AFGROW Workshop 2017

AFGROW Release 5.3

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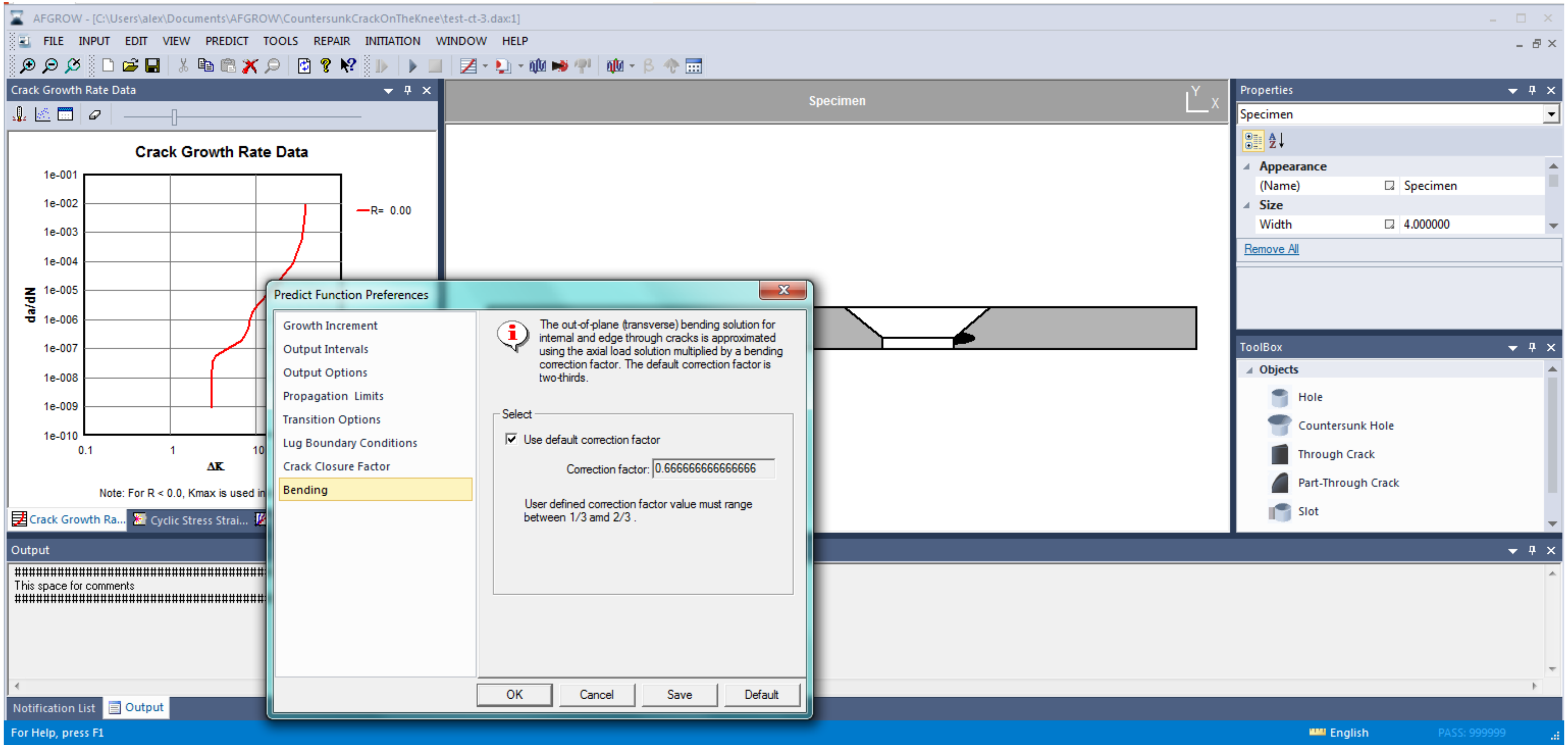
AFGROW Release 5.3



AFGROW Release 5.3 – Highlights

- Release Candidate Availability Date - September 27, 2017
- 64 bit version
- Multilingual support
- Material Database redesign and outgoing data update – more then 2000 new material tests will be loaded. A-10, T-38, NRC and additional Air Force provided data.
- New downloadable material data in tabular lookup format will available online
- Spectrum Manager to create and edit spectra included in the release

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AFGROW Release 5.3 – New Functionality

- Numerous K-solution changes/enhancements
- Ability to use different material data as a function of spectrum level
- Ability to apply different material data to different crack directions
- Corrosion Effects
  - Exfoliation
  - Intergranular
  - Pitting
- Added a new spectrum format that supports above changes and future enhancements
- Ability to open read only material data from the network or online folder. System administrator managed feature.

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AFGROW Release 5.3 – New K-Solution Functionality

- 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:
    - Classic edge crack
    - Classic double edge crack
    - Classic through crack
    - All advanced cracks where bending was not available with the exception of crack at slot
- New solution for a corner crack at the countersink knuckle
- Bearing solution for advanced through crack(s) at a hole
- 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%
- Single edge crack model with the finite height – provided by SAFE
- Added global “Constrained” property for advanced model in-plane bending - only applicable for notch solutions.

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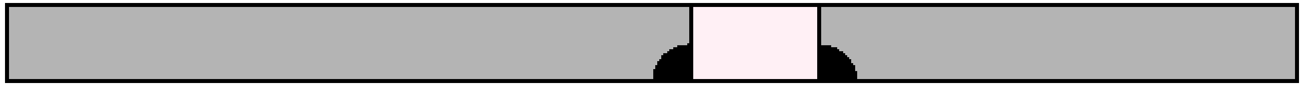
64 Bit AFGROW Performance Test

Advanced double cracked hole with offset



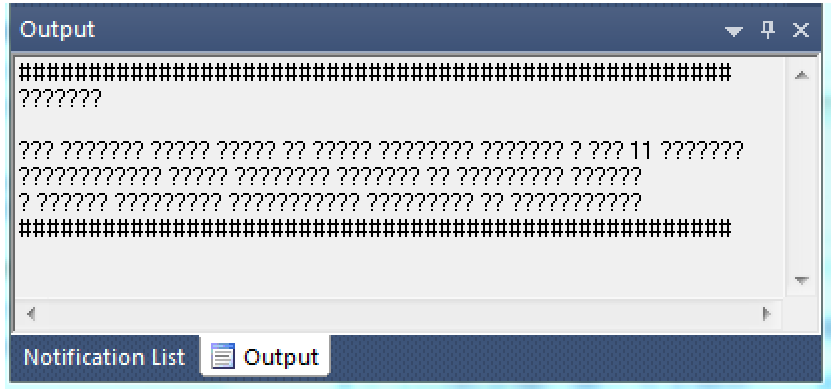
Model	Spectrum	Time 5.2 (sec)	Time 5.3 (sec)	Difference
Multipoint	FALSTAF	122	90	35.56%
Multipoint	Const Amplitude	8	6	33.33%
2 points	FALSTAF	73	62	17.74%
2 points	Const Amplitude	5	4	25.00%

