

AFGROW Workshop 2016

AFGROW Release 5.3 Status

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Feature List for the release 5.3

- **64 bit version - 100%**
- **Converted AFGROW encoding from western Latin character set to Unicode 32 – 100%**
- **New spectrum format in AFGROW - 100%** (Currently, only the Axial component is used)
- **New weight functions solutions (crack at hole, stress distribution in the C-direction for part through cracks) -99%**
- **Using different material data as a function of spectrum data – 100%**
- **Applying different material data to different crack directions – 100%**
- ~~**Ability to Replicate Results From Previous Versions (back to Version 5.01)**~~
- **Option to Save Input File With Retardation State Data for Later Restart – 30%**

Bold – Work started
Red – High Priority
Blue - Finished

Feature List for the release 5.3

- Adding an option to control the % of the axial load solution that is used to approximate the out-of-plane bending solution for straight through-the-thickness cracks.– 50%
- Corrosion – Exfoliation – 100%
- Corrosion – Intergranular – 100%
- Corrosion – Pitting – 80%
- Corrosion - Crevice – 60-80%
- ~~Undo-Redo~~
- **New solution for a corner crack at the countersink knuckle – 50%**
- **Server based material database – requested by Gulfstream – 70%**
- **Convert material data from AFMAT to a useable format in AFGROW**
- **Bearing solution for corner crack(s) at a countersunk hole – 15%**
- **Bearing solution for the advanced through crack(s) at hole– 100%**
- AFGROW output post processing
- **New 2D table for residual stress data (similar to the 2-D user defined beta) 100%**

Bold – Work started
Red – High Priority
Blue - Finished

Feature List for the release 5.3

- Output intervals printed in "hours" if the option to display life in hours is selected in the Output Intervals tab, the crack length plots also should be converted to hours
- In the Propagation Limit tab, the option to stop at a cycle limit should be automatically switched to hours if the User has elected to display the life in hours.
- **Add the capability to use the current 2-D User-Defined Beta model for 2, inter-dependent through cracks that can be assigned different plate thickness values = 100%**
- **Add single edge crack model with the finite height – provided by SAFE, Inc - 100%**

Bold – Work started
Red – High Priority
Blue - Finished

New weight functions solutions

- Added 3 new solutions
 - Corner cracks with stress distribution along the C direction
 - Single through edge crack with symmetry condition at the crack edge
 - Single through edge crack with symmetry condition at the edge away from the crack
- Status: Finished coding the solutions, coding verification is done, testing solutions accuracy and applicability, AFGROW GUI modified
- To do: finish testing the accuracy and applicability of the solutions

64 Bit AFGROW Performance Test

Advanced double cracked hole with offset



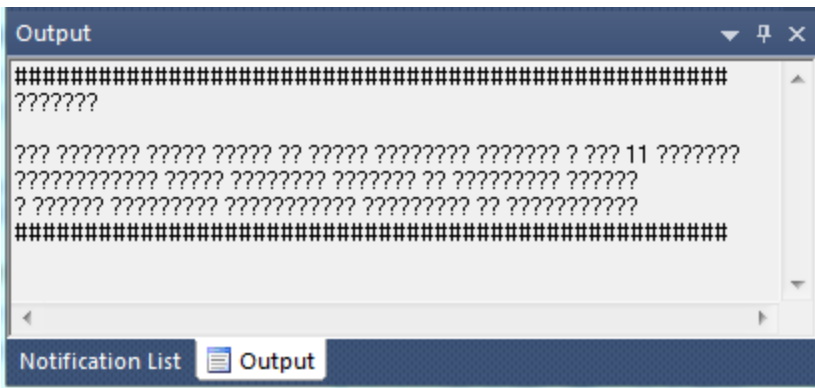
Model	Spectrum	Time 5.2 (sec)	Time 5.3 (sec)	Difference
Multipoint	FALSTAF	122	90	35.56%
Multipoint	Const Amplitude	8	6	33.33%
2 points	FALSTAF	73	62	17.74%
2 points	Const Amplitude	5	4	25.00%

32 to 64 bit upgrade was sponsored by APES

Unicode

- Provides ability to have localized strings in AFGROW, like comments, material names, etc.
- Supports localized file and folder names

5.02



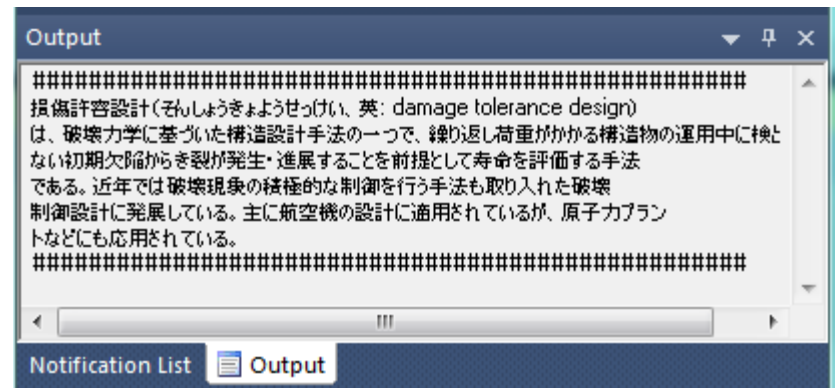
Output

```
#####
???????

??? ?????? ????? ????? ?? ????? ????????? ?????? ? ??? 11 ??????
????????????? ????? ????????? ?????? ?? ????????? ??????
? ?????? ????????? ?????????? ?????????? ?? ??????????
#####
```

Notification List Output

5.03



Output

```
#####
損傷許容設計(そんしょうきょうようせつけい、英: damage tolerance design)
は、破壊力学に基づいた構造設計手法の一つで、繰り返し荷重がかかる構造物の運用中に検と
ない初期欠陥からき裂が発生・進展することを前提として寿命を評価する手法
である。近年では破壊現象の積極的な制御を行う手法も取り入れた破壊
制御設計に発展している。主に航空機の設計に適用されているが、原子力プラント
などにも応用されている。
#####
```

Notification List Output

New solution for a corner crack at the countersink knuckle

- Based on Jody Cronenberger master's thesis
- Tension loading only
- Solution Space:
 - $D/T - 0.3$ to 2.6 ;
 - CD (Countersunk Depth)/ $T - 0.001$ to 0.99 (0.15),
 - $C/T - 0.0125(D/T) + 0.002$ to $2.5(D/T)$
 - $A/C/T - 0.5$ to 4
- Status: Finished coding the solution implementation
- To do: Understand the solution boundaries and do verification runs, add COM API support, finish GUI integration

