Curve Fitting Crack Growth Rate Data from the Fracture Mechanics Database

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Anthony Sadler

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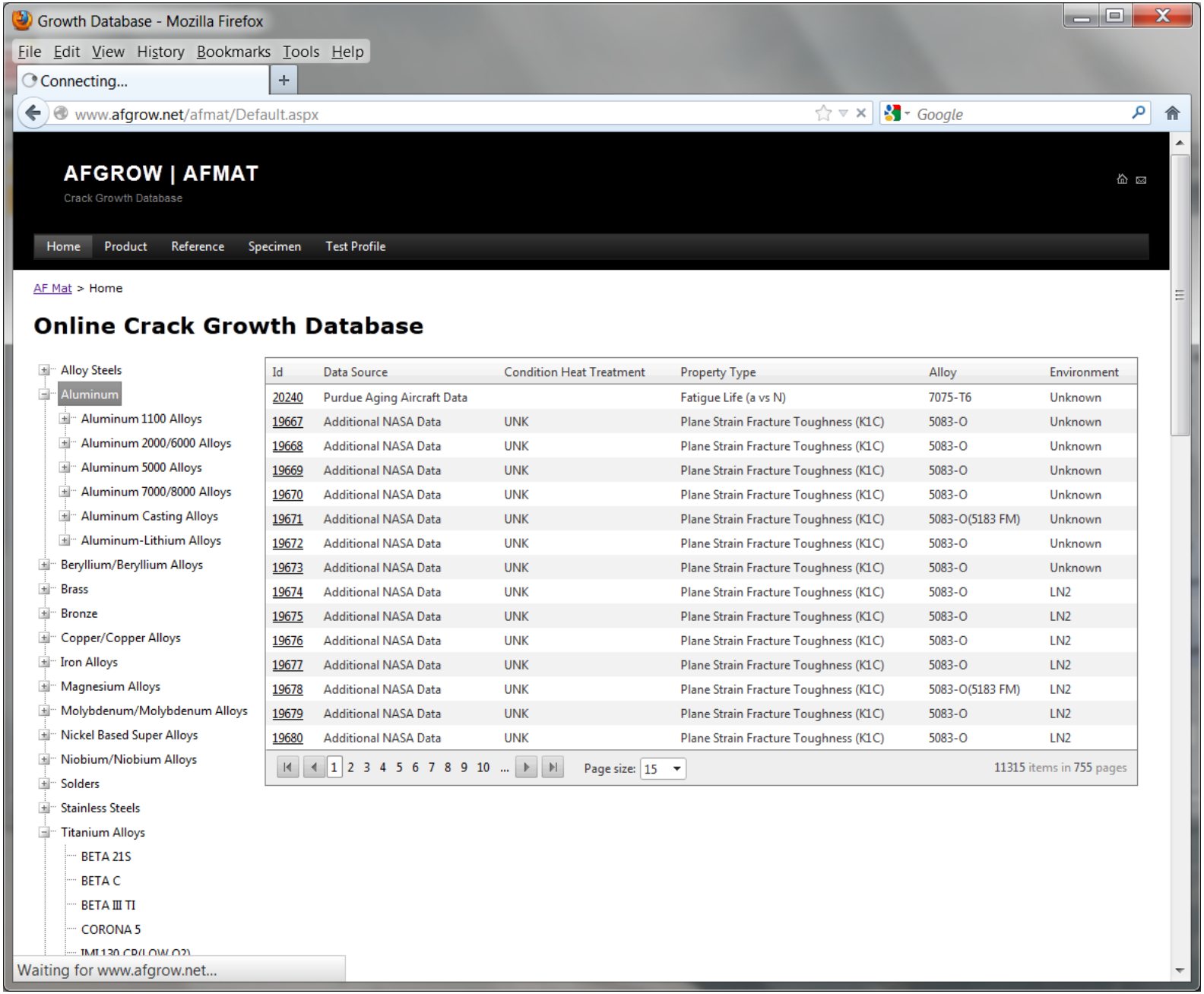
Growth Database - Mozilla Firefox
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Connecting...
www.afgrow.net/afmat/Default.aspx
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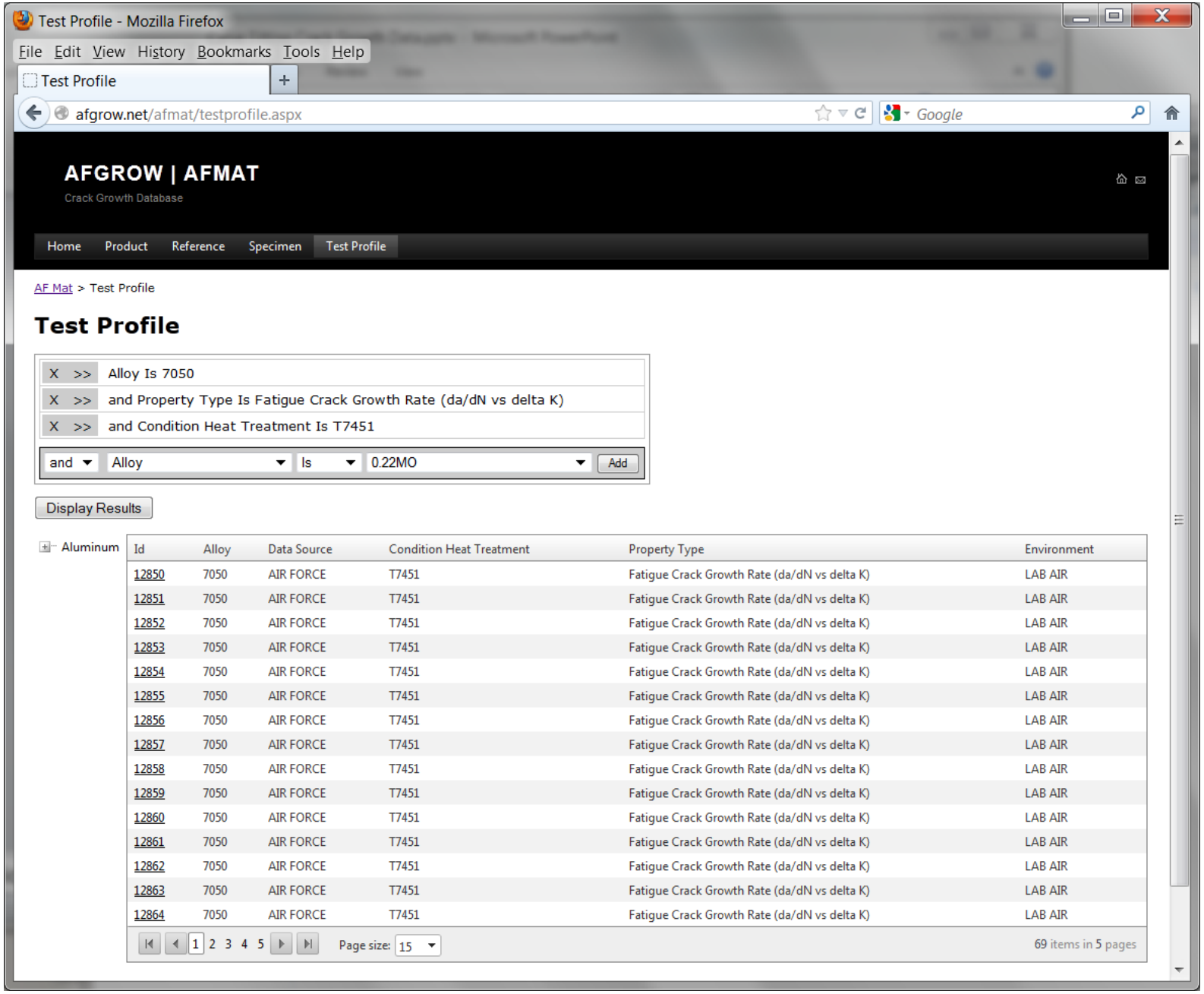
AFGROW | AFMAT
Crack Growth Database
Home Product Reference Specimen Test Profile
AF Mat > Home
Online Crack Growth Database
Alloy Steels
Aluminum
Aluminum 1100 Alloys
Aluminum 2000/6000 Alloys
Aluminum 5000 Alloys
Aluminum 7000/8000 Alloys
Aluminum Casting Alloys
Aluminum-Lithium Alloys
Beryllium/Beryllium Alloys
Brass
Bronze
Copper/Copper Alloys
Iron Alloys
Magnesium Alloys
Molybdenum/Molybdenum Alloys
Nickel Based Super Alloys
Niobium/Niobium Alloys
Solders
Stainless Steels
Titanium Alloys
BETA 21S
BETA C
BETA III TI
CORONA 5
Id | Data Source | Condition Heat Treatment | Property Type | Alloy | Environment
20240 | Purdue Aging Aircraft Data | | Fatigue Life (a vs N) | 7075-T6 | Unknown
19667 | Additional NASA Data | UNK | Plane Strain Fracture Toughness (K1C) | 5083-O | Unknown