32 to 64 bit upgrade was sponsored by APES

Multilingual Support

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

5.02



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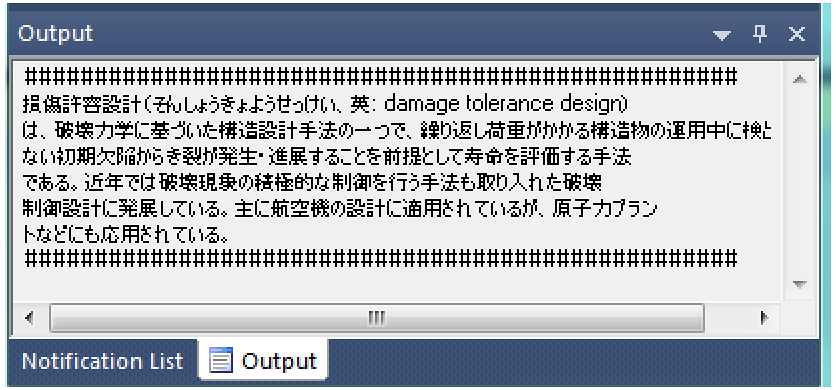
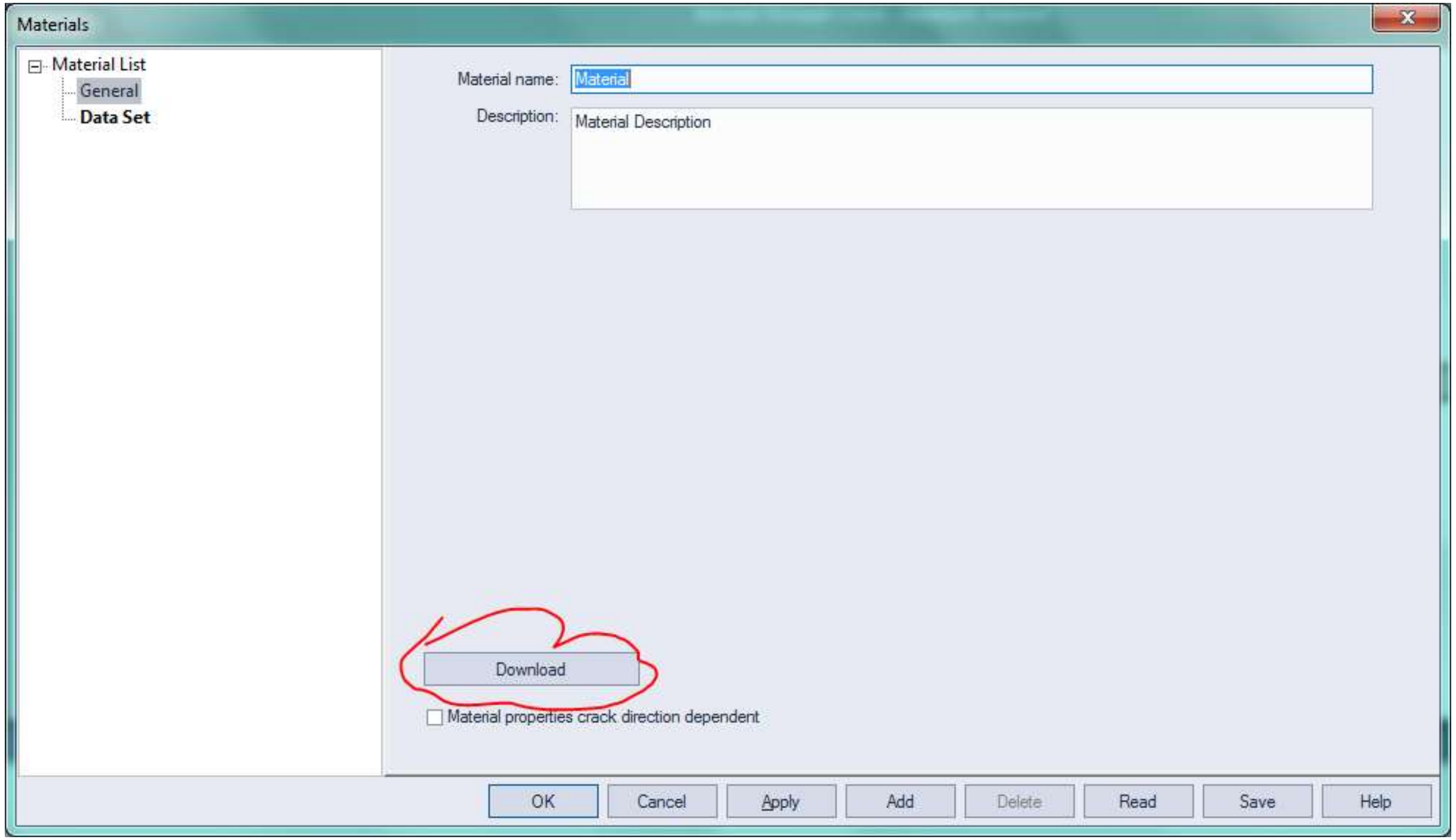