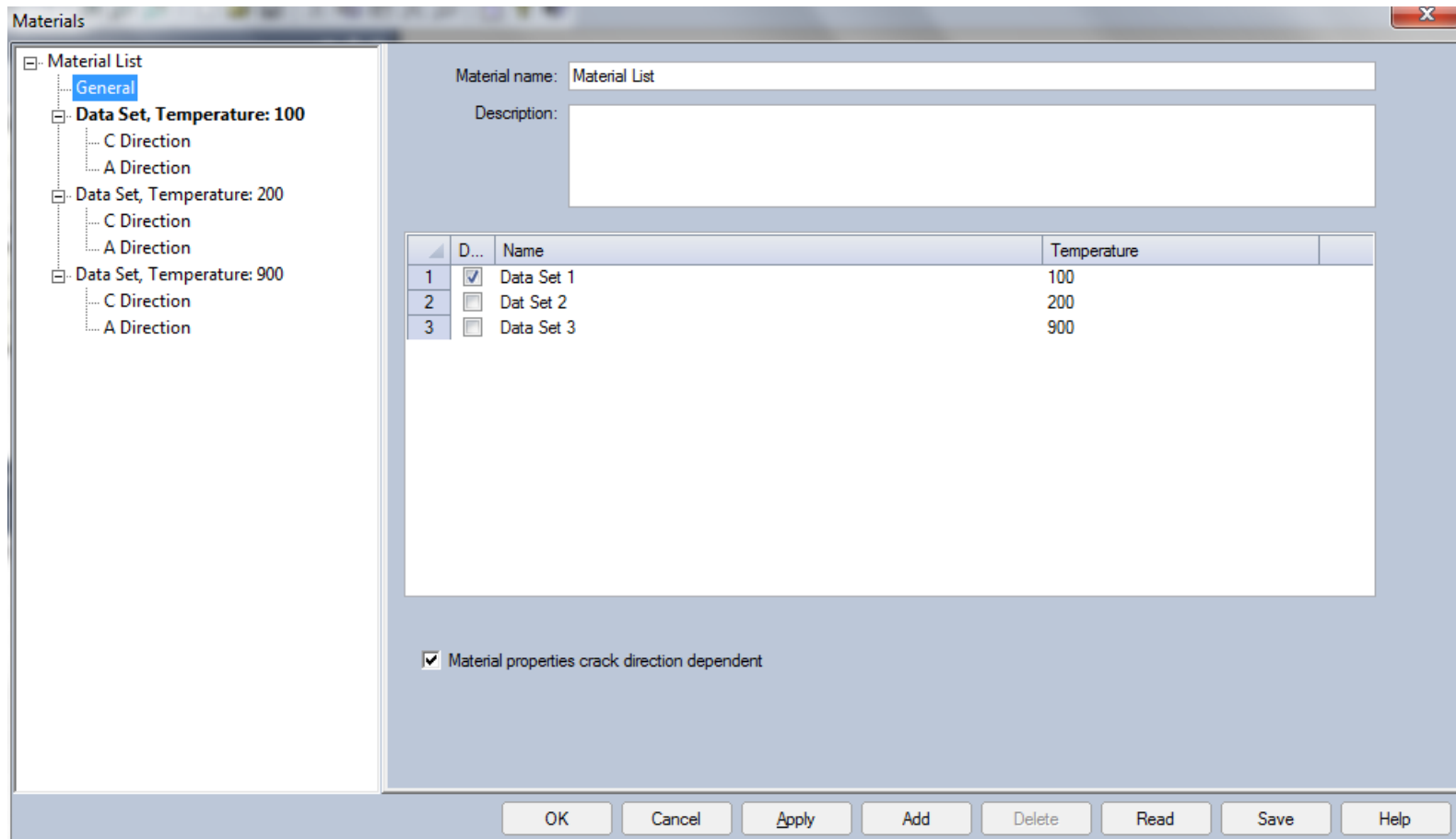
Using different material data as a function of the spectrum

- Status: Finished the Spectrum Manager changes, finished AFGROW coding
- Material data will consist of different material “sets”
- One material “set” is always default
- Material sets can be tagged for different conditions
- Only the temperature “tag” can be used right now
- Applicable only for tabular lookup data, but code infrastructure has been changed to handle any AFGROW material model if necessary, and requires only GUI changes
- Requires a spectrum with temperature “tags” applied to the sub-spectra
- Must be used with the new XML spectrum format
- New XML tabular lookup data file format
- Ability to use old tabular lookup data files for either growth direction
- The resulting DAX input file is backward and upward compatible

Applying different material data to different crack directions

- Status: Finished AFGROW coding
- Works only with A and C directions (Ct and C direction use the same material data)
- Applicable only for tabular lookup data, but code infrastructure has been changed to handle any AFGROW material model if necessary, and requires only GUI changes
- C direction is always the default direction
- Will not work with the Advanced multipoint corner crack(s) at a hole model
- Can be used in conjunction with the “Using different material data as a function of spectrum” change
- DAX file is backward and upward compatible
- Plugin model needs to be changed to handle different material data to the different crack directions

New Material features dialog changes – General



New material features dialog changes - Material set property

Materials

Material List

- General
 - Data Set, Temperature: 100
 - C Direction
 - A Direction
 - Data Set, Temperature: 200
 - C Direction
 - A Direction
 - Data Set, Temperature: 900
 - C Direction
 - A Direction

Input values of Delta_K for da/dN values and up to 10 different R(stress ratio) values. Matrix must have at least two R values and two da/dN values. Input Delta_K for R >= 0, input Kmax for R < 0.0

Name: Data Set 1

Number of da/dn Sets: 27 Number of R Sets: 2

		R[1]	R[2]
		0.1	0.601
da/dN[1]	1.00e-009	2.606	1.38
da/dN[2]	3.00e-009	2.636	1.409
da/dN[3]	1.00e-008	2.673	1.503
da/dN[4]	2.00e-008	2.685	1.66
da/dN[5]	4.00e-008	2.729	1.897
da/dN[6]	6.00e-008	2.792	2.089
da/dN[7]	1.00e-007	2.954	2.355
da/dN[8]	2.00e-007	3.307	2.814
da/dN[9]	3.00e-007	3.605	3.133
da/dN[10]	4.00e-007	3.839	3.383
da/dN[11]	6.00e-007	4.209	3.744
da/dN[12]	1.00e-006	4.781	4.355
da/dN[13]	2.00e-006	5.696	5.218
da/dN[14]	4.00e-006	6.873	6.254
da/dN[15]	1.00e-005	8.825	8.014
da/dN[16]	2.00e-005	10.684	9.61

Ultimate Strength: 66

Young's Modulus: 10500

Coefficient of Thermal Expansion: 1.25e-005

Poisson's Ratio: 0.33

Upper limit on da/dN, DADNHI: 0.01

Lower limit on da/dN, DADNLO: 1e-009

Plane Stress Fracture Toughness, KC: 62.777

Plane Strain Fracture Toughness, KIC: 35

Delta K threshold value @R=0: 2.831

Yield Strength, YLD: 47

Lower limit on R shift (Max: 0): -0.3

Upper limit on R shift (0, 1): 0.63

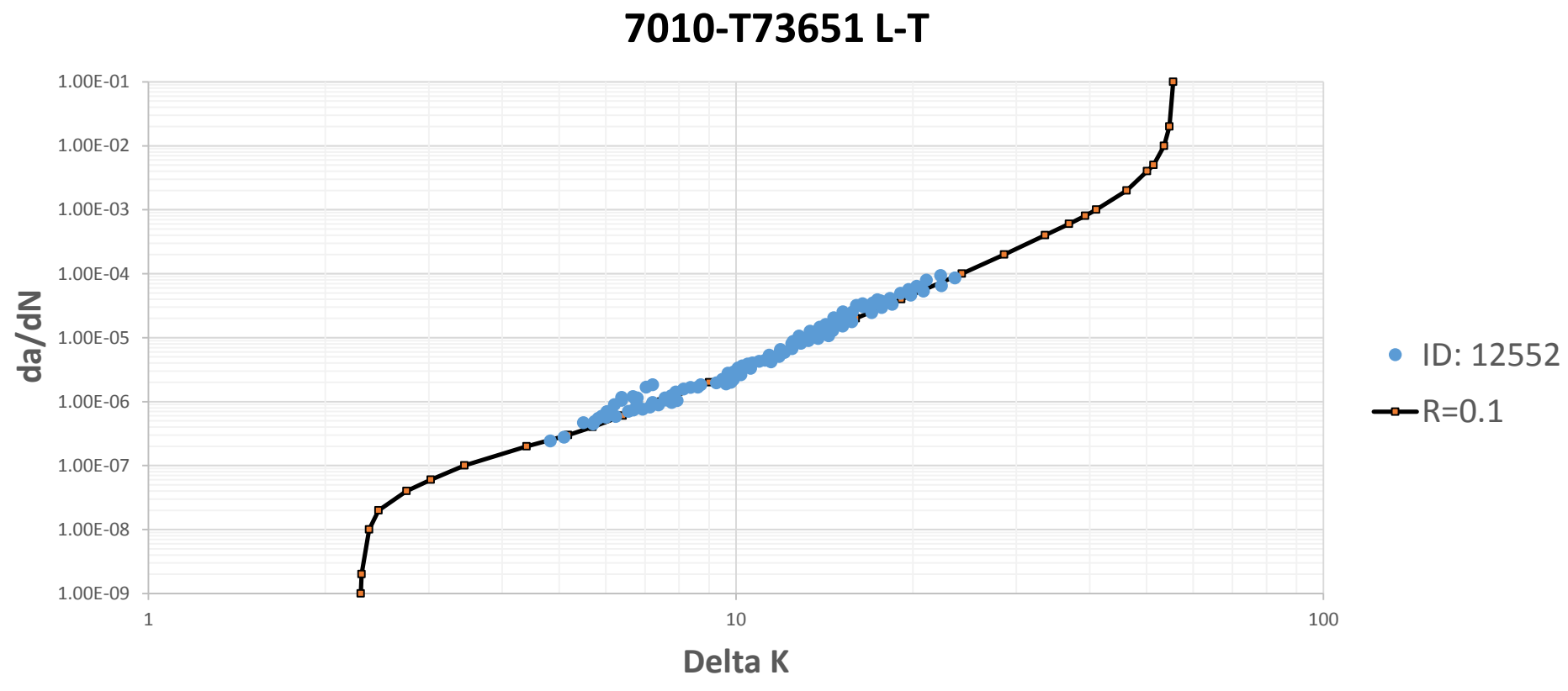
OK Cancel Apply Add Delete Read Save Help