19668 | Additional NASA Data | UNK | Plane Strain Fracture Toughness (K1C) | 5083-O | Unknown
19669 | Additional NASA Data | UNK | Plane Strain Fracture Toughness (K1C) | 5083-O | Unknown
19670 | Additional NASA Data | UNK | Plane Strain Fracture Toughness (K1C) | 5083-O | Unknown
19671 | Additional NASA Data | UNK | Plane Strain Fracture Toughness (K1C) | 5083-O(5183 FM) | Unknown
19672 | Additional NASA Data | UNK | Plane Strain Fracture Toughness (K1C) | 5083-O | Unknown
19673 | Additional NASA Data | UNK | Plane Strain Fracture Toughness (K1C) | 5083-O | Unknown
19674 | Additional NASA Data | UNK | Plane Strain Fracture Toughness (K1C) | 5083-O | LN2
19675 | Additional NASA Data | UNK | Plane Strain Fracture Toughness (K1C) | 5083-O | LN2
19676 | Additional NASA Data | UNK | Plane Strain Fracture Toughness (K1C) | 5083-O | LN2
19677 | Additional NASA Data | UNK | Plane Strain Fracture Toughness (K1C) | 5083-O | LN2
19678 | Additional NASA Data | UNK | Plane Strain Fracture Toughness (K1C) | 5083-O(5183 FM) | LN2
19679 | Additional NASA Data | UNK | Plane Strain Fracture Toughness (K1C) | 5083-O | LN2
19680 | Additional NASA Data | UNK | Plane Strain Fracture Toughness (K1C) | 5083-O | LN2
1 2 3 4 5 6 7 8 9 10 ... Page size: 15
11315 items in 755 pages
Waiting for www.afgrow.net...