Network or Online Access to Material Data

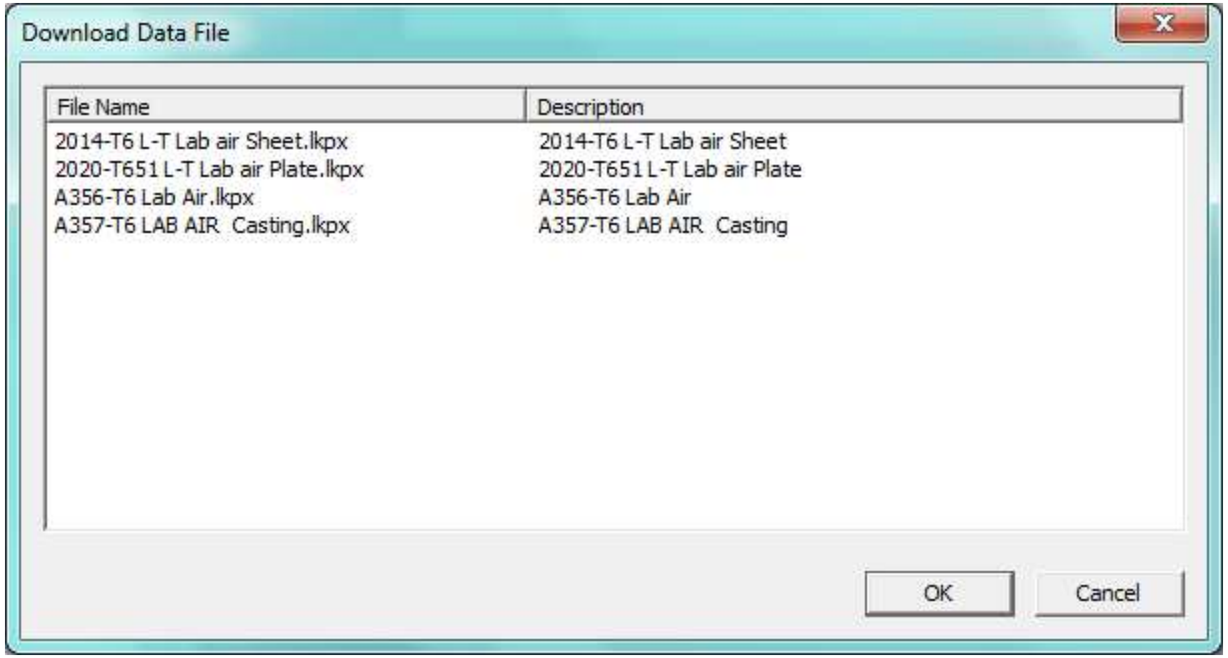
- Only tabular lookup format right now
- Require modification to the AFGROW configuration file and can be done only by administrator
- Require a data configuration file that points to all material data files
- Material files need to be in the lkpx (XML based format)

```
<configuration>
    <appSettings>
        <add key="MaterialLookupListUrl" value="http://www.afgrow.net/material/MaterialLookupList.xml" />
    <!--<add key="MaterialLookupListUrl" value="Z:\ServerFolders\Users\Alex\XML-Material-Data_load\MaterialLookupList.xml" />-->
    </appSettings>
  <custom.settings>
```

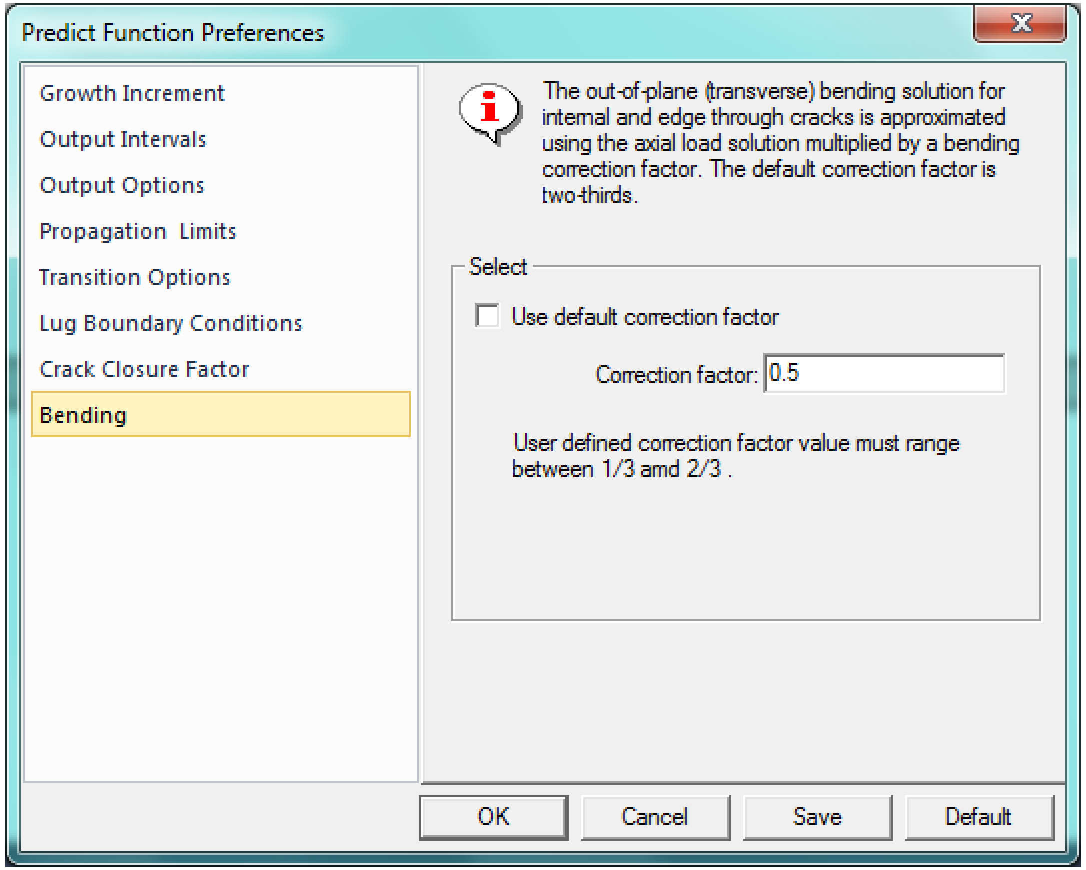
Network or Online Access to Material Data



Network or Online Access to Material Data – Download Data Dialog



Option to Approximate the Thru-Crack Out-of-Plane Bending Solution

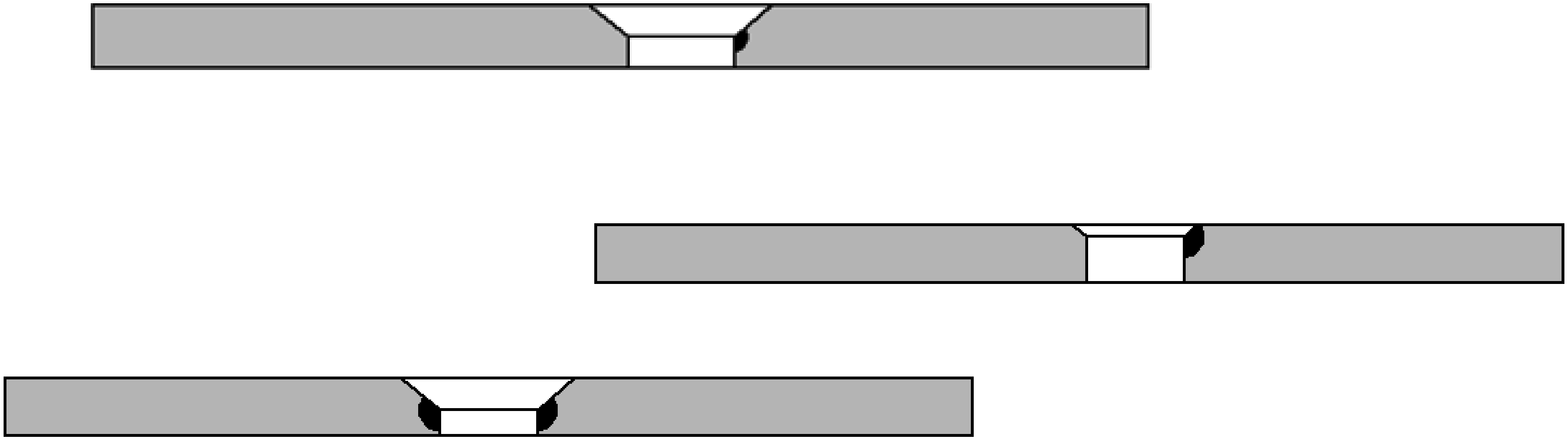


- Classic edge crack
- Classic double edge crack
- Classic through crack
- All advance cracks where bending was not available with the exception of crack at slot