Example Problem with 7010-T73651 L-T and L-S Data

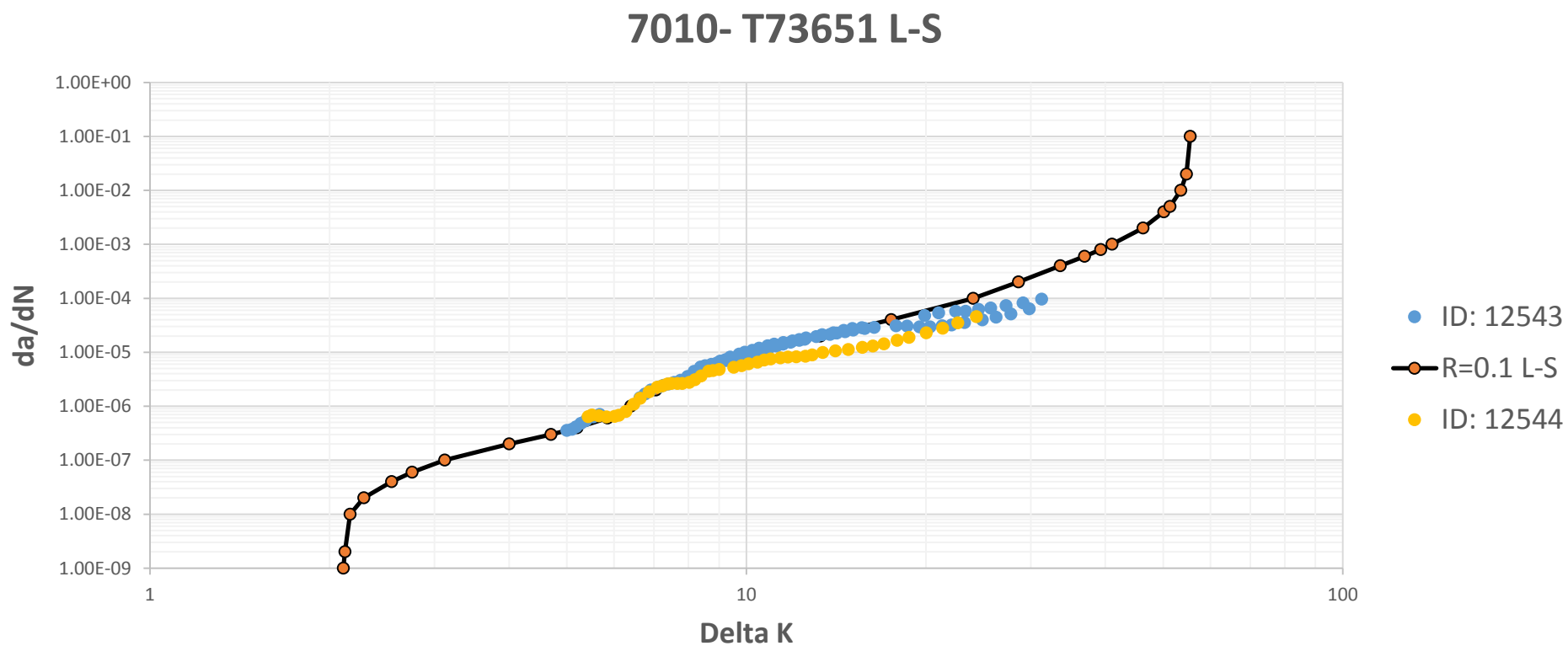


- Used Single Edge Corner Crack-Standard Solution With initial crack size for $C=0.05$ and $A=0.05$ Width=4 and Thickness=0.25
- Constant amplitude loading, SMF=14

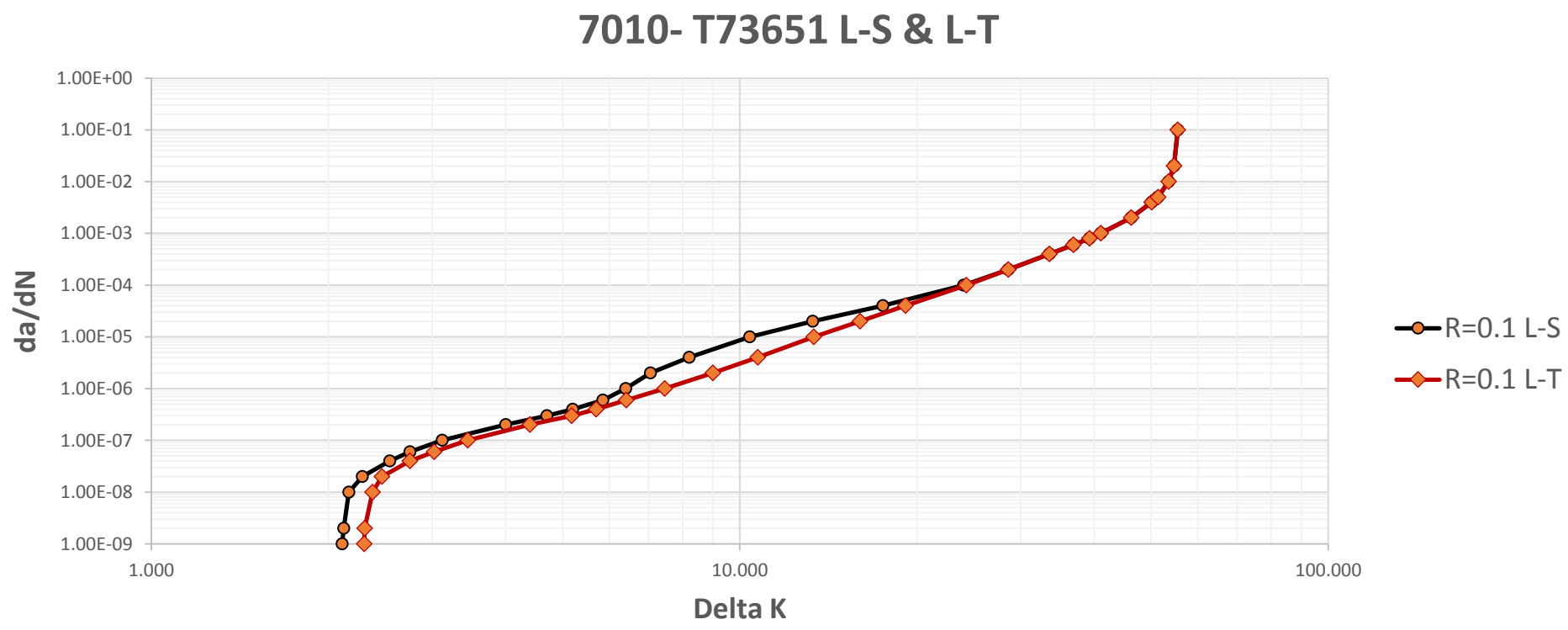
7010-T73651 L-T Data Plot for R=0.1



7010-T73651 L-S Data Plot for R=0.1



7010-T73651 Comparison for L-S and L-T Data Fits for R=0.1



Different material data to different crack directions example – C direction

Materials

Material List

- General
- Data Set
 - C Direction
 - A Direction

Input values of Delta_K for da/dN values and up to 10 different R(stress ratio) values. Matrix must have at least two R values and two da/dN values. Input Delta_K for R >= 0, input Kmax for R < 0.0

Name: 7010-T73651 L-S Plt Lab Air

Number of da/dn Sets: 29 Number of R Sets: 2

		R[1]	R[2]
		0.1	0.3
da/dN[1]	1.00e-009	2.109	1.72
da/dN[2]	2.00e-009	2.122	1.733
da/dN[3]	1.00e-008	2.166	1.783
da/dN[4]	2.00e-008	2.284	1.895
da/dN[5]	4.00e-008	2.542	2.126
da/dN[6]	6.00e-008	2.75	2.305
da/dN[7]	1.00e-007	3.12	2.622
da/dN[8]	2.00e-007	4	3.368
da/dN[9]	3.00e-007	4.7	3.961
da/dN[10]	4.00e-007	5.2	4.382
da/dN[11]	6.00e-007	5.85	4.929
da/dN[12]	1.00e-006	6.4	5.391
da/dN[13]	2.00e-006	7.05	5.95
da/dN[14]	4.00e-006	8.2	6.9
da/dN[15]	1.00e-005	10.4	8.745
da/dN[16]	2.00e-005	13.3	11.172