- The AFGROW Fracture Mechanics Database was used to search for crack growth rate data for 7050-T74 Aluminum
- A large amount of data were available for plate and extrusion products
- The data were fit manually fit in Excel
- The Harter T-Method was used to provided continuity in the curve fits as a function of the stress ratio (R)

Using the Database Search Engine


Test Profile - Mozilla Firefox
File Edit View History Bookmarks Tools Help
Test Profile
afgrow.net/afmat/testprofile.aspx
Google
AFGROW | AFMAT
Crack Growth Database
Home Product Reference Specimen Test Profile
AF Mat > Test Profile
Test Profile
X >> Alloy Is 7050
X >> and Property Type Is Fatigue Crack Growth Rate (da/dN vs delta K)
X >> and Condition Heat Treatment Is T7451
and Alloy Is 0.22MO Add
Display Results
Aluminum
Id Alloy Data Source Condition Heat Treatment Property Type Environment
12850 7050 AIR FORCE T7451 Fatigue Crack Growth Rate (da/dN vs delta K) LAB AIR
12851 7050 AIR FORCE T7451 Fatigue Crack Growth Rate (da/dN vs delta K) LAB AIR
12852 7050 AIR FORCE T7451 Fatigue Crack Growth Rate (da/dN vs delta K) LAB AIR
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12864 7050 AIR FORCE T7451 Fatigue Crack Growth Rate (da/dN vs delta K) LAB AIR
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General | Specimen | Reference | Product | Test and Data | Plot

Basic Information

Data Source:	AIR FORCE		
Property Type:	Fatigue Crack Growth Rate (da/dN vs delta K)		
Alloy:	7050		
Environment:	LAB AIR		
Date:		Heat Nbr:	
Humidity:	104		
Kicl:		Kich:	
Rcl:		Rch:	
Strength:		Temperature:	75
Ysh:		Ysl:	

General | Specimen | Reference | Product | Test and Data | Plot

Specimen

Type:	Center Cracked Panel (CCP) (Max Load Specified)		
Orientation:	L-T		
Width:	4.001	Thickness:	0.25

General | Specimen | Reference | Product | Test and Data | Plot

Product

Form Type:	Plate	Thickness:	0.5

General | Specimen | Reference | Product | Test and Data | Plot

Test Information

Stress Ratio:	0.55	Specimen Description:		Stress Intensity Format:	1
Composition:		Joint Preparation:		Wave Form:	0
Preheat Temperature:		Frequency High:	10	Interpass Temperature:	
Frequency Low:	0	Postheat Temperature:		Percent Reduction in Area:	
Percent Elongation:		Voltage:		Amperage:	
Tensile Test Orientation:	0	Tensile Test Temperature:		Heat Input:	
Test Standard Year:		Test Standard:		Travel Speed:	
Filler Size/Diameter:		Filler Type/Name:	0	Data Source:	1
Reduction Method:	3	Error Criteria:	000XX301*XX	Pressure:	
Notch Length:	0	Product Width:	0	Total Side Groove Depth:	

Data Code	dAdN	Delta K	Max Load	K Max
T	5.036E-08	1.8968	5	0
T	5.684E-08	1.9634	5	0
T	6.286E-08	2.0244	5	0
T	8.386E-08	2.1084	5	0
T	1.085E-07	2.2387	5	0
T	1.2089E-07	2.3699	5	0
T	1.3024E-07	2.509	5	0
T	1.5032E-07	2.7026	5	0
T	1.6426E-07	2.8086	5	0
T	1.8681E-07	2.9852	5	0
T	2.157E-07	3.1908	5	0
T	2.4705E-07	3.3797	5	0
T	3.1014E-07	3.6063	5	0

