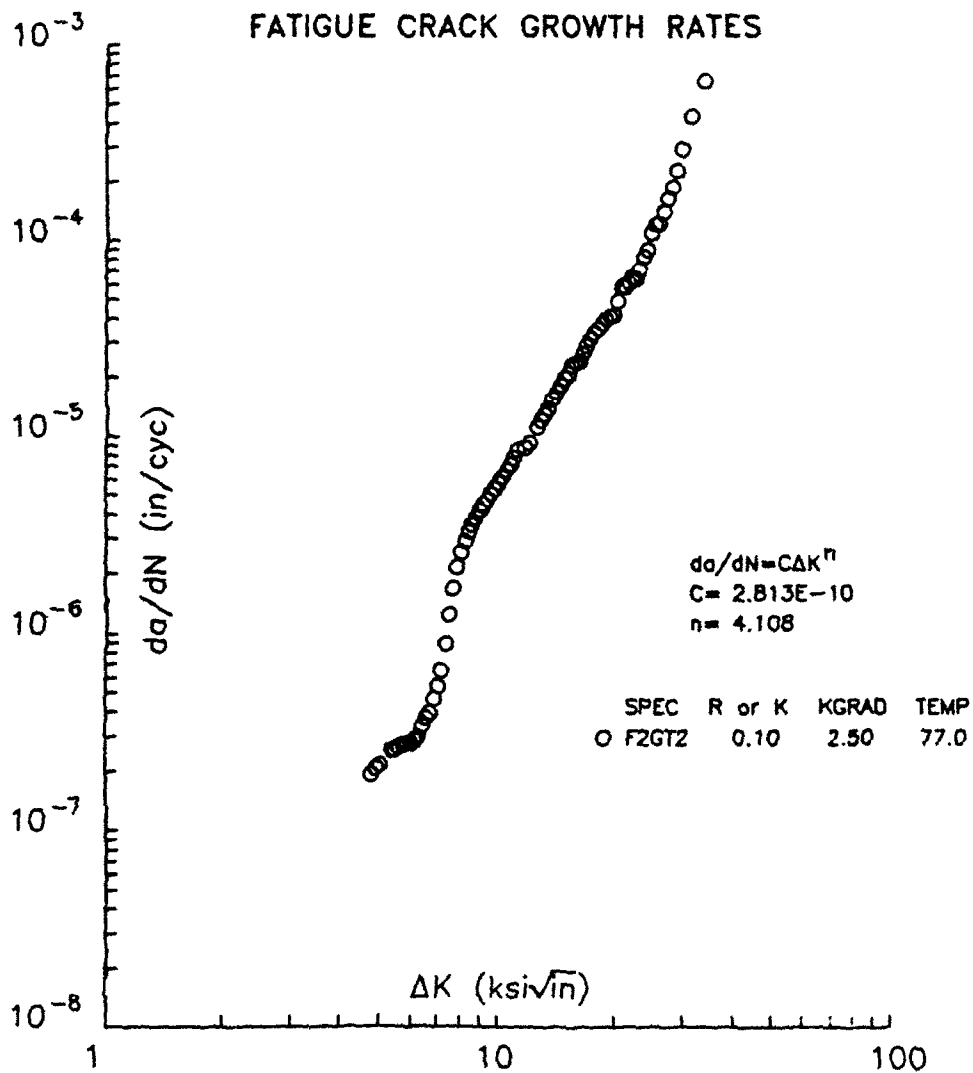


Figure I12. Fatigue Crack Growth Rate Data for 2095-T8 0.5 Inch Thick Plate (T-L orientation, KGRAD 2.50). Northrop.