Ultimate Strength: 72.5

Young's Modulus: 10000

Coefficient of Thermal Expansion: 1.31e-005

Poisson's Ratio: 0.33

Upper limit on da/dN, DADNHI: 0.1

Lower limit on da/dN, DADNLO: 1e-009

Plane Stress Fracture Toughness, KC: 62

Plane Strain Fracture Toughness, KIC: 25

Delta K threshold value @R=0: 2.299

Yield Strength, YLD: 63

Lower limit on R shift (Max: 0): -0.33

Upper limit on R shift (0, 1): 0.65

OK Cancel Apply Add Delete Read Save Help

Select the C-Direction sub header to enter the material data for the C-Direction

Different material data to different crack directions example – A direction

Materials

- Material List
 - General
 - Data Set, Temperature: 70
 - C Direction
 - A Direction**

Input values of Delta_K for da/dN values and up to 10 different R(stress ratio) values. Matrix must have at least two R values and two da/dN values. Input Delta_K for R >= 0, input Kmax for R < 0.0

Name: 7010-T73651 L-T Plt Lab Air

Number of da/dn Sets: 29 Number of R Sets: 4

		R[1]	R[2]	R[3]
		0.1	0.3	0.5
da/dN[1]	1.00e-009	2.3	1.875	1.5
da/dN[2]	2.00e-009	2.305	1.882	1.57
da/dN[3]	1.00e-008	2.375	1.955	1.64
da/dN[4]	2.00e-008	2.465	2.045	1.72
da/dN[5]	4.00e-008	2.75	2.3	1.94
da/dN[6]	6.00e-008	3.025	2.535	2.14
da/dN[7]	1.00e-007	3.45	2.9	2.45
da/dN[8]	2.00e-007	4.4	3.705	3.13
da/dN[9]	3.00e-007	5.18	4.365	3.65
da/dN[10]	4.00e-007	5.7	4.803	4.06
da/dN[11]	6.00e-007	6.415	5.405	4.57
da/dN[12]	1.00e-006	7.45	6.275	5.3
da/dN[13]	2.00e-006	9	7.575	6.4
da/dN[14]	4.00e-006	10.725	9.025	7.67
da/dN[15]	1.00e-005	13.35	11.225	9.62
da/dN[16]	2.00e-005	16	13.44	11.1

Ultimate Strength: 73

Young's Modulus: 10000

Coefficient of Thermal Expansion: 1.31e-005

Poisson's Ratio: 0.33

Upper limit on da/dN, DADNH: 0.1

Lower limit on da/dN, DADNLO: 1e-009

Plane Stress Fracture Toughness, KC: 62

Plane Strain Fracture Toughness, KIC: 34

Delta K threshold value @R=0: 2.5057

Yield Strength, YLD: 63

Lower limit on R shift (Max: 0): -0.33

Upper limit on R shift (0, 1): 0.75

OK Cancel Apply Add Delete Read Save Help

Select the A-Direction sub header to enter the material data for the A-Direction

AFGROW Results for L-T Data in Both C and A Directions

Output

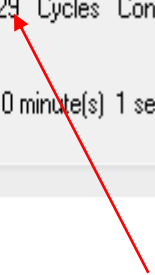
C Crack size= 1.4948 Beta Tension= 1.9687 Beta Compression= 1.9687 R(k)= 0.0000 R(final)= 0.0000 Delta k=5.9729e+001 D(j)/DN=1.0000e-002
Max stress = 14.000 r = 0.00 380621 Cycles Constant amp.: 3807 Pass: 3807

*****Fracture based on 'Kmax' Criteria (current maximum stress)

C Crack size= 1.5748 Beta Tension= 2.0731 Beta Compression= 2.0731 R(k)= 0.0000 R(final)= 0.0000 Delta k=6.4558e+001 D(j)/DN=1.0000e-002
Max stress = 14.000 r = 0.00 380629 Cycles Constant amp.: 3807 Pass: 3807

Stress State in the 'C' direction (PSC): 2

Fracture has occurred- run time: 0 hour(s) 0 minute(s) 1 second(s)



AFGROW Results for L-S Data in Both C and A Directions

```
Output
C Crack size= 1.4672 Beta Tension=1.9347 Beta Compression=1.9347 R(k)= 0.0000 R(final)= 0.0000      Delta k=5.8152e+001 D()/DN=7.4241e-003
Max stress = 14.000 r= 0.00 257623 Cycles Constant amp.: 2577 Pass: 2577

*****Fracture based on 'Kmax' Criteria (current maximum stress)
C Crack size= 1.5414 Beta Tension=2.0283 Beta Compression=2.0283 R(k)= 0.0000 R(final)= 0.0000      Delta k=6.2489e+001 D()/DN=1.0000e-001
Max stress = 14.000 r= 0.00 257633 Cycles Constant amp.: 2577 Pass: 2577

Stress State in the 'C' direction (PSC): 2
Fracture has occurred- run time: 0 hour(s) 0 minute(s) 1 second(s)
```

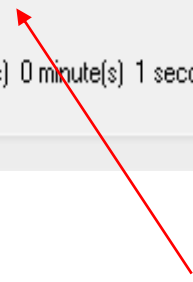
Total number of cycles= 257633

AFGROW Results for L-T Data in C-Direction and L-S in A-Direction

```
Output
C Crack size= 1.4717 Beta Tension= 1.9402 Beta Compression= 1.9402 R(k)= 0.0000 R(final)= 0.0000 Delta k=5.8406e+001 D()/DN=7.8965e-003
Max stress = 14.000 r = 0.00 325461 Cycles Constant amp.: 3255 Pass: 3255

*****Fracture based on 'Kmax' Criteria (current maximum stress)
C Crack size= 1.5506 Beta Tension= 2.0405 Beta Compression= 2.0405 R(k)= 0.0000 R(final)= 0.0000 Delta k=6.3053e+001 D()/DN=-1.#QNBe+000
Max stress = 14.000 r = 0.00 325471 Cycles Constant amp.: 3255 Pass: 3255

Stress State in the 'C' direction (PSC): 2
Fracture has occurred- run time: 0 hour(s) 0 minute(s) 1 second(s)
```