Approach

- The data were imported to excel according to product form, grain orientation, environment, etc.
- A single set of growth rates were selected to allow a smooth curve to be created using a log-log interpolation between rate points
- The data for each available stress ratio were manually fit to capture the “average” behavior using engineering judgment
- m-values were calculated at each rate point and plotted to check for smoothness

Example: 7050-T74

0			0.1			0.5			0.8	
R=0			R=0.1			R=0.5			R=0.8	
delta K	da/dn	m (0,0.1)	delta K	da/dn	m (0.1,0.5)	delta K	da/dn	m (0.5,0.8)	delta K	da/dn
1.71	1.00E-09	0.66099176	1.65	1.00E-09	0.6585994	1.35	1.00E-09	0.6559845	0.985	1.00E-09
1.73	2.00E-09	0.66498093	1.67	2.00E-09	0.6631212	1.37	2.00E-09	0.6672886	1.01	2.00E-09
1.762	1.00E-08	0.68788671	1.705	1.00E-08	0.7185105	1.445	1.00E-08	0.7219435	1.12	1.00E-08
1.81	2.00E-08	0.68004089	1.75	2.00E-08	0.7658651	1.525	2.00E-08	0.7653799	1.23	2.00E-08
2.015	4.00E-08	0.68878453	1.95	4.00E-08	0.7665801	1.7	4.00E-08	0.7644661	1.37	4.00E-08
2.19	6.00E-08	0.69167335	2.12	6.00E-08	0.7682315	1.85	6.00E-08	0.7855754	1.52	6.00E-08
2.397	8.00E-08	0.69010431	2.32	8.00E-08	0.7474934	2	8.00E-08	0.8226339	1.7	8.00E-08
2.74	1.00E-07	0.68300952	2.65	1.00E-07	0.6833847	2.2	1.00E-07	0.8108988	1.85	1.00E-07
4.2	2.00E-07	0.67823286	4.06	2.00E-07	0.5546876	3.125	2.00E-07	0.7564708	2.5	2.00E-07
5.1	4.00E-07	0.60091087	4.89	4.00E-07	0.5484136	3.75	4.00E-07	0.7564708	3	4.00E-07
5.45	6.00E-07	0.55432087	5.2	6.00E-07	0.5536403	4	6.00E-07	0.7834192	3.28	6.00E-07
5.65	8.00E-07	0.57045966	5.4	8.00E-07	0.5724394	4.2	8.00E-07	0.7978995	3.49	8.00E-07
5.935	1.00E-06	0.53292291	5.65	1.00E-06	0.5551452	4.35	1.00E-06	0.7995158	3.62	1.00E-06
7.26	2.00E-06	0.51729149	6.9	2.00E-06	0.5187662	5.2	2.00E-06	0.8077176	4.36	2.00E-06
9.65	4.00E-06	0.54675211	9.2	4.00E-06	0.4605254	6.7	4.00E-06	0.8235916	5.7	4.00E-06
13.75	1.00E-05	0.54037247	13.1	1.00E-05	0.5406035	10	1.00E-05	0.6787362	7.45	1.00E-05
17.05	2.00E-05	0.63108695	16.4	2.00E-05	0.6307087	13.2	2.00E-05	0.5820189	9	2.00E-05
21.075	4.00E-05	0.69103603	20.4	4.00E-05	0.6898168	17	4.00E-05	0.5149459	10.9	4.00E-05
28.5	0.0001	0.66099176	27.5	0.0001	0.6773985	22.75	0.0001	0.4504732	13.75	0.0001
35.15	0.0002	0.60016539	33.7	0.0002	0.6541061	27.5	0.0002	0.4089242	16	0.0002
43.45	0.0004	0.56418755	41.5	0.0004	0.5841121	32.5	0.0004	0.3398879	17.75	0.0004
49.5	0.0006	0.46764244	46.8	0.0006	0.5178222	35.25	0.0006	0.3022914	18.6	0.0006
53.2	0.0008	0.41120836	50	0.0008	0.4738801	36.7	0.0008	0.2901008	19.15	0.0008
56.5	0.001	0.39304848	53	0.001	0.4451246	38.25	0.001	0.2647213	19.5	0.001
76	0.004	0.3540895	71	0.004	0.2615714	46	0.004	0.0964423	20.1	0.004
85.8	0.008	0.33568689	80	0.008	0.200384	50	0.008	0.0216117	20.4	0.008
88.5	0.01	0.27597825	82	0.01	0.1837045	50.75	0.01	0.0106997	20.5	0.01

m (0, 0.1)	m (0.1, 0.5)	m (0.5, 0.8)
0.66099	0.658599	0.655984
0.66498	0.663121	0.667289
0.68789	0.71851	0.721943
0.68004	0.765865	0.76538
0.68878	0.76658	0.764466
0.69167	0.768231	0.785575
0.6901	0.747493	0.822634
0.68301	0.683385	0.810899
0.67823	0.554688	0.756471
0.60091	0.548414	0.756471
0.55432	0.55364	0.783419
0.57046	0.572439	0.7979
0.53292	0.555145	0.799516
0.51729	0.518766	0.807718
0.54675	0.460525	0.823592
0.54037	0.540603	0.678736
0.63109	0.630709	0.582019
0.69104	0.689817	0.514946
0.66099	0.677399	0.450473
0.60017	0.654106	0.408924
0.56419	0.584112	0.339888
0.46764	0.517822	0.302291
0.41121	0.47388	0.290101
0.39305	0.445125	0.264721
0.35409	0.261571	0.096442
0.33569	0.200384	0.021612
0.27598	0.183704	0.0107