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

Corner Crack at the Countersink Knuckle



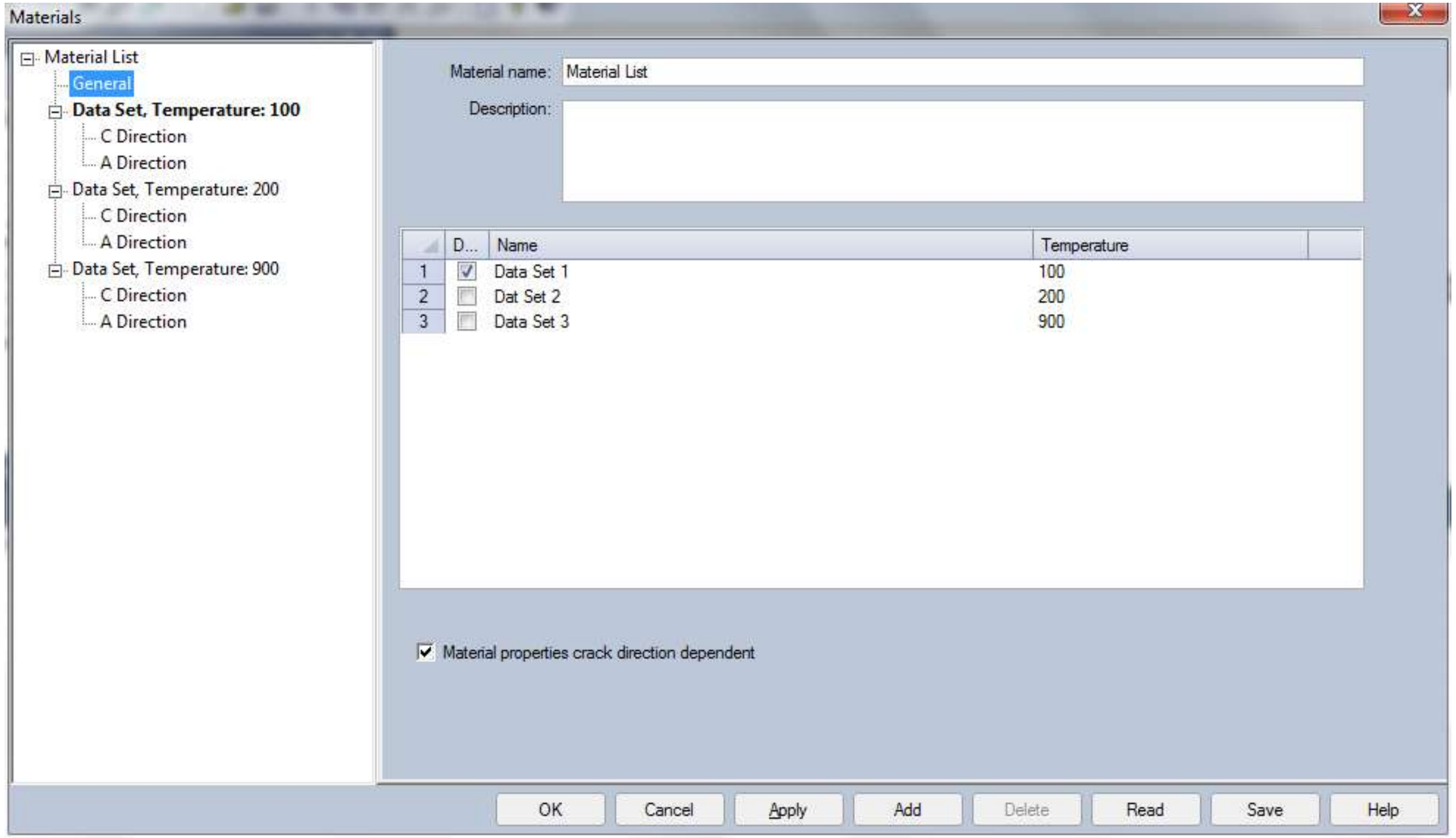
Using different material data as a function of spectrum levels

- Material data will consist of different material "sets"
- One material "set" is always default
- Material sets can be tagged for different conditions
- Only the Environment "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
- Spectrum with Environment "tags" applied to a level
- 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

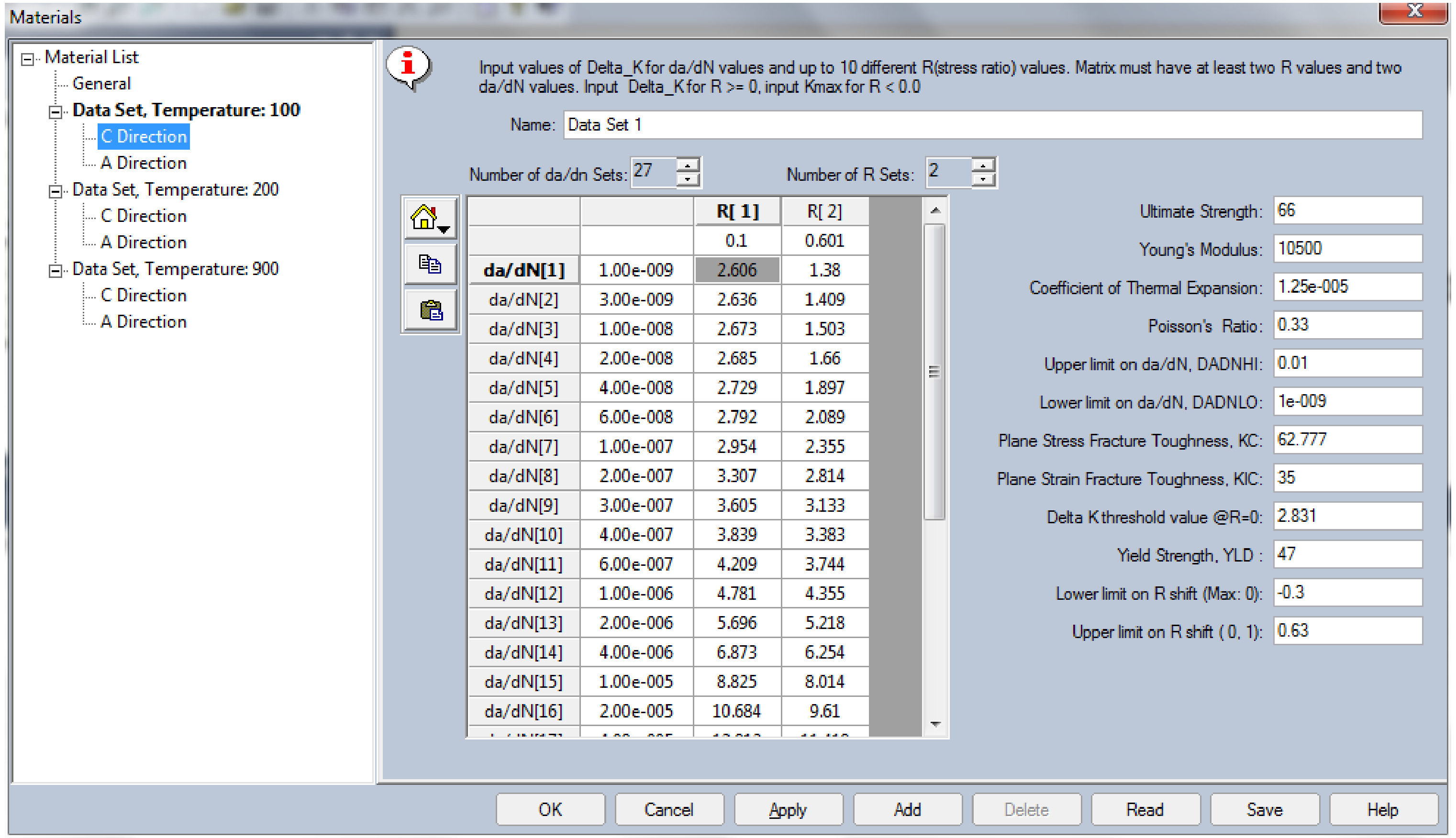
Applying different material data to different crack directions