TABLE I36

Fatigue Crack Growth Data Associated with Figure I12 (Specimen F2GT2)

AUTOMATED FATIGUE CRACK  
GROWTH RATE ANALYSIS

Specimen Id.	F2GT2	Geometry	C(T)
Contract #	WB02115N	Orientation	T-L
Material	WELDALITE	Yield (ksi)	101.0
Temperature (F)	77	Modulus	10.8
Environment	Lab. air		

Specimen Dimensions (In)

Thickness	0.494	Notch depth	0.605
Width	2.999	Gage length	0.200
Height	3.600	Alpha ratio	1.000

Pre-crack Parameters

Pmax (lbs)	1166.0	Stress ratio (R)	0.10
Final a (in)	0.665	Kmax	6.21

Test Parameters

Initial a (in)	0.741	Initial K	4.60
K-gradient	2.50	Stress ratio (R)	0.10

K Coeff	EvB/P Coeff	Analysis Codes
0.886000	1.000980	KRP 1 0
4.640000	-4.569510	
-13.320000	18.460100	
14.720000	-236.824997	
-5.600000	1214.880000	
0.000000	-2143.570100	

Visual Observations

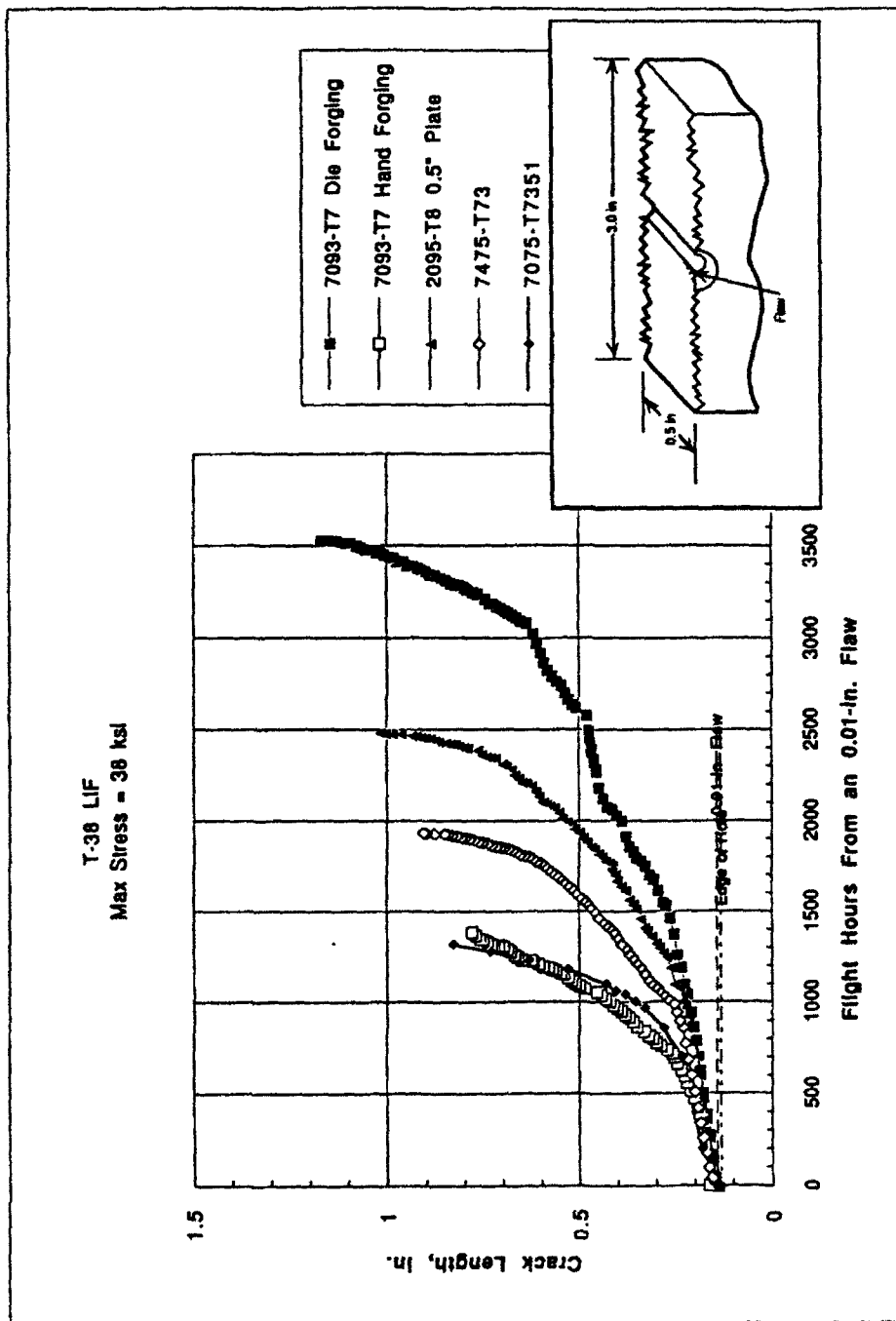
EvB/P	Crack (EvB/P)	Crack (visual)	Error	CAF
21.66	0.785	0.795	0.010	1.006
23.23	0.844	0.842	-0.002	1.005
28.22	1.003	0.990	-0.014	1.001
34.19	1.154	1.151	-0.003	0.998
36.97	1.213	1.219	0.005	0.997
46.28	1.377	1.379	0.002	0.993