0	0.1	0.5	0.8
R=0	R=0.1	R=0.5	R=0.8
delta K	delta K	delta K	delta K
1.71043	1.65	1.35	0.985
1.73034	1.67	1.37	1.01
1.75632	1.705	1.445	1.12
1.79371	1.75	1.525	1.23
1.99855	1.95	1.7	1.37
2.17241	2.12	1.85	1.52
2.38255	2.32	2	1.7
2.73989	2.65	2.2	1.85
4.25503	4.06	3.125	2.5
5.12829	4.89	3.75	3
5.45039	5.2	4	3.28
5.64882	5.4	4.2	3.49
5.92112	5.65	4.35	3.62
7.25887	6.9	5.2	4.36
9.73807	9.2	6.7	5.7
13.7497	13.1	10	7.45
17.0507	16.4	13.2	9
21.0777	20.4	17	10.9
28.4508	27.5	22.75	13.75
34.9508	33.7	27.5	16
43.3589	41.5	32.5	17.75
49.239	46.8	35.25	18.6
52.8499	50	36.7	19.15
56.1908	53	38.25	19.5
76.7445	71	46	20.1
87.0319	80	50	20.4
89.3646	82	50.75	20.5

Calculating *m*-values

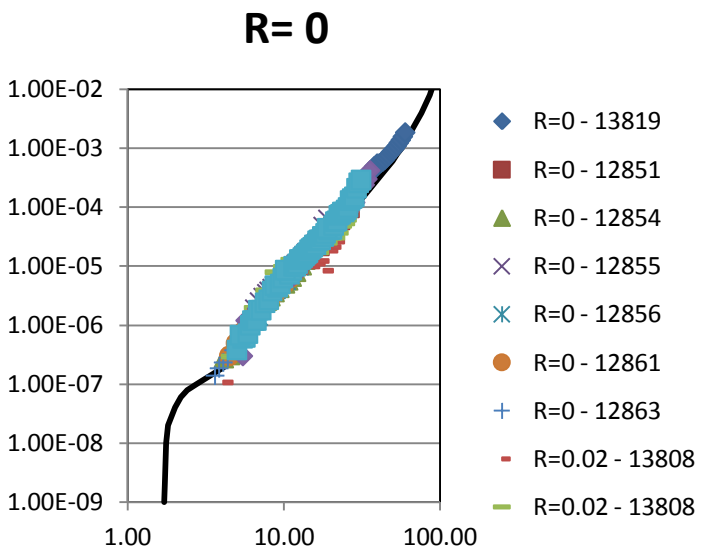
$$m = 1 + \left[\log_{10}\left(\frac{\Delta K_1}{\Delta K_2} \right) / \log_{10}\left(\frac{(1 - R_2)}{(1 - R_1)} \right) \right] \qquad \text{if } R_1 \text{ and } R_2 \geq 0$$

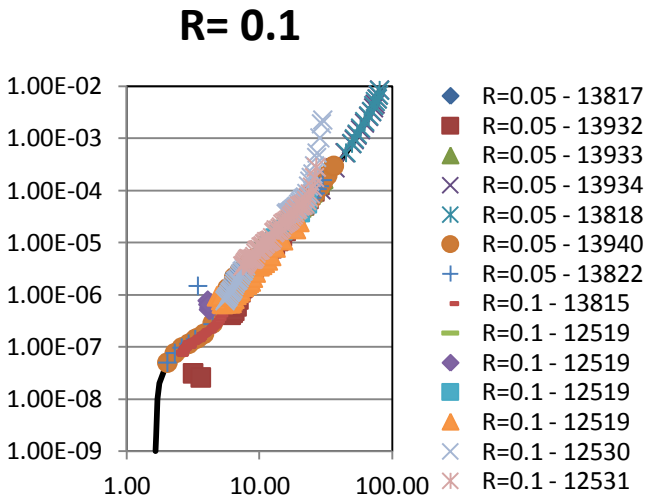
$$m = 1 + \left[\log_{10}\left(\frac{K_{\max 1}}{\Delta K_2} \right) / \log_{10}\left((1 - R_1)(1 - R_2) \right) \right] \qquad \text{if } R_1 < 0 \text{ and } R_2 \geq 0$$