- 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” option
- DAX input file is backward and upward compatible
- Plugin model changed to handle different material data for different crack directions

New Tabular Look-Up Material Dialog Changes General



New Material Dialog Changes
Material Set Property



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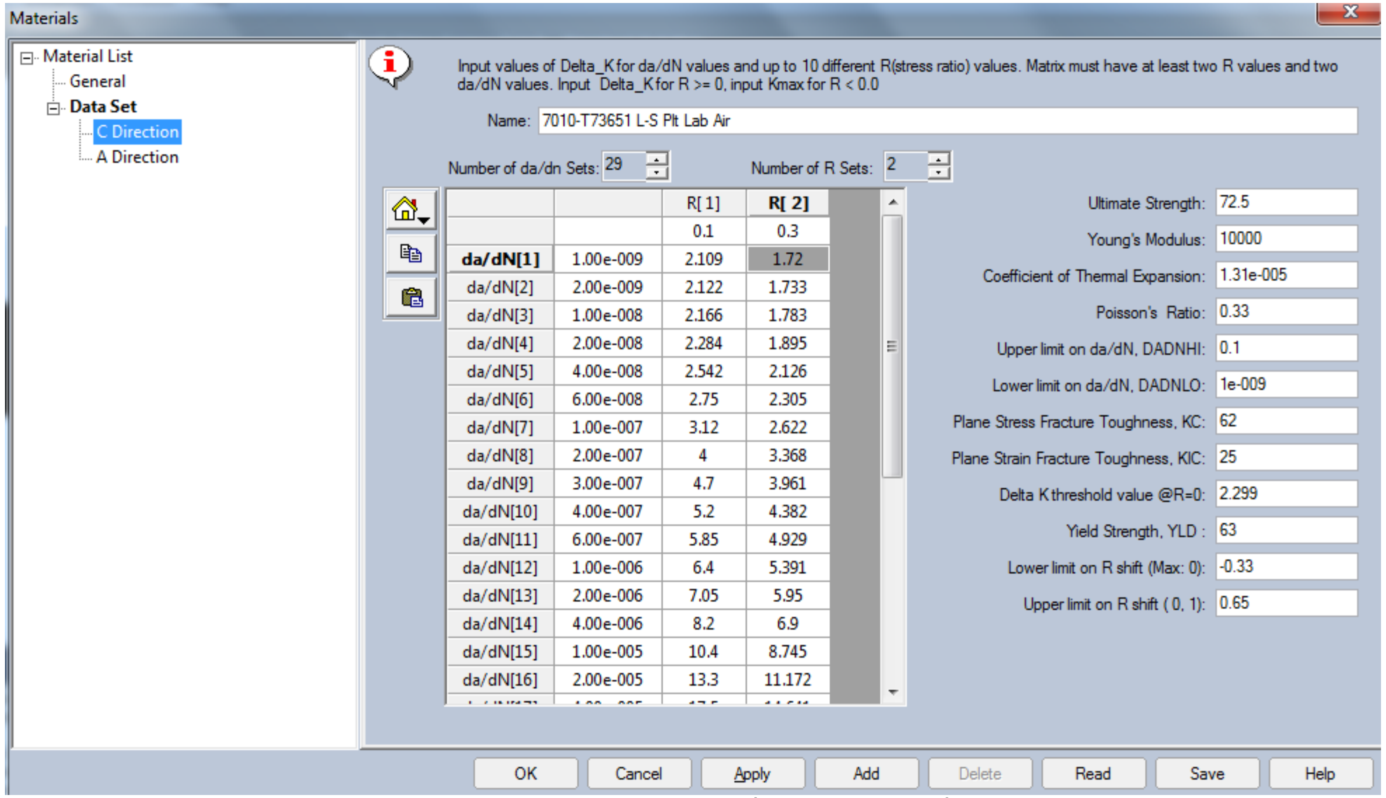
Using Different Material Data for Different Crack Directions