Total number of cycles= 325471

AFGROW Results for L-S Data in C-Direction and L-T in A-Direction

```

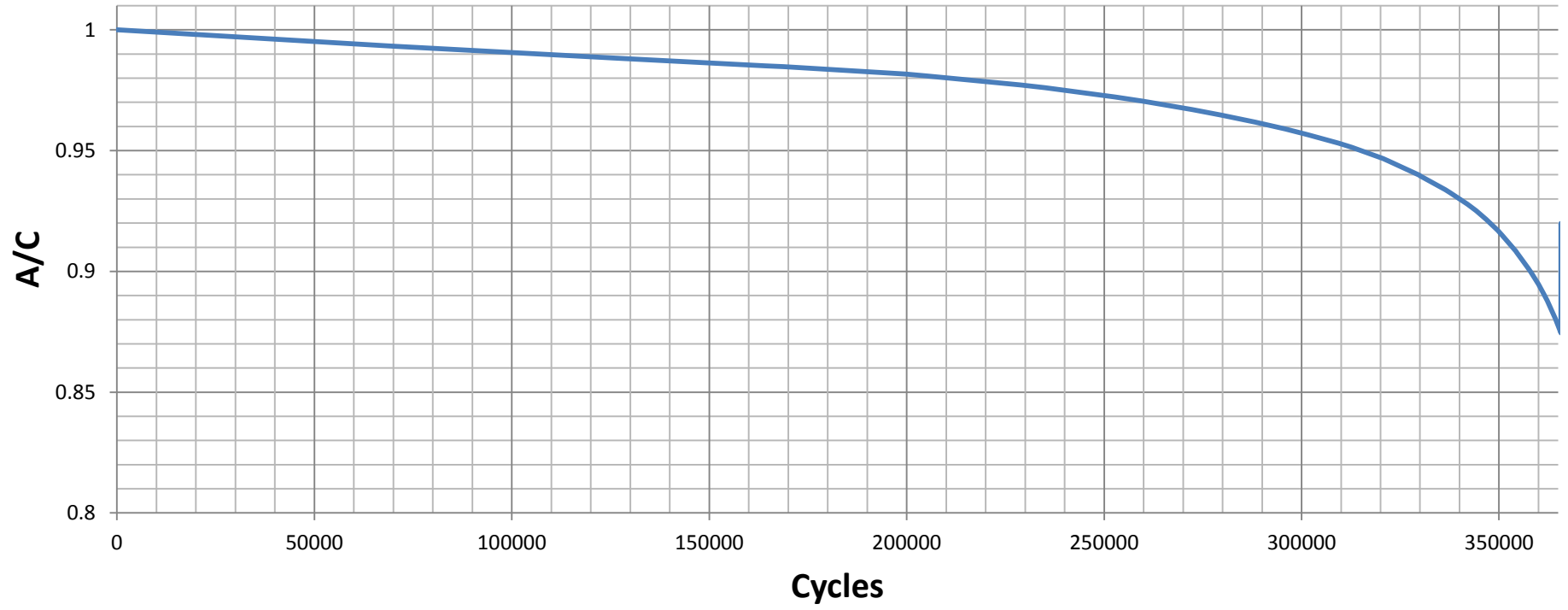
Output
C Crack size= 1.5206 Beta Tension= 2.0013 Beta Compression= 2.0013 R(k)= 0.0000 R(final)= 0.0000      Delta k=6.1238e+001 D()/DN=5.2113e-002
Max stress = 14.000 r = 0.00 307382 Cycles Constant amp.: 3074 Pass: 3074

*****Fracture based on 'Kmax' Criteria (current maximum stress)
C Crack size= 1.6248 Beta Tension= 2.1433 Beta Compression= 2.1433 R(k)= 0.0000 R(final)= 0.0000      Delta k=6.7794e+001 D()/DN=1.0000e-001
Max stress = 14.000 r = 0.00 307384 Cycles Constant amp.: 3074 Pass: 3074

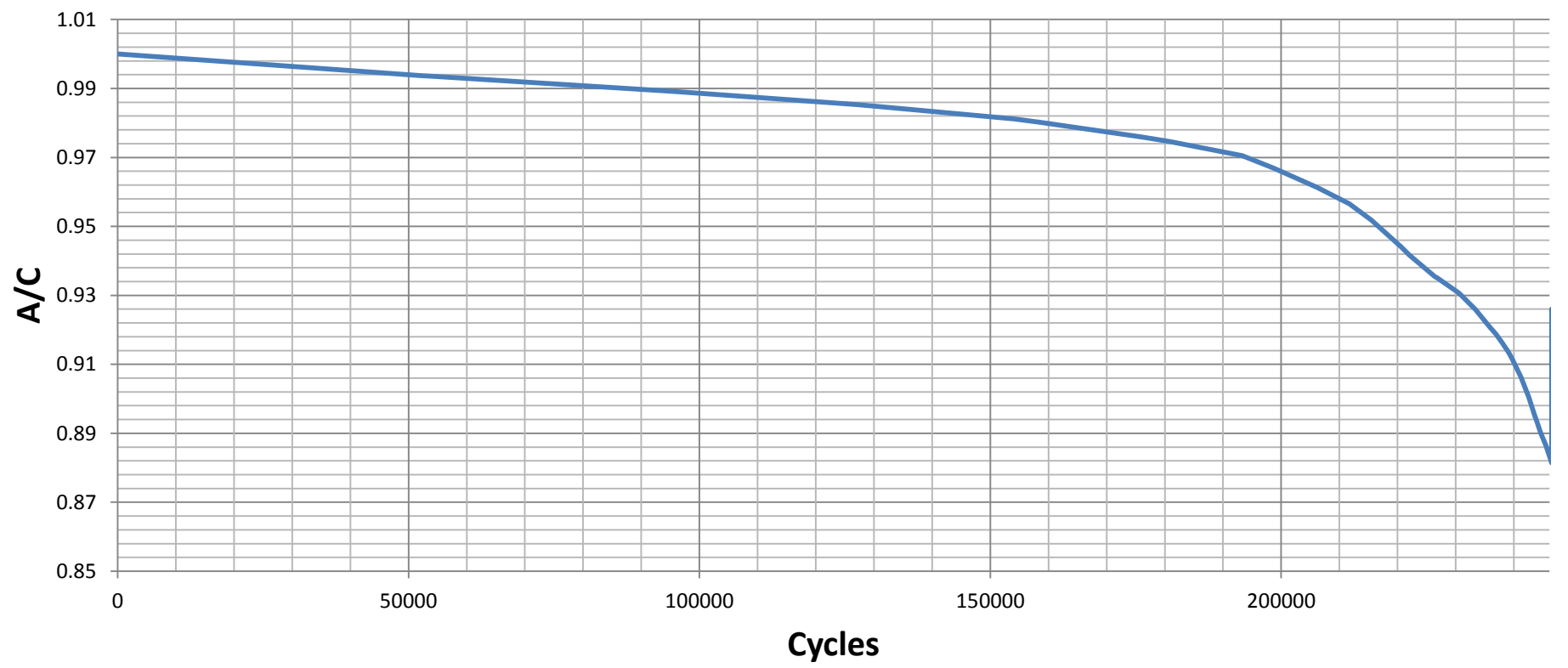
Stress State in the 'C' direction (PSC): 2
Fracture has occurred- run time: 0 hour(s) 0 minute(s) 1 second(s)
    
```

Total number of cycles=307384

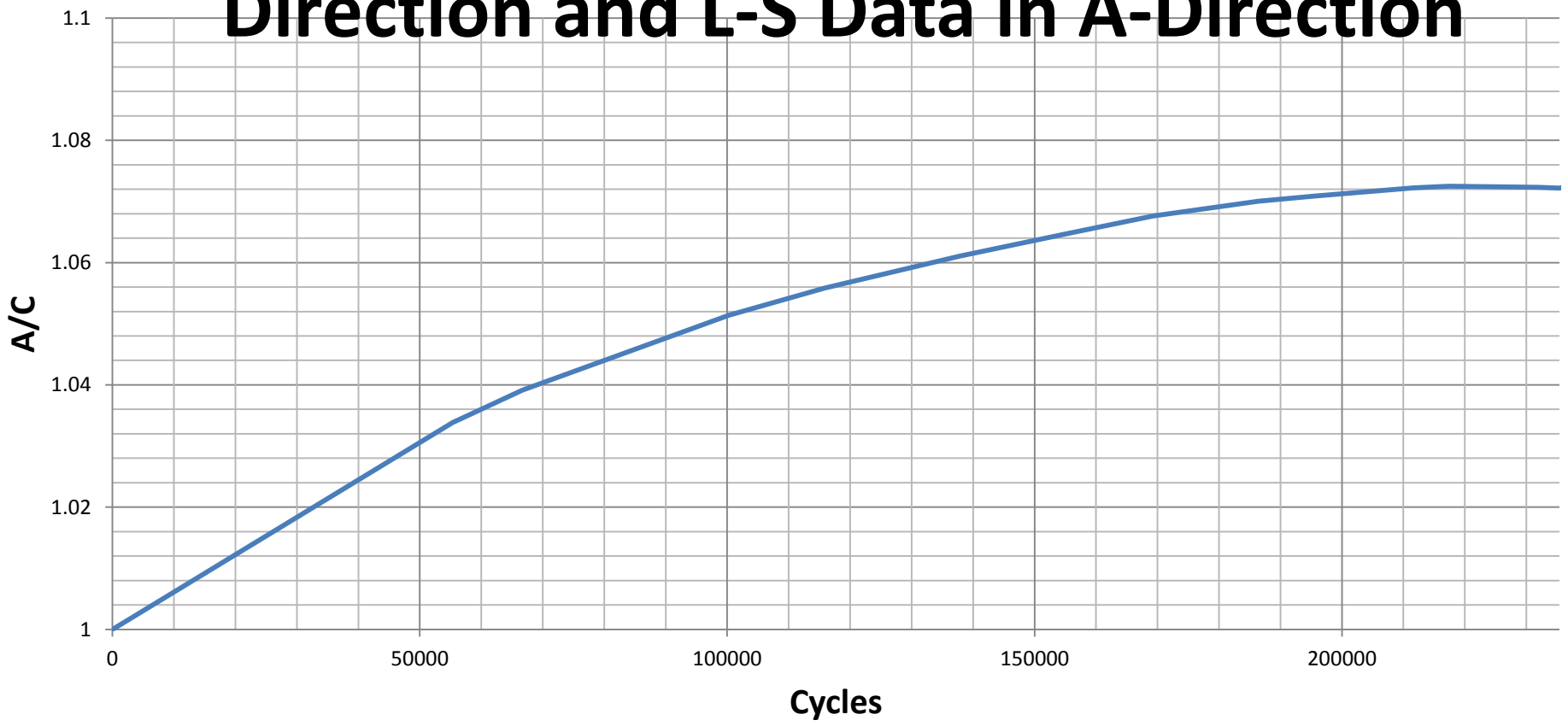
A/C vs. Cycles Plot for L-T Data in Both A and C Directions