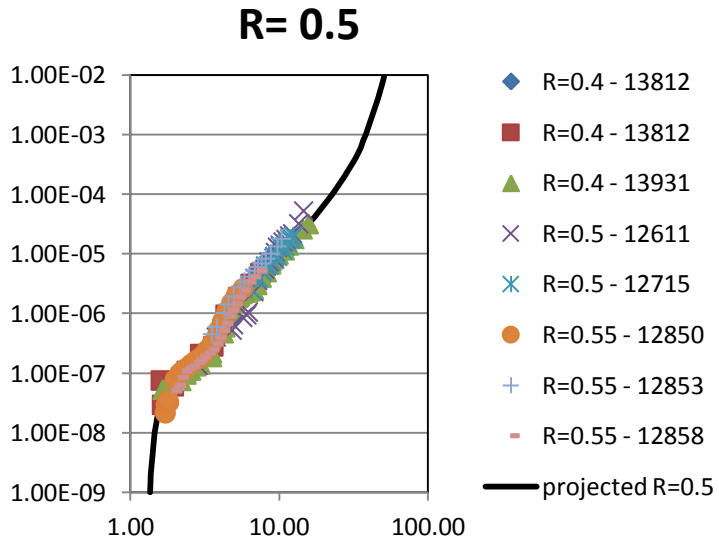
$$m = 1 - \left[\log_{10}\left(\frac{K_{\max 1}}{K_{\max 2}} \right) / \log_{10}\left(\frac{(1 - R_2)}{(1 - R_1)} \right) \right] \qquad \text{if } R_1 \text{ and } R_2 < 0$$