Comments

Date of test: 02-12-1992

TABLE I36 (Continued)

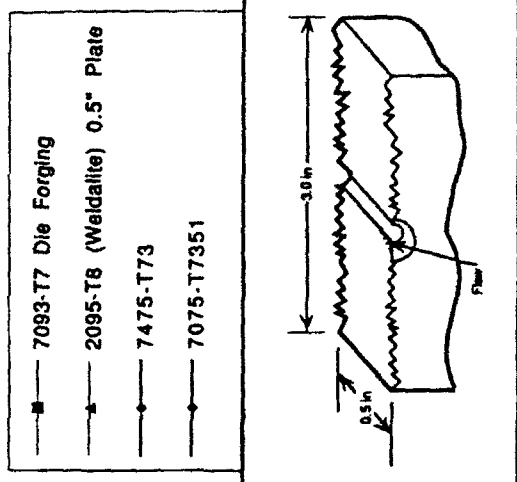
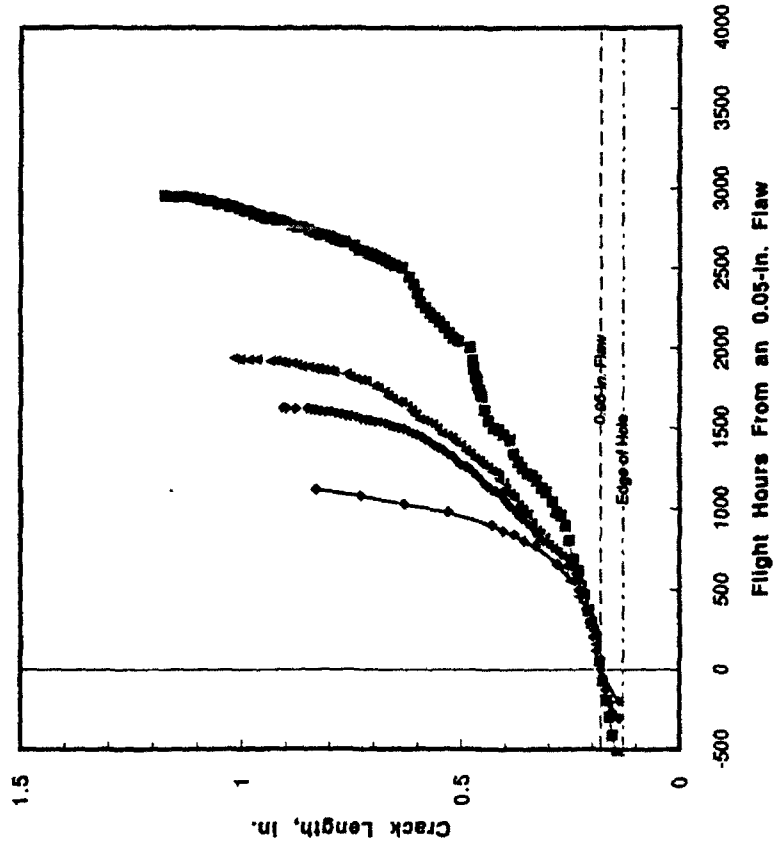
Specimen Id. F2GT2				Page 1				Specimen Id. F2GT2				Page 2			
Pmax (lbs)	E48/P (in)	M (X1)	Aa (in)	AN (X1)	ΔL/ΔN (in/cyc)	AK (ksi/in)	Pmax (lbs)	E48/P (in)	M (X1)	Aa (in)	AN (X1)	ΔL/ΔN (in/cyc)	AK (ksi/in)		
878	21.74	0.7885	0.0239	122269	1.957E-07	4.76	1816	38.21	1.2378	1007739	0.0185	1.842E-05	14.38		
895	22.13	0.8035	0.0178	89112	2.094E-07	4.91	1842	38.67	1.2467	1008195	0.0168	1.995E-05	14.70		
908	22.36	0.8124	0.0177	81995	2.162E-07	5.02	1869	39.08	1.2546	1008581	0.0172	2.135E-05	15.04		
	22.60	0.8213					1895	39.58	1.2640	1009003	0.0182	2.337E-05	15.36		
	23.84	0.8301					1922	40.05	1.2728	1009359	0.0188	2.428E-05	15.71		
951	23.15	0.8415	0.0154	59790	2.583E-07	5.39	1948	40.50	1.2808	1009696	0.0163	2.467E-05	16.05		
964	23.34	0.8484	0.0175	67507	2.585E-07	5.49	1976	40.95	1.2891	1010019	0.0175	2.718E-05	16.40		
978	23.59	0.8570	0.0178	66576	2.674E-07	5.62	2004	41.48	1.2984	1010341	0.0189	2.991E-05	16.77		
992	24.10	0.8658	0.0177	64210	2.749E-07	5.74	2034	42.03	1.3080	1010651	0.0187	3.210E-05	17.17		
1007	24.35	0.8748	0.0174	62704	2.768E-07	5.87	2065	42.56	1.3171	1010924	0.0184	3.452E-05	17.58		
1022	24.61	0.8835	0.0176	62694	2.804E-07	6.01	2095	43.11	1.3264	1011184	0.0180	3.648E-05	17.98		
1037	24.88	0.8921	0.0178	61327	2.899E-07	6.14	2124	43.64	1.3351	1011419	0.0171	3.856E-05	18.39		