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

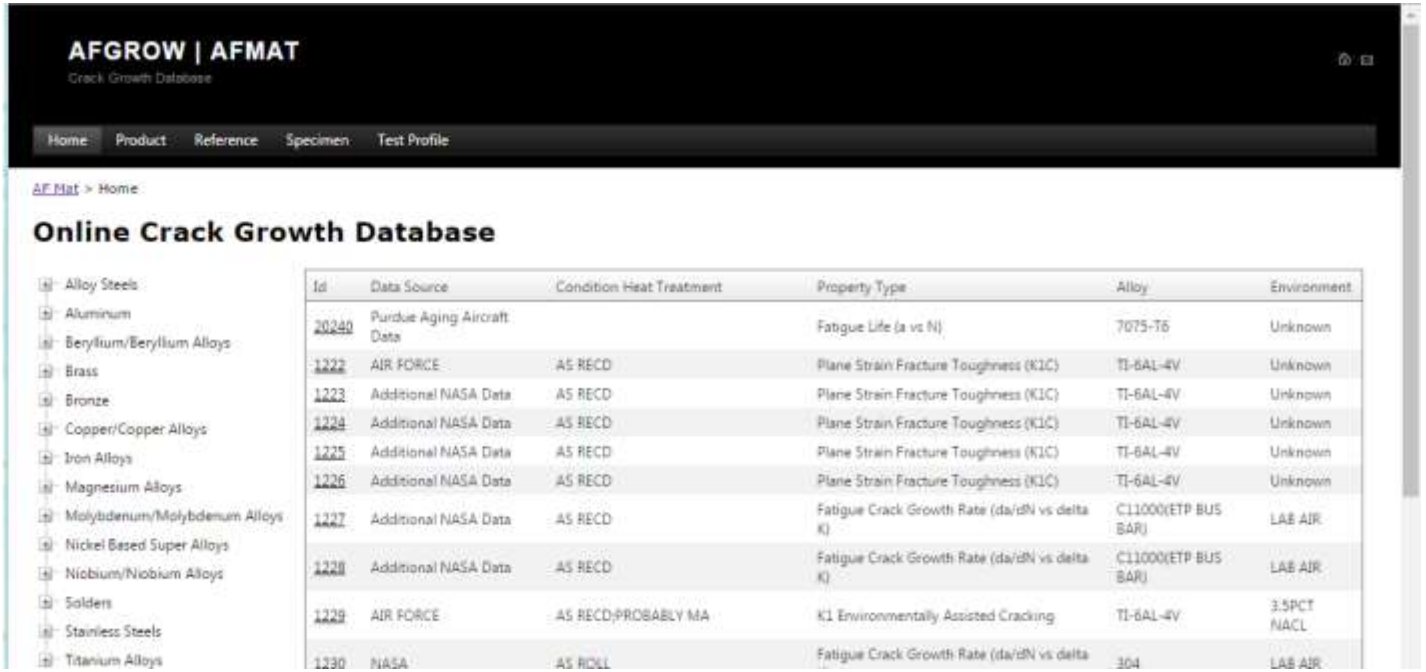
Material Data from AFMAT Converted to Tabular Lookup Format in AFGROW

73 Materials Converted, 53 Approved

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



Id	Data Source	Condition Heat Treatment	Property Type	Alloy	Environment
20240	Purdue Aging Aircraft Data		Fatigue Life (a vs N)	7075-T6	Unknown
1222	AIR FORCE	AS RECD	Plane Strain Fracture Toughness (K1C)	TI-6AL-4V	Unknown
1223	Additional NASA Data	AS RECD	Plane Strain Fracture Toughness (K1C)	TI-6AL-4V	Unknown
1224	Additional NASA Data	AS RECD	Plane Strain Fracture Toughness (K1C)	TI-6AL-4V	Unknown
1225	Additional NASA Data	AS RECD	Plane Strain Fracture Toughness (K1C)	TI-6AL-4V	Unknown
1226	Additional NASA Data	AS RECD	Plane Strain Fracture Toughness (K1C)	TI-6AL-4V	Unknown
1227	Additional NASA Data	AS RECD	Fatigue Crack Growth Rate (da/dN vs delta K)	C11000(ETP BUS BAR)	LAB AIR
1228	Additional NASA Data	AS RECD	Fatigue Crack Growth Rate (da/dN vs delta K)	C11000(ETP BUS BAR)	LAB AIR
1229	AIR FORCE	AS RECD;PROBABLY MA	K1 Environmentally Assisted Cracking	TI-6AL-4V	3.5PCT NACL
1230	NASA	AS ROLL	Fatigue Crack Growth Rate (da/dN vs delta	304	LAB AIR