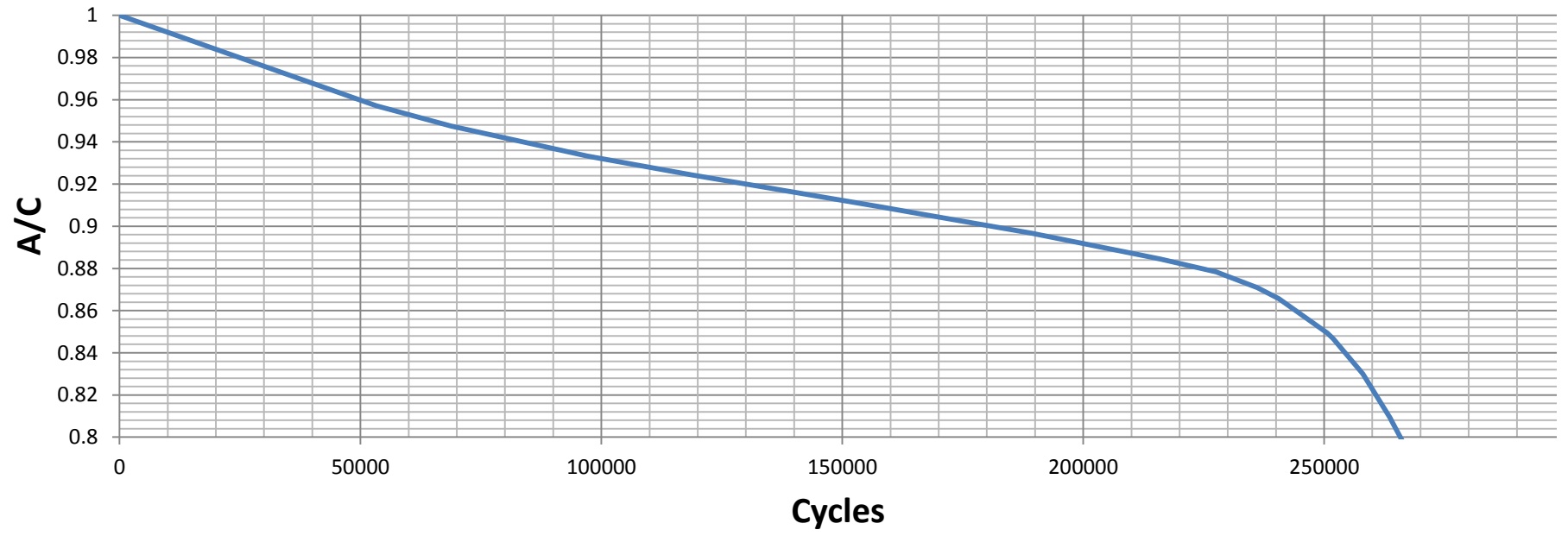
A/C vs. Cycles Plot for L-S Data in Both A and C Directions



A/C vs. Cycles Plot for L-T Data in C-Direction and L-S Data in A-Direction



A/C vs. Cycles Plot for L-S data in the C-Direction and L-T Data in the A-Direction



Material data from AFMAT converted to tabular lookup format in AFGROW

2000 Series	7000 Series	7000 Series (cont)	Steel	Nickel-Based Superalloy
2024-T3 L-T LAB AIR SHEET	7010-T73651 L-T LAB AIR PLATE	7075-T76511 L-T LHA EXTRUSION	15-5PH H1025	ASTROLOY 901
2024-T351 L-T LAB AIR PLATE	7050-T74 L-T LAB AIR FORGING	7150-T7751 LAB AIR PLATE	17-4PH H1025 LAB AIR T-L ROUND BAR	IN100
2024-T3511 L-T LAB AIR EXTRUTION	7050-T7451 L-T HHA	7150-T77511 LAB AIR EXTRUSION	300M	INCONEL 718 C-R LAB AIR DISC
2024-T42 L-T LAB AIR PLATE	7050-T73511 L-T HHA EXTRUSION	7175-T736 L-T HHA FORGING	316L (800)	WASPALOY
2024-T851 L-T LAB AIR PLATE	7050-T7452 L-T Forging Lab air	7175-T74 L-T LAB AIR FORGING	4340	
2124-T851 L-T LAB AIR PLATE	7050-T73651 L-T LAB AIR Plate	7178-T6 L-T LAB AIR SHEET	PH13-8Mo-H1000	
2219-T87 T-L LAB AIR PLATE	7050-T74511 L-T LA EXTRUSION	7475-T761 L-T LAB AIR SHEET	PH13-8Mo-H1050	
2324-T39 L-T LA & HHA	7050-T76511 L-T LAB AIR EXTRUSION	7475-T7351 L-T HHA PLATE	A508 T-L PWR H2O FORGING	
2091-T8 T-L HHA PLT & SHT	7050-T76511 L-T STW EXTRUTION	7475-T7651 L-T LAB AIR PLATE		
2090-T86 T-L LAB AIR TEE EXTRUSION	7075-T76 L-T LHA SHEET	7475-T7351 L-T LAB AIR PLATE		
	7075-T651 L-T LAB AIR Plt & Extr	X7090-T7E69 S-T GN2 Plate		
	7075-T7351 L-T LAB AIR PLATE			
	7075-T73511 L-T LAB AIR EXTRUSION			
	7075-T6 L-T LAB AIR SHEET			
	7075-T7651 L-T LHA PLATE			

Material data from AFMAT converted to tabular lookup format in AFGROW

- Will be distributed through AFMAT
- Material data will be in new tabular-Lookup format that is going to be introduced in AFGROW 5.3

AFGROW | AFMAT
Crack Growth Database

Home Product Reference Specimen Test Profile










[AF Mat](#) > Home

Online Crack Growth Database

	Id	Data Source	Condition Heat Treatment	Property Type	Alloy	Environment
<input type="checkbox"/> Alloy Steels	20240	Purdue Aging Aircraft Data		Fatigue Life (a vs N)	7075-T6	Unknown
<input type="checkbox"/> Aluminum	1222	AIR FORCE	AS RECD	Plane Strain Fracture Toughness (K1C)	TI-6AL-4V	Unknown
<input type="checkbox"/> Beryllium/Beryllium Alloys	1223	Additional NASA Data	AS RECD	Plane Strain Fracture Toughness (K1C)	TI-6AL-4V	Unknown
<input type="checkbox"/> Brass	1224	Additional NASA Data	AS RECD	Plane Strain Fracture Toughness (K1C)	TI-6AL-4V	Unknown
<input type="checkbox"/> Bronze	1225	Additional NASA Data	AS RECD	Plane Strain Fracture Toughness (K1C)	TI-6AL-4V	Unknown
<input type="checkbox"/> Copper/Copper Alloys	1226	Additional NASA Data	AS RECD	Plane Strain Fracture Toughness (K1C)	TI-6AL-4V	Unknown
<input type="checkbox"/> Iron Alloys	1227	Additional NASA Data	AS RECD	Fatigue Crack Growth Rate (da/dN vs delta K)	C11000(ETP BUS BAR)	LAB AIR
<input type="checkbox"/> Magnesium Alloys	1228	Additional NASA Data	AS RECD	Fatigue Crack Growth Rate (da/dN vs delta K)	C11000(ETP BUS BAR)	LAB AIR
<input type="checkbox"/> Molybdenum/Molybdenum Alloys	1229	AIR FORCE	AS RECD;PROBABLY MA	K1 Environmentally Assisted Cracking	TI-6AL-4V	3.5PCT NACL
<input type="checkbox"/> Nickel Based Super Alloys	1230	NASA	AS ROLL	Fatigue Crack Growth Rate (da/dN vs delta K)	304	LAB AIR
<input type="checkbox"/> Niobium/Niobium Alloys						
<input type="checkbox"/> Solders						
<input type="checkbox"/> Stainless Steels						
<input type="checkbox"/> Titanium Alloys						