1052	25.15	0.9099	0.0169	55847	3.018E-07	6.27	2154	44.15	1.3435	1011628	0.0170	4.059E-05	18.79		
1068	25.39	0.9179	0.0171	50008	3.423E-07	6.42	2185	44.69	1.3521	1011838	0.0183	4.236E-05	19.23		
1083	25.68	0.9270	0.0184	49275	3.744E-07	6.56	2215	45.30	1.3618	1012059	0.0186	4.284E-05	19.66		
1100	25.97	0.9364	0.0183	45915	3.990E-07	6.71	2254	45.88	1.3707	1012273	0.0216	5.035E-05	20.22		
1116	26.26	0.9453	0.0175	37374	4.673E-07	6.87	2281	46.70	1.3834	1012489	0.0191	5.992E-05	20.61		
1133	26.54	0.9538	0.0171	31500	5.435E-07	7.02	2317	47.12	1.3898	1012591	0.0141	5.919E-05	21.14		
1150	26.82	0.9625	0.0181	27552	6.575E-07	7.18	2345	47.63	1.3975	1012727	0.0169	6.259E-05	21.56		
1168	27.14	0.9719	0.0193	21664	8.924E-07	7.35	2375	48.26	1.4067	1012861	0.0178	6.640E-05	22.00		
1186	27.47	0.9818	0.0184	14654	1.254E-06	7.52	2408	48.84	1.4153	1012995	0.0175	7.262E-05	22.50		
1204	27.77	0.9903	0.0171	10089	1.682E-06	7.70	2441	49.47	1.4242	1013128	0.0185	7.262E-05	23.01		
1223	28.07	0.9989	0.0182	8338	2.192E-06	7.88	2476	50.15	1.4337	1013249	0.0191	8.337E-05	23.55		
1240	28.40	1.0085	0.0175	6790	2.579E-06	8.04	2510	50.84	1.4434	1013358	0.0187	9.139E-05	24.11		
1259	28.69	1.0164	0.0163	5587	2.926E-06	8.23	2547	51.51	1.4524	1013454	0.0189	1.109E-04	24.70		
1276	28.99	1.0248	0.0170	5179	3.280E-06	8.40	2582	52.25	1.4623	1013528	0.0191	1.228E-04	25.27		
1314	29.30	1.0334	0.0175	4905	3.567E-06	8.59	2622	52.96	1.4715	1013609	0.0199	1.228E-04	25.92		