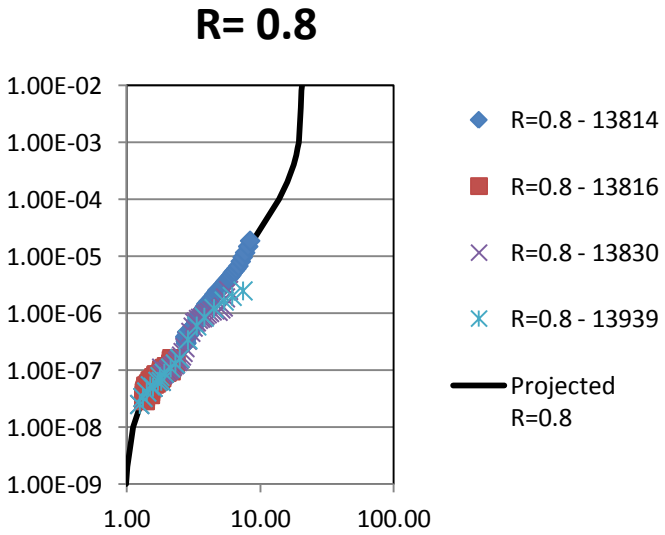
Note: $0 \leq m \leq 1$

7050-T74 Plate

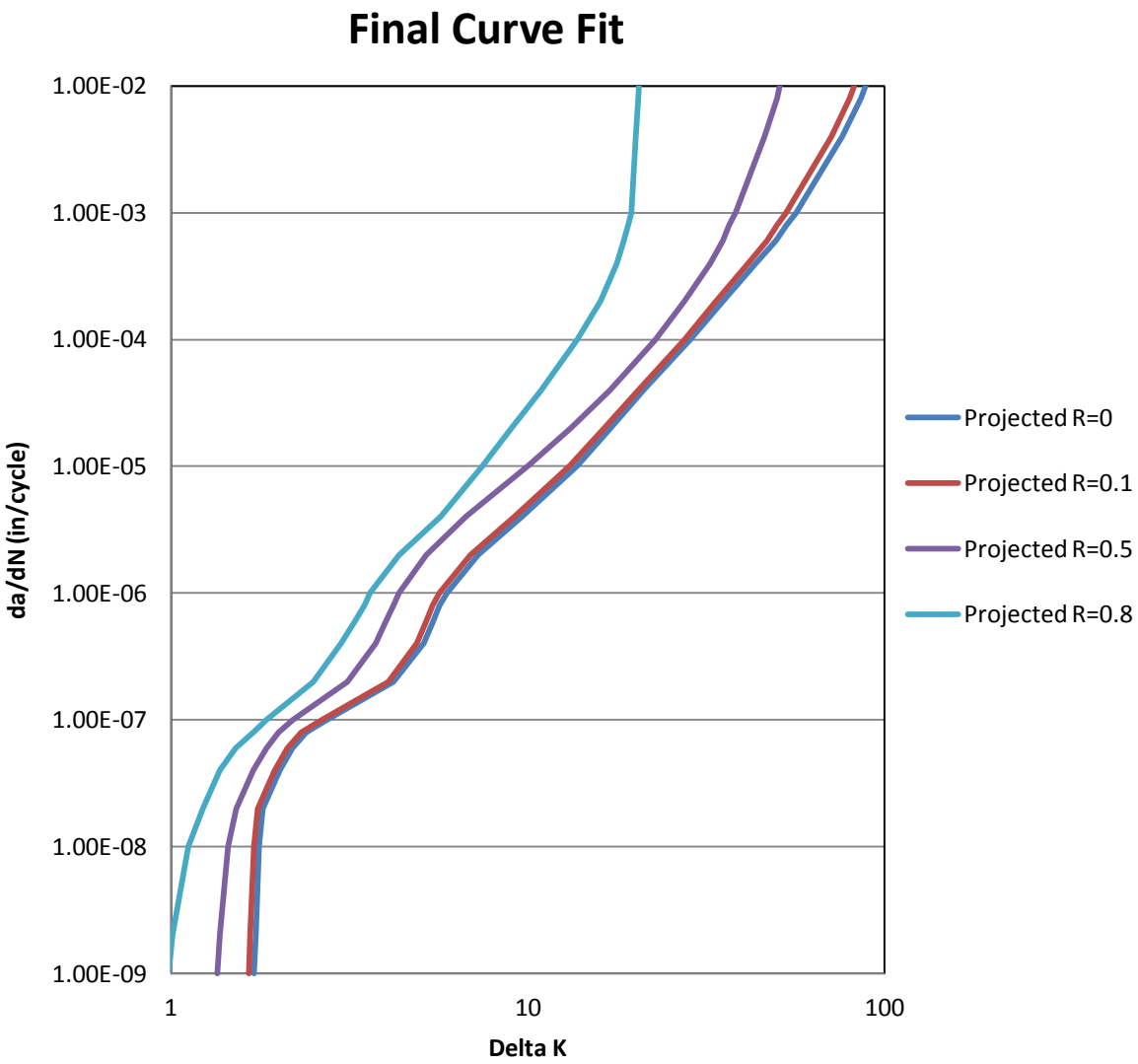




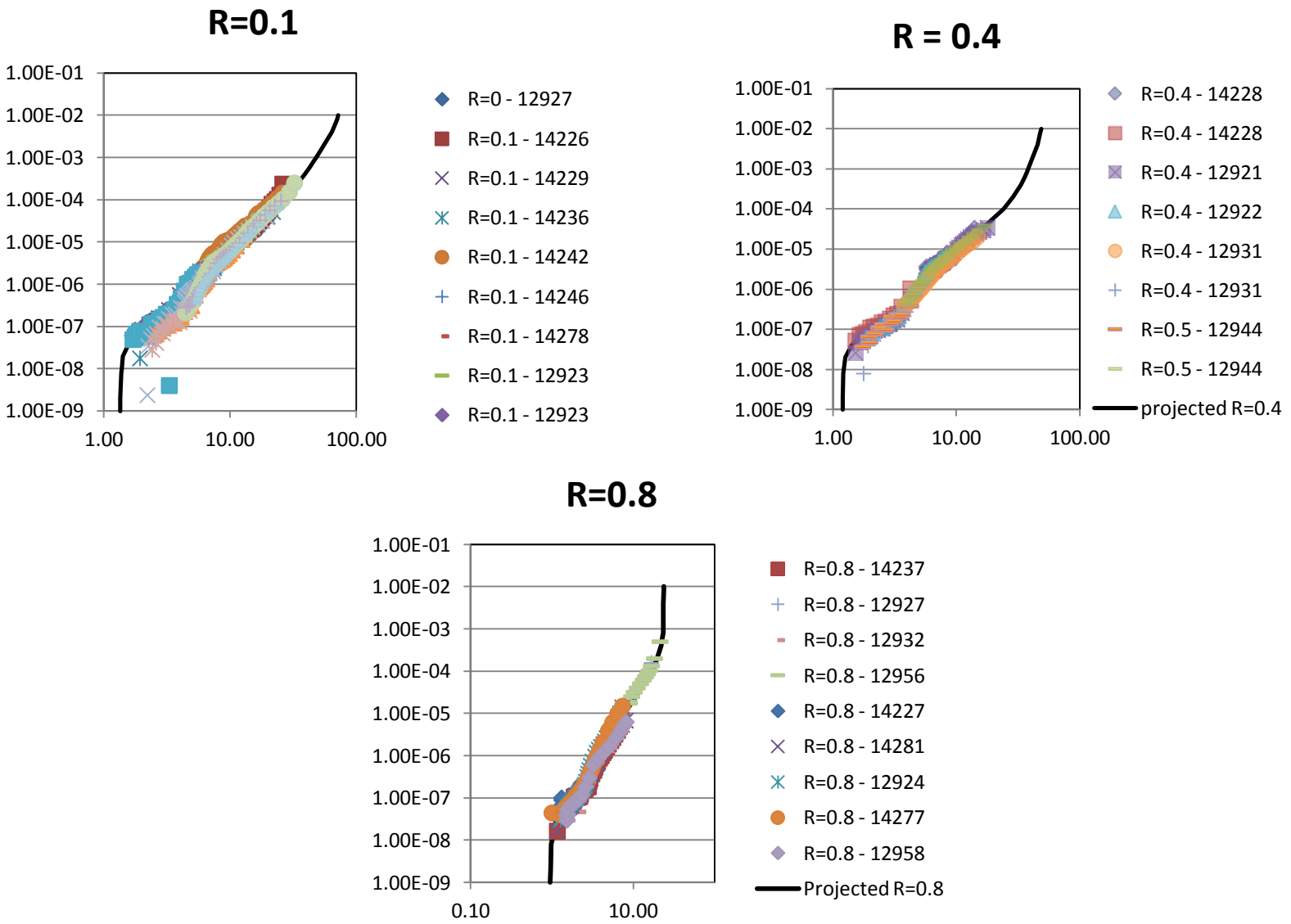




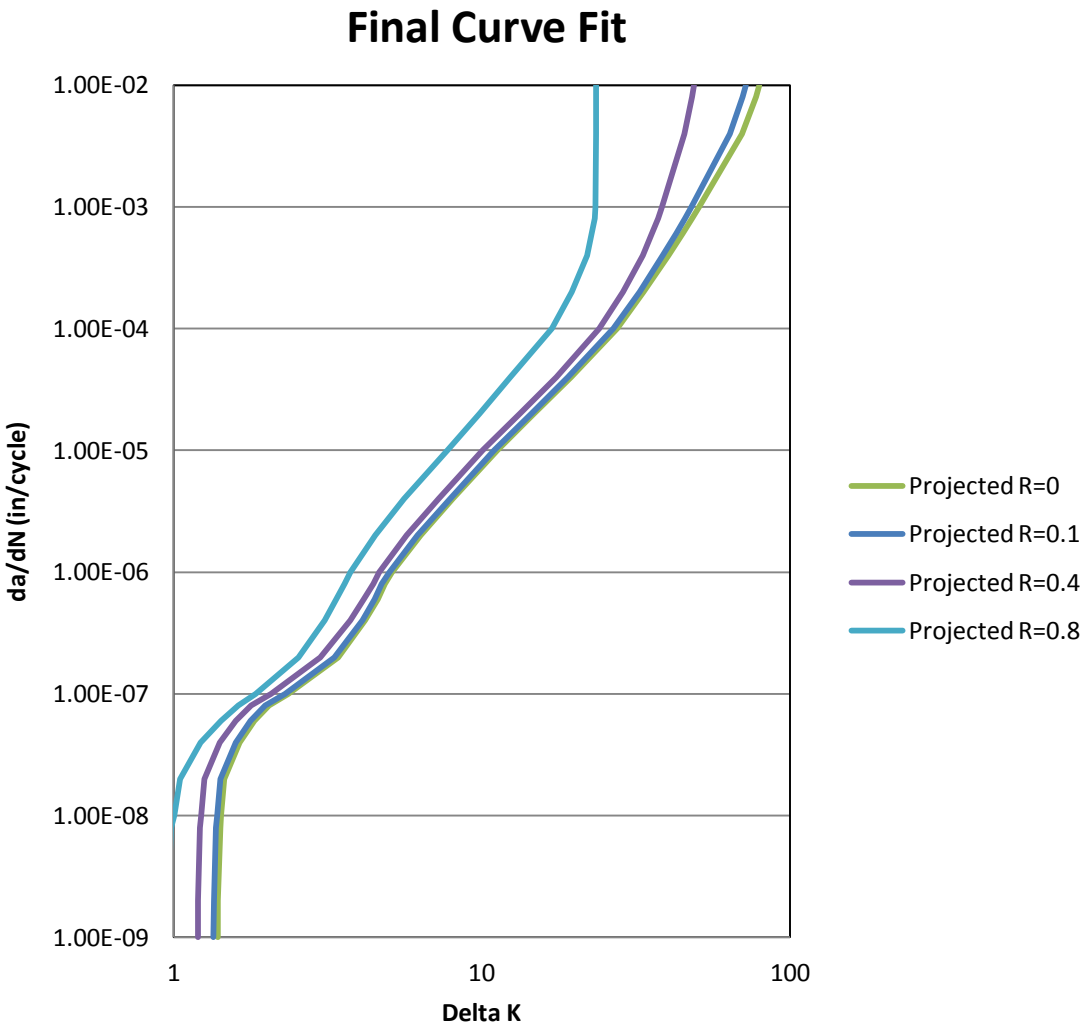
7050-T74 Plate



7050-T7451 Extrusion



7050-T7451 Extrusion



These curve fits will be included in the next AFGROW release in the tabular look-up format

Suggested Materials

2024-T3511
7175-T74
2024-T351
2024-T3
7075-T6
17-7PH
2024-T42
AMS6526
7075-T76
7075-T76511
4340
7075-T73

Discussion

Option to store read-only material data files in the on-line fracture mechanics database