New Classic Models

- Single corner crack model with the finite height
- 2 inter-dependent through cracks that can be assigned different plate thickness values


Model	Description of the Configurations	Beta Solution
<input type="checkbox"/>	 Part Through Crack in Pipe	Application Defined
<input type="checkbox"/>	 Through Crack	User Defined
<input type="checkbox"/>	 Interdependent Through Cracks	User Defined
<input checked="" type="checkbox"/>	 Internal Through Crack	Application Defined
<input type="checkbox"/>	 Single Through Crack at Hole	Application Defined
<input type="checkbox"/>	 Double Through Crack at Hole	Application Defined
<input type="checkbox"/>	 Single Through Crack at a Semi-circular Notch	Application Defined
<input type="checkbox"/>	 Single Edge Through Crack	Application Defined
<input type="checkbox"/>	 Single Edge Through Crack in a Finite Height ...	Application Defined

Two inter-dependent through cracks model



Model Geometry/Dimension/Load Dialog

Geometry
Dimension
Load

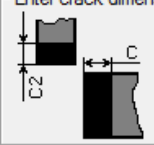


Model dimensions are initialized to default values at start-up or when a new model configuration is selected.

Enter specimen dimensions

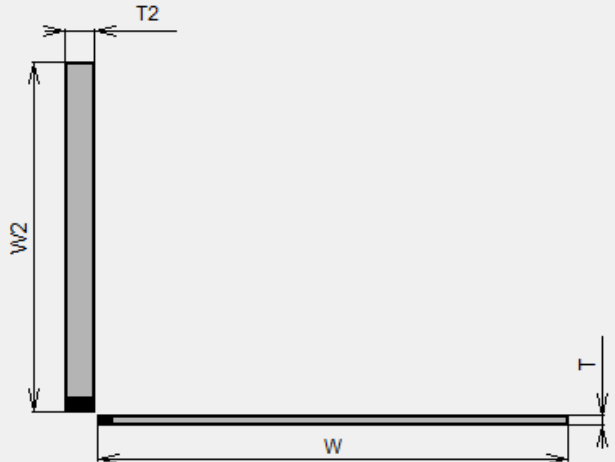
Width (W): <input style="width: 80%;" type="text" value="4"/>	Width 2 (W2): <input style="width: 80%;" type="text" value="3"/>
Thickness (T): <input style="width: 80%;" type="text" value="0.09"/>	Thickness 2 (T2): <input style="width: 80%;" type="text" value="0.25"/>

Enter crack dimensions



Crack Length '-C' Direction:	<input style="width: 80%;" type="text" value="0.15"/>
Crack Length '-C2' Direction:	<input style="width: 80%;" type="text" value="0.15"/>

OK
Cancel
Apply
Help



User Defined Beta Dialog

- Input
- Edit
- View
- Predict
- Title Ctrl+I
- Material
- Model
- Spectrum Ctrl+P
- Spectrum Filters
- Retardation
- Stress State
- β User-Defined Beta**
- Environment
- Beta Correction
- Residual Stresses
- K-Solution Filters

Dialog

Enter 'C1' beta sets

Number of sets:

		C1[1]	C1[2]	C1[3]	C1[4]
		1.105	1.205	1.405	1.605
C2[1]	1.3	1.342	1.4	1.431	1.442
C2[2]	1.5	1.565	1.59	1.64	1.665
C2[3]	2	1.993	2.056	2.197	2.365
C2[4]	2.2	2.151	2.251	2.434	2.678
C2[5]	2.5	2.423	2.523	2.791	3.176
C2[6]	3	2.769	2.953	3.373	4

Enter 'C2' beta sets

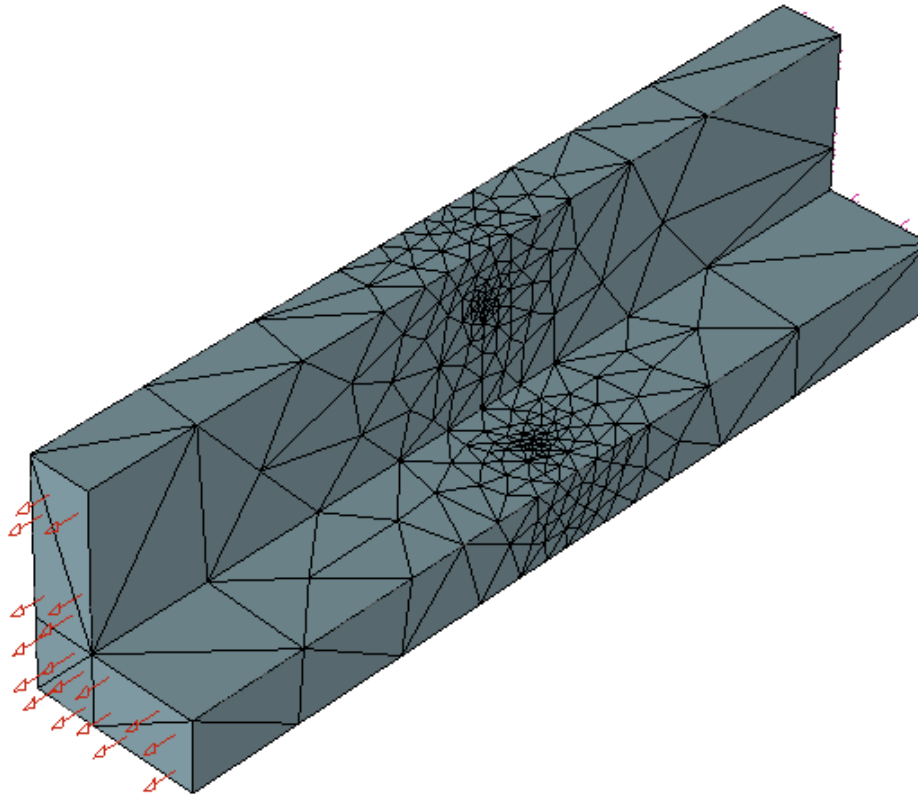
Number of sets:

		C1[1]	C1[2]	C1[3]	C1[4]
		1.105	1.205	1.405	1.605
C2[1]	1.3	1.289	1.387	1.58	1.765
C2[2]	1.5	1.307	1.399	1.634	1.873
C2[3]	2	1.308	1.432	1.707	2.086
C2[4]	2.2	1.297	1.426	1.724	2.161
C2[5]	2.5	1.276	1.418	1.728	2.234
C2[6]	3	1.296	1.457	1.764	2.314

OK
Apply
Read
Save
Cancel

- New Beta table Files are (*.linx)

Example of FEA model



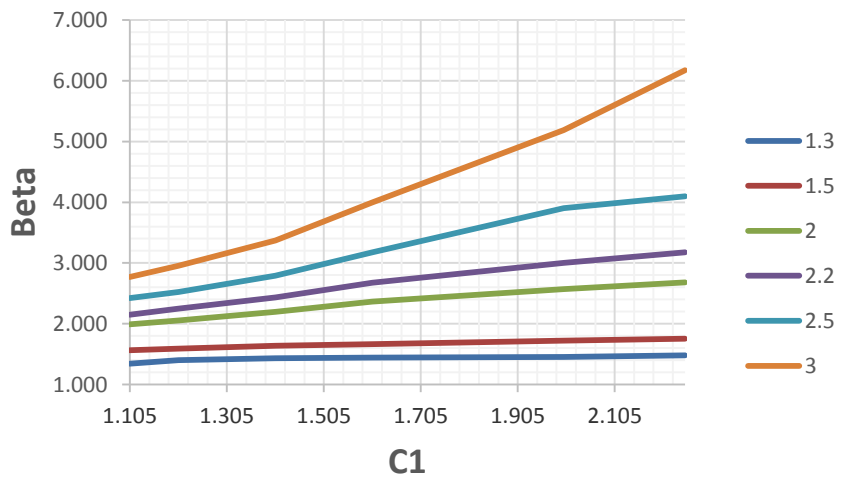
Beta Tables Generated FEA

C1 Beta Table							
		C1[1]	C1[2]	C1[3]	C1[4]	C1[5]	C1[6]
		1.105	1.205	1.405	1.605	2	2.25
C2[1]	1.3	1.342	1.400	1.431	1.442	1.457	1.479
C2[2]	1.5	1.565	1.590	1.640	1.665	1.721	1.752
C2[3]	2	1.993	2.056	2.197	2.365	2.568	2.682
C2[4]	2.2	2.151	2.251	2.434	2.678	3.000	3.174
C2[5]	2.5	2.423	2.523	2.791	3.176	3.902	4.100
C2[6]	3	2.769	2.953	3.373	4.000	5.190	6.172