1334	29.64	1.0423	0.0179	4606	3.882E-06	8.78	2660	53.79	1.4821	1013688	0.0210	1.426E-04	26.56		
1354	29.97	1.0513	0.0178	4206	4.226E-06	8.98	2703	54.62	1.4925	1013756	0.0213	1.691E-04	27.29		
1374	30.31	1.0601	0.0180	3983	4.509E-06	9.19	2741	55.51	1.5035	1013815	0.0196	1.921E-04	27.94		
1394	30.66	1.0693	0.0177	3677	4.803E-06	9.39	2789	56.23	1.5121	1013859	0.0212	2.340E-04	28.77		
1415	31.00	1.0778	0.0168	3286	5.103E-06	9.60	2840	57.29	1.5247	1013905	0.0288	3.017E-04	29.68		
1435	31.33	1.0860	0.0174	3197	5.429E-06	9.82	2925	58.71	1.5409	1013954	0.0441	4.411E-04	31.23		
1457	31.69	1.0951	0.0184	3168	5.811E-06	10.04	3056	61.26	1.5688	1014005	0.0715	6.679E-04	33.69		
1479	32.07	1.1044	0.0181	2901	6.237E-06	10.27		65.57	1.6124	1014061					
1500	32.44	1.1132	0.0172	2542	6.785E-06	10.50									
1523	32.79	1.1217	0.0172	2360	7.285E-06	10.74									
1545	33.17	1.1304	0.0180	2279	7.893E-06	10.98									
1593	33.57	1.1397	0.0184	2132	8.632E-06	11.23									
1617	33.97	1.1488	0.0360	4047	8.883E-06	11.76									
1663	35.18	1.1756	0.0357	3811	9.359E-06	12.03									
1688	35.59	1.1845	0.0166	1463	1.136E-05	12.56									
1711	35.96	1.1922	0.0168	1365	1.231E-05	12.85									
1738	36.39	1.2013	0.0180	1369	1.312E-05	13.12									
1762	36.83	1.2102	0.0193	1363	1.415E-05	13.45									
1791	37.34	1.2206	0.0180	1147	1.571E-05	13.73									
	37.72	1.2282	0.0172	1017	1.696E-05	14.08									