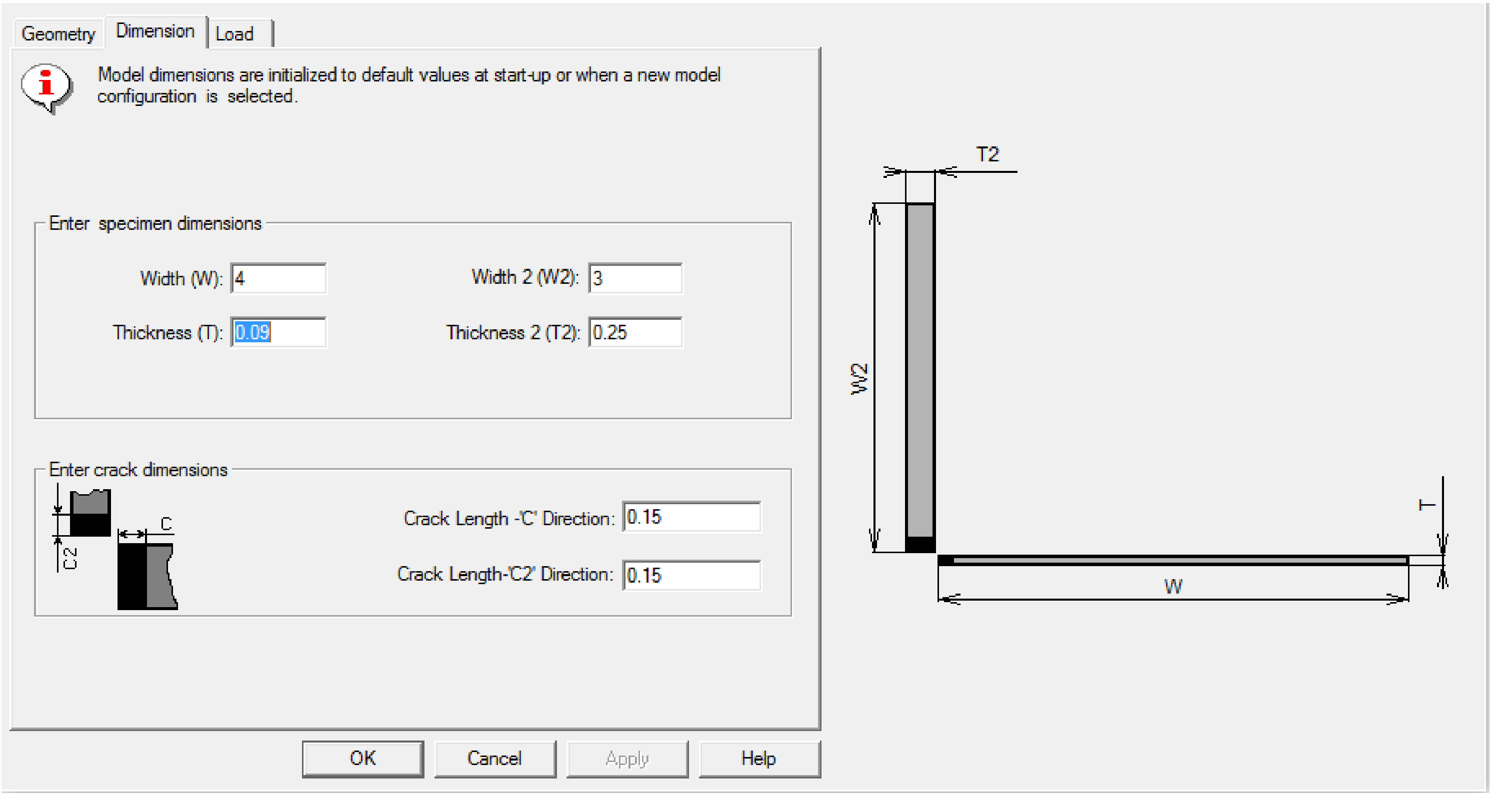
New Classic Models

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

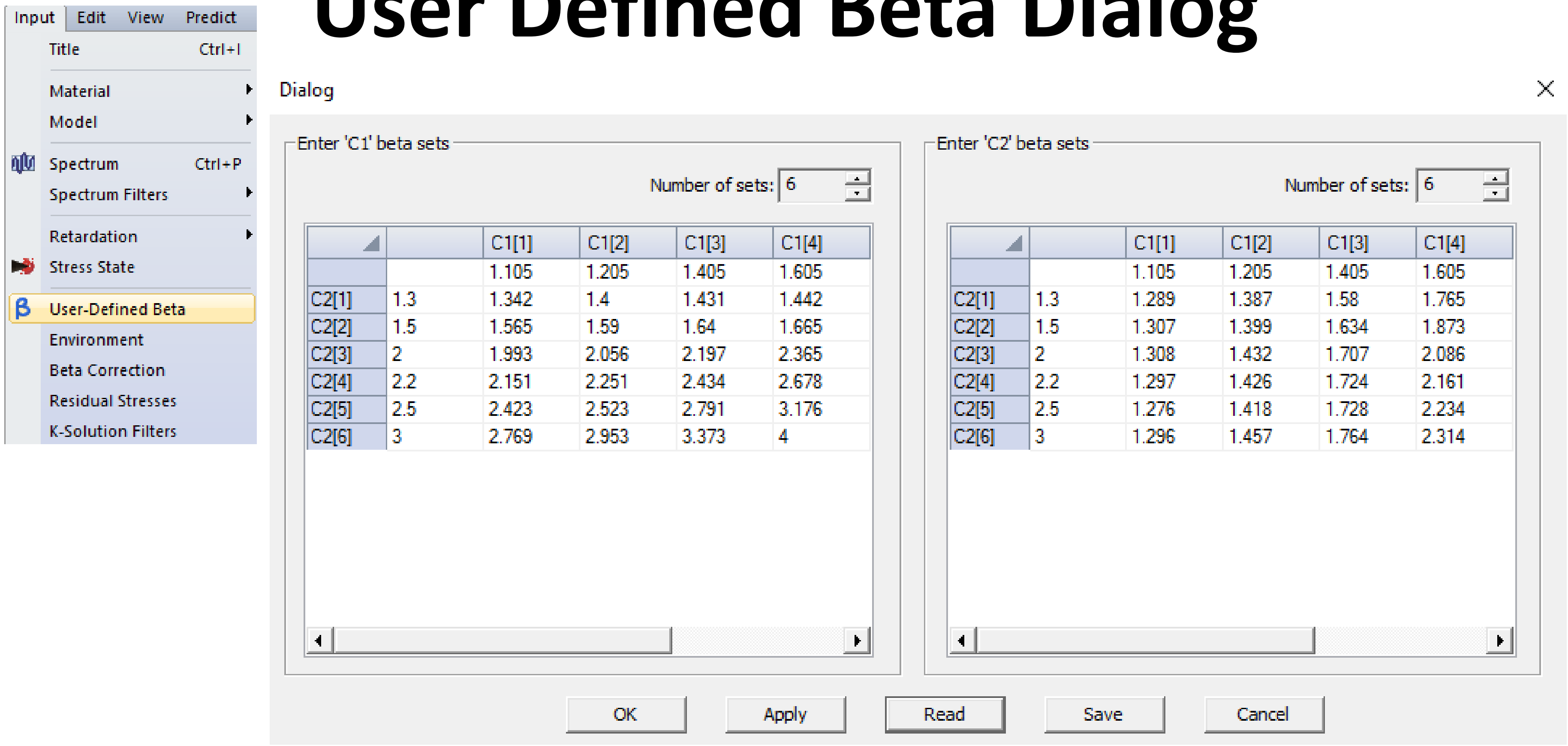
Model	Description of the Configurations	Beta Solution
[ ]	Part Through Crack in Pipe	Application Defined
[ ]	Through Crack	User Defined
[ ]	Interdependent Through Cracks	User Defined
[x]	Internal Through Crack	Application Defined
[ ]	Single Through Crack at Hole	Application Defined
[ ]	Double Through Crack at Hole	Application Defined
[ ]	Single Through Crack at a Semi-circular Notch	Application Defined
[ ]	Single Edge Through Crack	Application Defined
[ ]	Single Edge Through Crack in a Finite Height ...	Application Defined

Two inter-dependent through cracks model

Model Geometry/Dimension/Load Dialog



User Defined Beta Dialog



Enter 'C1' beta 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

		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

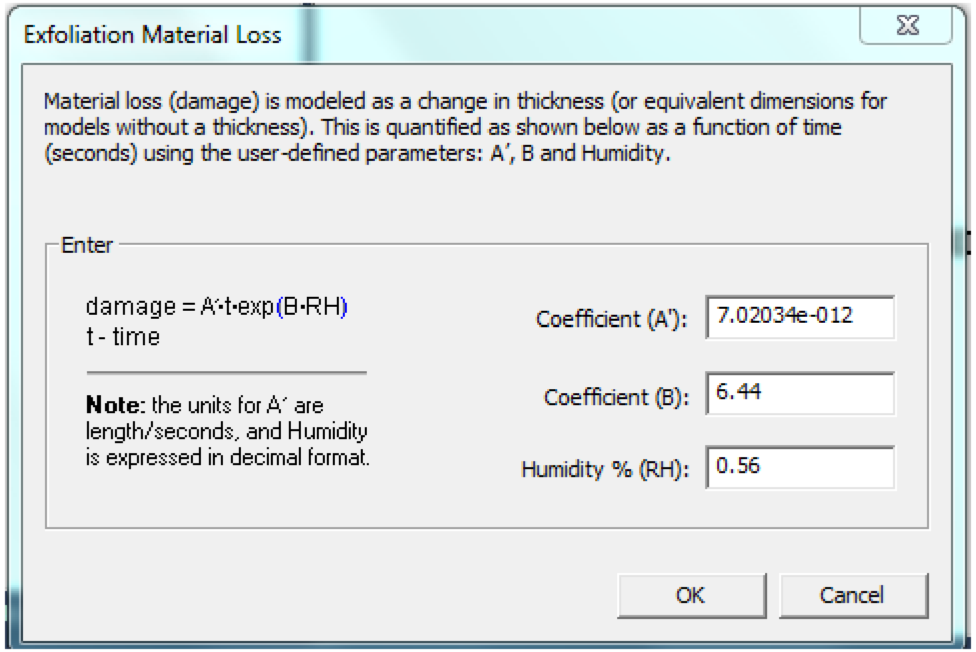
- New Beta table Files are (*.linx)