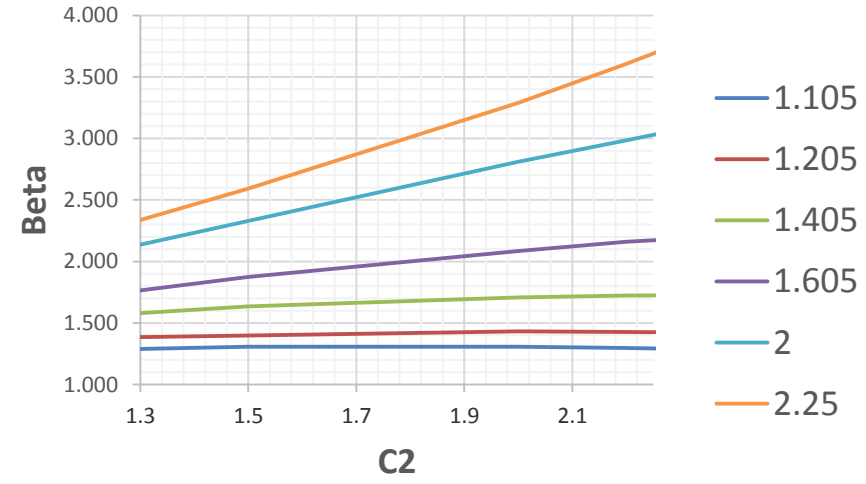
C2 Beta Table							
		C1[1]	C1[2]	C1[3]	C1[4]	C1[5]	C1[6]
		1.105	1.205	1.405	1.605	2	2.25
C2[1]	1.3	1.289	1.387	1.580	1.765	2.136	2.336
C2[2]	1.5	1.307	1.399	1.634	1.873	2.330	2.593
C2[3]	2	1.308	1.432	1.707	2.086	2.810	3.290
C2[4]	2.2	1.297	1.426	1.724	2.161	2.984	3.607
C2[5]	2.5	1.276	1.418	1.728	2.234	3.252	4.114
C2[6]	3	1.296	1.457	1.764	2.314	3.632	4.987

Beta Value Plots

C1 Beta Values



C2 Beta Values



Corrosion

- $d(\text{geometry})/d(\text{time})$ models: intergranular corrosion model, exfoliation corrosion modeling, and user defined equation model.
- Only one of three can be used at the same time
- Initial crack size: pitting and crevice model. Only one of two can be used at the same time
- Pitting model is not time dependent, it calculates maximum possible pit size under given environment for a specified material
- Crevice model calculates time that is required for crevice to develop under given environment for a specified material. Can be used similar to initiation model in AFGROW. Require time dependent spectrum in the old .st3 or new .spx format
- Developed under contract with SAFE

Corrosion - Exfoliation

- Require time dependent spectrum in the old .st3 or new .spx format
- Changes thickness/thickness equivalent dimension
- Depends on material properties and humidity

Exfoliation Material Loss

Material loss (damage) is modeled as a change in thickness (or equivalent dimensions for models without a thickness). This is quantified as shown below as a function of time (seconds) using the user-defined parameters: A', B and Humidity.

Enter

damage = $A' \cdot t \cdot \exp(B \cdot RH)$
t - time

Note: the units for A' are length/seconds, and Humidity is expressed in decimal format.

Coefficient (A'):

Coefficient (B):

Humidity % (RH):

Corrosion - Intergranular

- Require time dependent spectrum in the old .st3 or new .spx format
- Modeled as length from user defined initial defect size
- Not used in the crack growth predictions, but is reported in the output for reference purposes
- Depends on material and environment properties

The screenshot shows a dialog box titled "Intergranular Corrosion" with a close button (X) in the top right corner. The dialog contains the following text and input fields:

Intergranular corrosion (damage) is modeled as a length from a user-defined initial defect size. It is quantified as a function of time (seconds) using the parameters: A and N as indicated below.

This is not used in crack growth predictions, but is reported in the output for reference purposes.

Enter

damage = $A t^N$
t - time

Note: the units for A are length/seconds

Coefficient (A):

Coefficient (N):

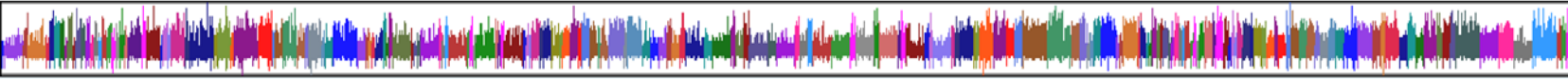
Initial defect size:

OK Cancel

Spectrum Manager

Spectrum Manager - C:\Users\alex\Documents\Visual Studio 2010\Projects\AfgrowDevelopment\Targets\dfstaf.sp3

Edit Preview Spectrum View



Spectrum Preview

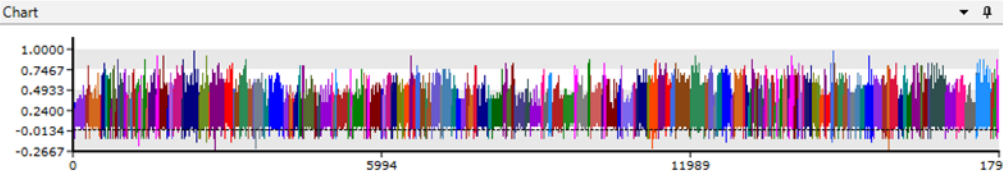
Sub Spectrums

- Falstaff
 - Sub Spectra
 - Flight 1
 - Flight 2
 - Flight 3
 - Flight 4
 - Flight 5
 - Flight 6
 - Flight 7
 - Flight 8
 - Flight 9
 - Flight 10
 - Flight 11
 - Flight 12
 - Flight 13
 - Flight 14
 - Flight 15
 - Flight 16
 - Flight 17
 - Flight 18
 - Flight 19

Exceedance Plot Sequence Data Spectrum Data

#	cycle	Max	Min	Cycles	Sub Spectrum Name
14	22	0.3462	0.1828	1	Flight 1
15	23	0.3054	0.1828	1	Flight 1
16	24	0.3462	0.1011	1	Flight 1
17	25	0.2236	0.1011	2	Flight 1
18	27	0.2645	0.1011	1	Flight 1
19	28	0.2236	0.1011	1	Flight 1
20	29	0.3462	0.1419	1	Flight 1
21	30	0.2645	0.1419	1	Flight 1
22	31	0.2645	0.1011	1	Flight 1
23	32	0.2236	0.1011	2	Flight 1
24	34	0.2645	-0.0624	1	Flight 1
25	35	0.0193	-0.0624	1	Flight 1

Chart



PropertiesWindow

A-Z

Spectrum

Title	Falstaff
SubSpectrum Label	Flight
Description	
Hours Per Pass	1

Statistics

Number Of Levels	15674
Number Of Cycles	17983
Max	1
Min	-0.2667

Properties Errors

Falstaff

Spectrum Manager Overview

- Visual spectrum design
- Spectrum level reordering
- Sub-spectra organized in any user-defined sequence
- Sub-spectra may be placed in the sequence more than once
- Sub-spectra may be re-ordered in the sequence
- Spectrum statistics at a glance
- Exceedance curve
- Sub-spectra tagging for future analysis
- Synchronized data views
- Spectrum level damage tagging

PropertiesWindow

A-Z

SubSpectrum

Name	Flight 2
Description	

Statistics

Number Of Levels	160
Number Of Cycles	215
Max	0.5505
Min	-0.1033

Tags

Humidity	100
Temperature	120

Name

Name of SubSpectrum

Acknowledgements

- A-10 and T-38 Structural Integrity and Analysis Group
- SAFE Inc.
- Analytical Processes / Engineered Solutions
- NRC (compounding solution for two cracks under bearing load)
- AFGROW Customers and Consortium Members