T-38 LIF & v. N 0.01" 4/24/92

Figure I13. T38 LIF Spectrum Fatigue Crack Growth Rate Data for 2095-T8 0.5 Inch Plate (Max Stress = 38 Ksi, Flaw = 0.01 inch). Northrop.

T-38 LIF  
Max Stress = 38 ksi



T-38 LIF a v. N 0.05" 5/8/92

Figure 114. T38 LIF Spectrum Fatigue Crack Growth Rate Data for 2095-T8 0.5 Inch Plate (Max Stress = 38 Ksi, Flaw = 0.05 inch). Northrop.

T-38 LIF Spectrum Fatigue

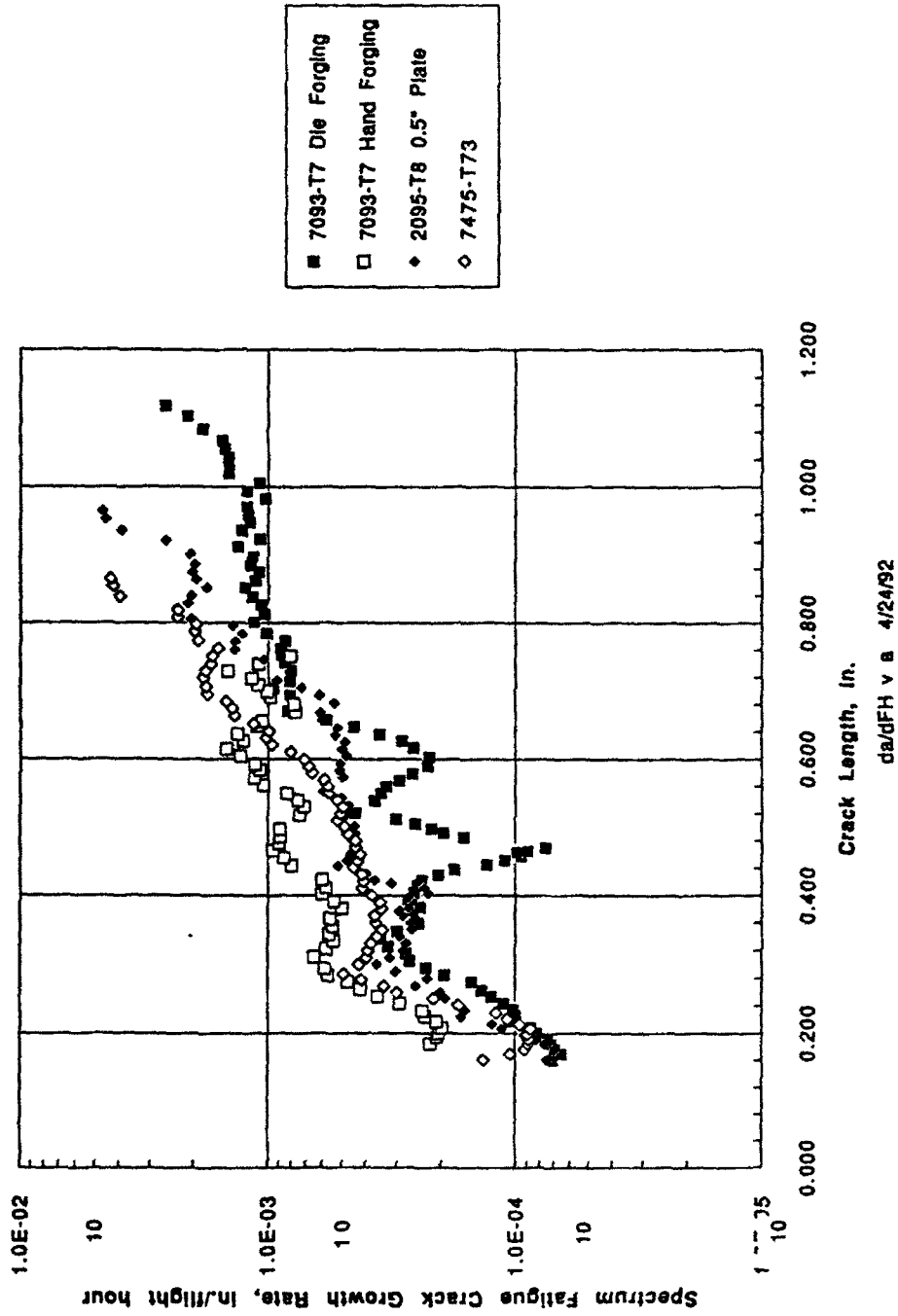


Figure I15. T38 LIF Spectrum Fatigue Crack Growth Rate Data for 2095-T8 0.5 Inch Plate (Max Stress = 38 Ksi). Northrop.

## SECTION V

### CONCLUSIONS

Seven aerospace laboratories participated in generating data on the 2095-T8 0.5-inch-thick plate for the cooperative test program. These data combined with previous interim reports on the Air Force/Industry Cooperative Test Program on Advanced Aluminum Alloys provide an extensive data base on aluminum-lithium alloys.