Corrosion Effects

- d(geometry)/d(time)models: intergranular corrosion model or exfoliation corrosion modeling.
- Requires the time dependent spectrum in the old .st3 or new .spx format
- Only one of two can be used at the same time
- Initial crack size (pitting model): Pitting model is not time dependent, it calculates maximum possible pit size for a given environment/specified material
- Developed under contract with SAFE

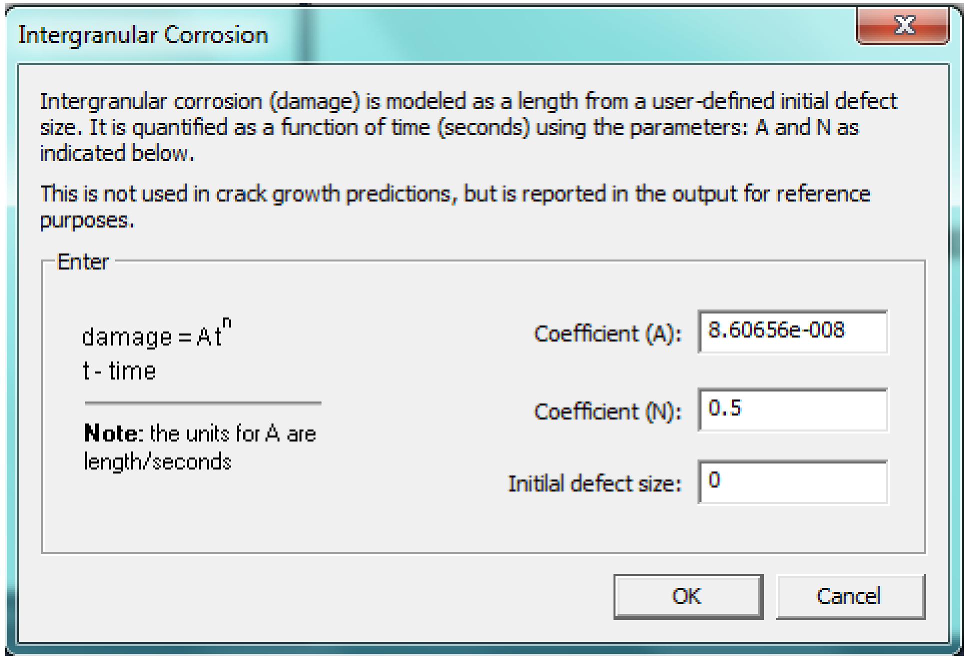
Corrosion - Exfoliation

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



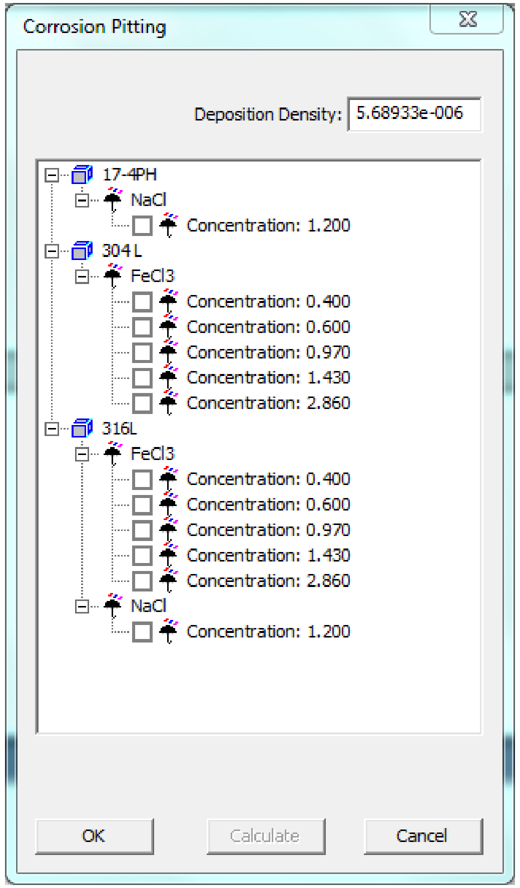
Corrosion - Intergranular

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



Corrosion - Pitting

- This model predicts the maximum pit size possible for 17-4PH, 304L, and 316 stainless steel surfaces under thin film electrolyte conditions for the available test data and assumes a hemispherical pit.
- The maximum pit size possible is predicted by coupling the maximum cathode current (I_{cath}) available from the thin film electrolyte with the minimum current (I_{anode}) needed to grow a hemispherical pit. Users have the option to choose from five different concentrations for FeC13 and one concentration for NaCl for the thin film conditions as indicated above
- The maximum pit size may be used to define an initial crack length for a subsequent life prediction. This will enable users to account for the total damage accumulated due to pitting corrosion for a given material and environmental conditions. The upper bound of the maximum pit radius is set to 0.0394 inches. This is believed to be the largest pit that one would ever expect to see on a surface



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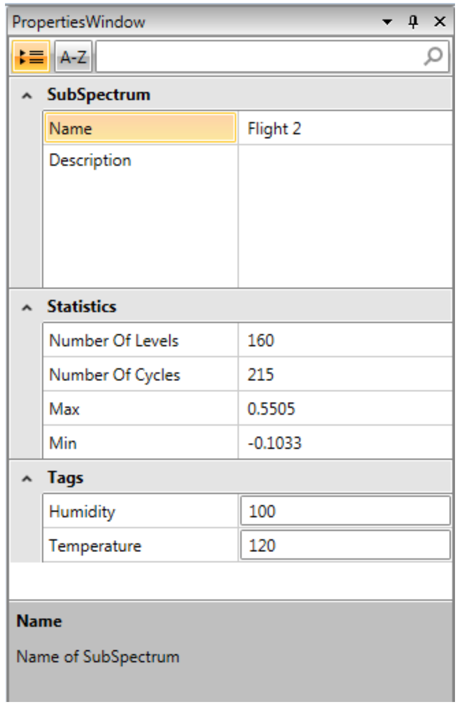
Spectrum Manager

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
- Spectra normalization/de-normalization
- Clipping/Truncation capability
- Import data from “old” sub files



Acknowledgements

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